



GREENPEAK PARTNERS

AI DEPLOYMENT AND OPERATIONS

CHAIR OF ARTIFICIAL INTELLIGENCE | PROF. DR. HEINER STUCKENSCHMIDT
GREENPEAK PARTNERS | LINDA HONG

PROJECT SEMINAR

HAPPY TO HAVE YOU ON BOARD!

Prof. Stuckenschmidt and I selected 12 students for this seminar.

Wochentag	Datum ▲	Von - Bis	Raum	
Mi	09.09.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	
Mi	23.09.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	→ We will proceed with the students passing the requirements today
Mi	07.10.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	
Mi	21.10.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	
Mi	04.11.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	
Mi	18.11.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	
Mi	02.12.2026	17:15 - 18:45	ZOOM-Lehre-104 (Virtuelles Gebäude)	→ Final group presentation

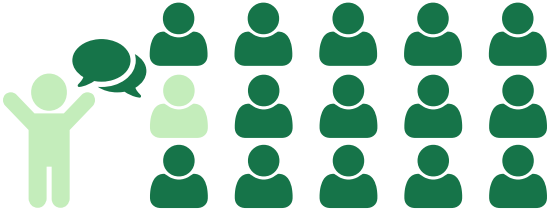
Please build groups of 3 students to proceed with the group work.

Since we are a small group, feel free to ask questions!

WHY ARE YOU IN THIS SEMINAR?

Let’s use the time to do get to know each other

Name	
Semester	
Other seminars visited	
Expectations for the seminar	



LEARNING GOALS

At the end of the seminar, you should be familiar with the following topics:

- Usage of an energy data set to predict the future electricity demand
- Basic understanding of the German electricity market and the current challenges and opportunities
- Basic understanding about what a Private Equity Company is doing and how we leverage AI in our operations
- Understand the usage of cloud technologies
- Usage of Azure to conduct a machine learning project
- Usage of Databricks to conduct cloud computation
- Usage of Terraform to configure infrastructure as code
- Usage of Github to track version control
- Conduct a group work to train working in teams

LEARNING GOALS

In today's session, we want to cover the following topics:

- **Usage of an energy data set to predict the future electricity demand**
- **Basic understanding of the German electricity market and the current challenges and opportunities**
- Basic understanding about what a Private Equity Company is doing and how we leverage AI in our operations
- Understand the usage of cloud technologies
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WE WILL GRADE A GROUP WORK WITH A FINAL PRESENTATION

1

Practical application

You will get a dataset, allowing you to apply the theoretical knowledge



The dataset contains information on Germany's electricity consumption

2

Group work

You will work in teams



We expect every team member to contribute to the project. The expected artifacts will be highlighted in the subsequent weeks (75% of the final grade).

3

Presentation skills

The results will be presented in the end



We evaluate the content, the presentation and the presentation style (25% of the final grade).

WE WILL USE THE SMARD DATASET ON GERMANY'S ELECTRICITY CONSUMPTION

About the data:

- We are using the German electricity consumption between 2019 and 2024
- Predict the daily and hourly energy consumption for Germany in 2024; You can find more information on the data [here](#)



These columns refer to the relevant time period; you will get access to daily and hourly data

Datum von	Datum bis	Netzlast [MWh] Berechnete Auflösungen
01.01.2019	02.01.2019	1.097.118,75
02.01.2019	03.01.2019	1.388.494,25
03.01.2019	04.01.2019	1.466.308,25
04.01.2019	05.01.2019	1.486.876,25

Use this as the outcome variable to predict

WE WILL USE THE SMARD DATASET ON GERMANY'S ELECTRICITY CONSUMPTION

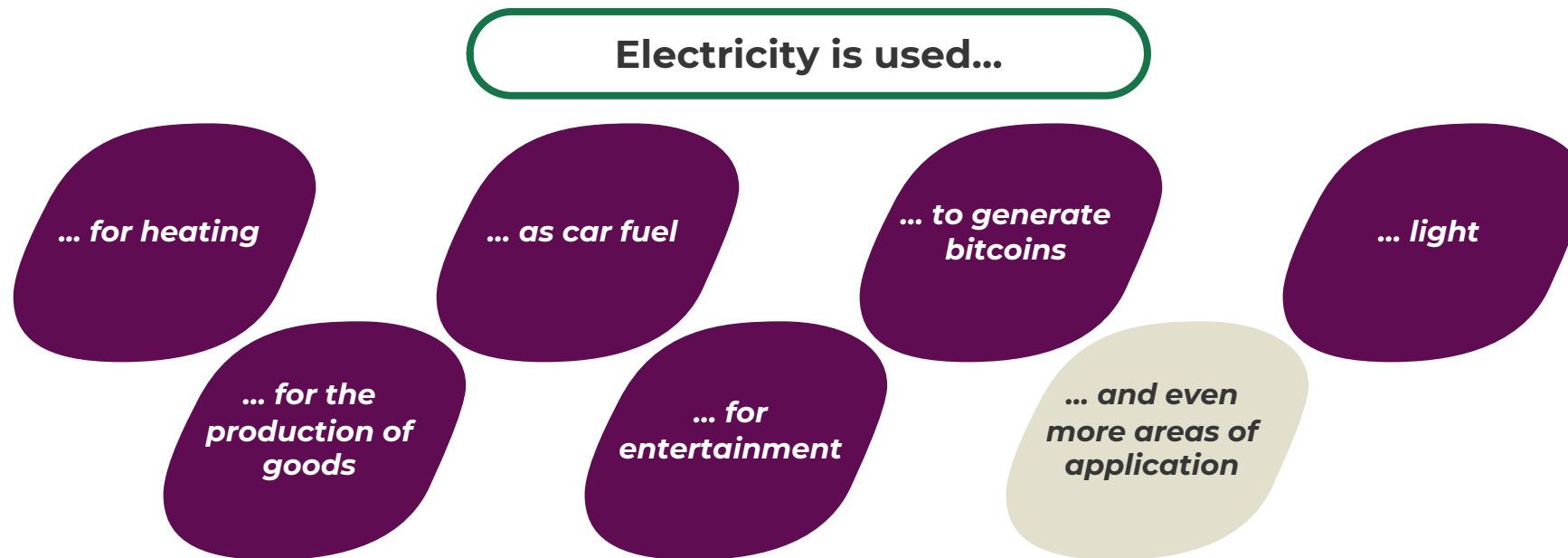
About the data:

- SMARD stands for Strom- und Gasmarktdaten
- The data is captured by the federal network agency (Bundesnetzagentur | BNetzA) which is the regulatory agency for all grid operations such as electricity, gas or railway; the BNetzA sets the rules and enforces compliance in Germany
- In the SMARD dataset, you can obtain detailed but also consolidated information about the energy consumption, generation, system stability or market trades of energy
- The data is openly available



WHY IS ELECTRICITY IMPORTANT AND INTERESTING?

Energy is the basis for all applications

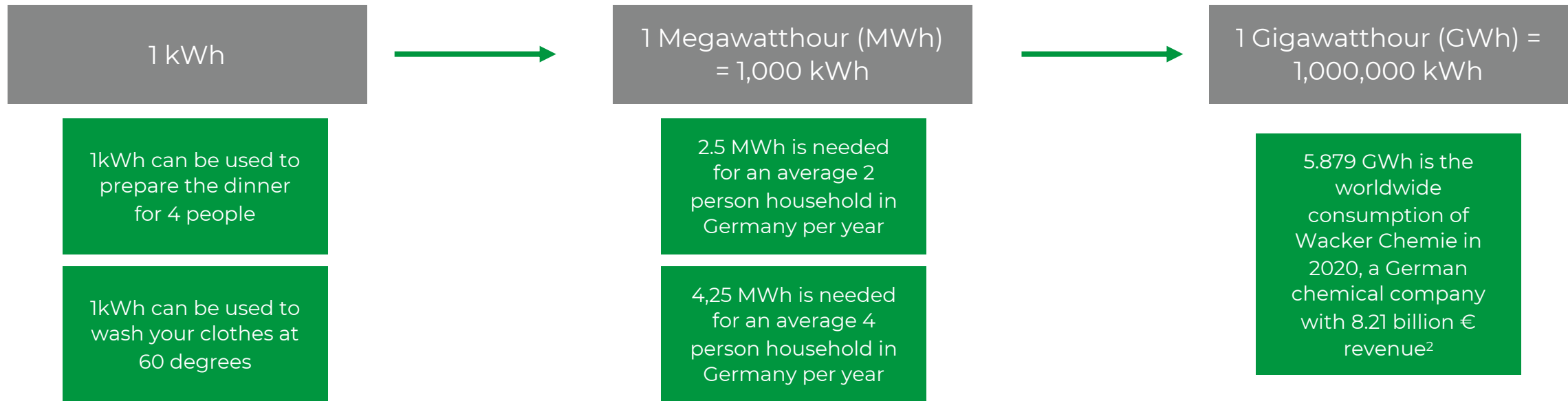


Electricity is increasingly used as the primary energy source for many applications. According to the International Energy Agency (IEA), the yearly electricity consumption will grow by 2,6%. Main reasons are increased wealth of developing countries such as China (+6,4% in 2023) or India (+7% in 2023), new areas of applications such as data centers (consumption of 460 TWh in 2022) or new regulations (e.g. energy transition in Germany). Electricity as an energy source most often contains less CO₂ than traditional means such as gas.¹

THE CONSUMPTION OF ENERGY IS MOST OFTEN MEASURED IN KILOWATT-HOURS (KWH)

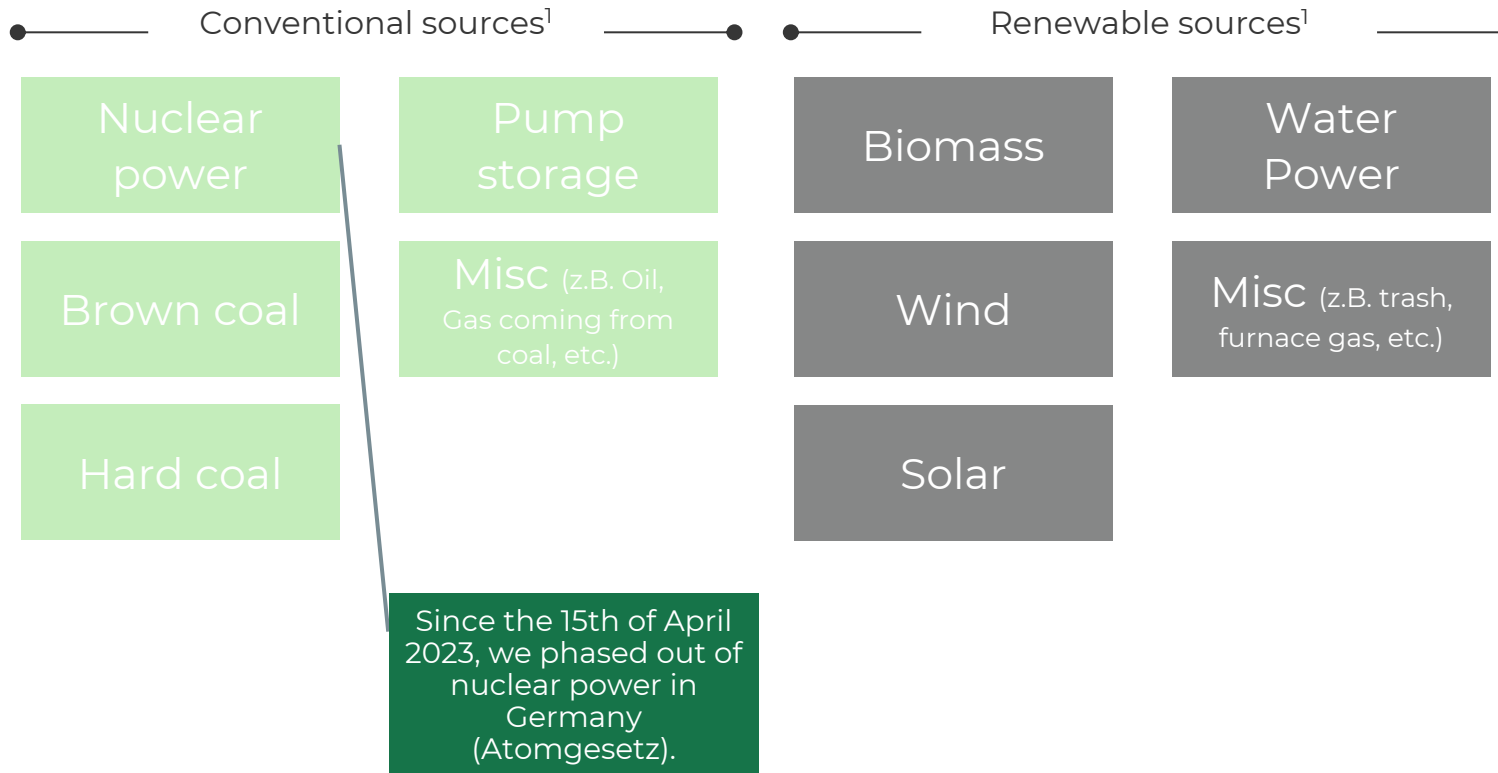
One watt describes the power capacity of an energy source. The kilowatt-hour – abbreviated as kWh – indicates as a unit of measurement how much energy (electricity or gas) a device consumes within a certain period of time. The power consumption of an electrical device within one hour can be calculated as follows:

$$\text{Watt} \times \text{hour} : 1.000 = \text{kWh}$$



ELECTRICITY CAN BE GENERATED WITH DIFFERENT SOURCES

Relevant energy sources for electricity generation

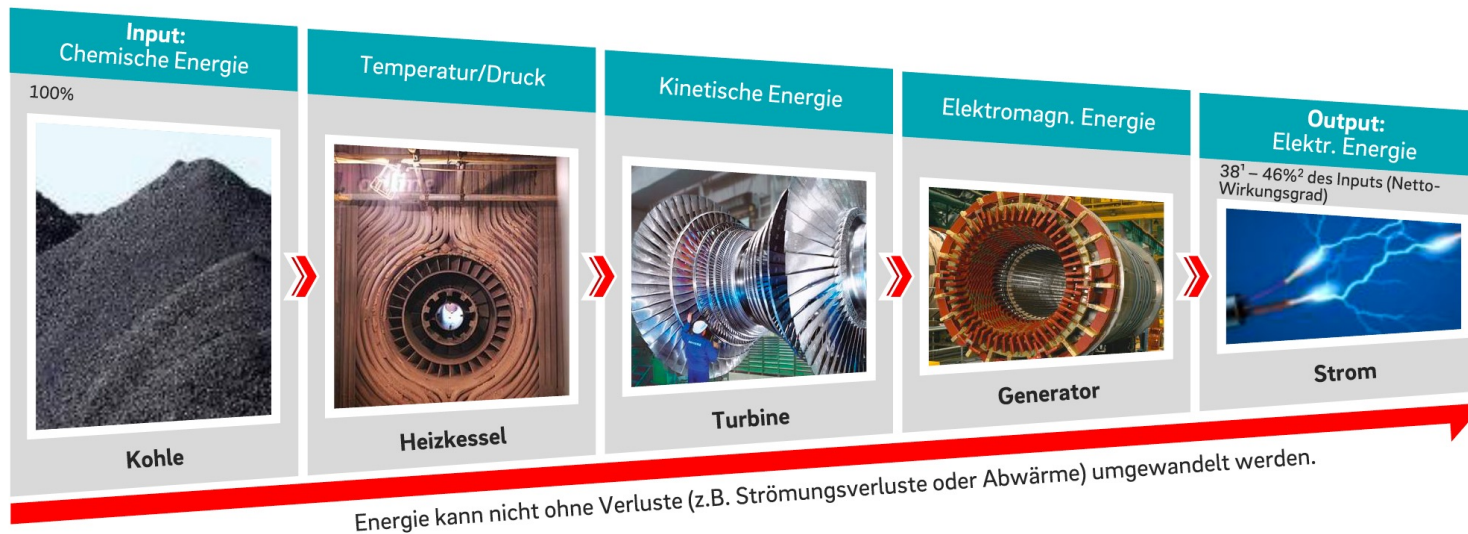


Important findings

- Electricity can be generated with conventional or renewable sources
- Conventional sources need fossil commodities to generate electricity
- Renewable sources are mostly dependent on the weather and are thus more volatile
- Germany phased out of most conventional sources, especially nuclear. Renewable sources should be used to generate electricity
- The most important sources in Germany were 2023: Wind (31%), coal (26%), gas (14%) & solar (12%)²
- However, we still use nuclear energy as Germany is part of the European energy market

ELECTRICITY IS GENERATED BY TRANSFORMING ENERGY

Energy transformation to generate electricity with coal³



By transforming energy several times, only a fraction of the used energy can be utilized in the end. The ratio is called efficiency. The higher the efficiency, the more energy can be used. The lower the efficiency, more energy is used for the energy generation process.

Efficiency for coal electricity generation⁴

- Coal cleansing
- Grinding of coal into pulverized coal for better combustion performance
- Combustion of the coal in the boiler
- Resulting heat is directed into a water-tube boiler
- Resulting steam is forwarded to a turbine connected to a generator
- Generator moves mechanically and generates electricity

Efficiency of different⁵

80-90% Water power

50% Wind power

40% Coal power

33% Nuclear power

20% Solar power

THE GERMAN ELECTRICITY GRID IS NOT ISOLATED; IT IS EXCHANGING WITH THE EUROPEAN GRID

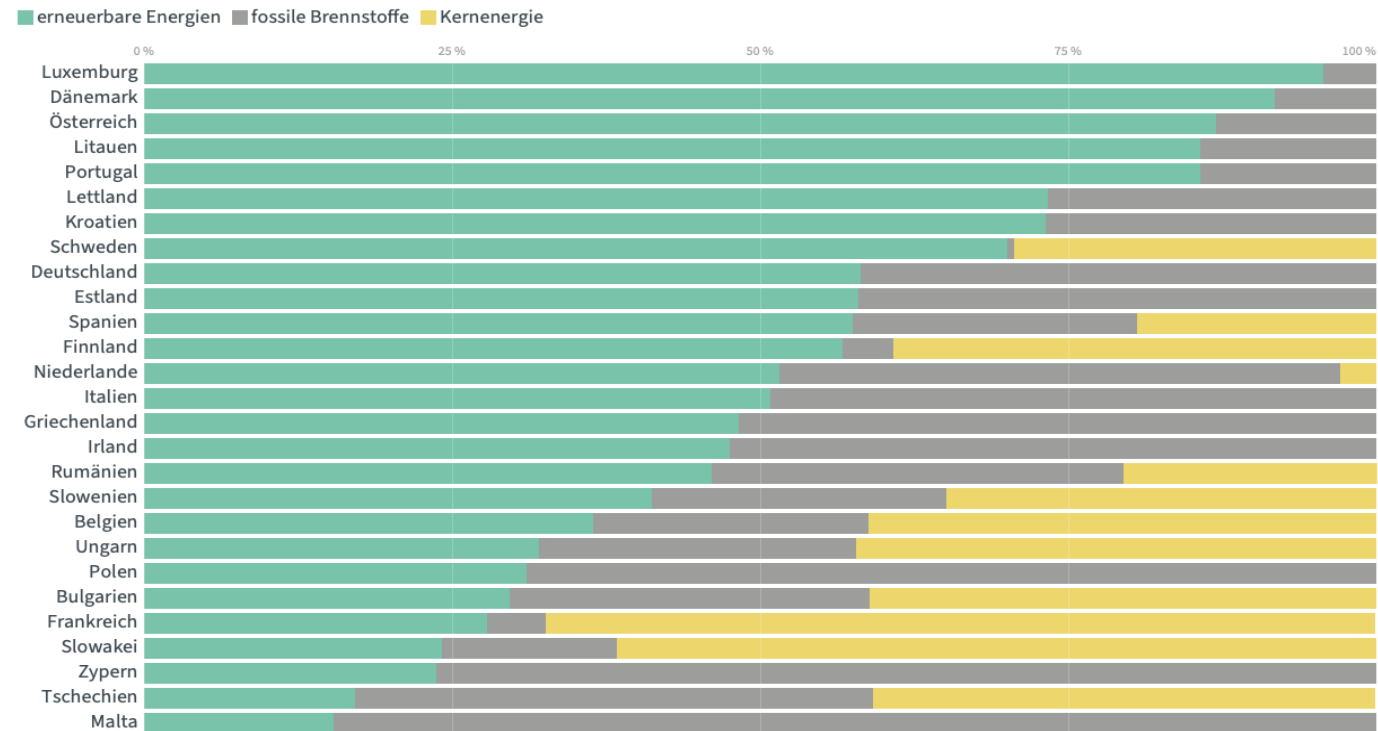
European neighbours in the grid¹

IM HERZEN DES EUROPÄISCHEN STROMNETZES

Die wichtigsten Interkonnektoren und Höchstspannungsleitungen (>300 kV) zwischen Deutschland und seinen Nachbarländern.



Energy mix in Europe²



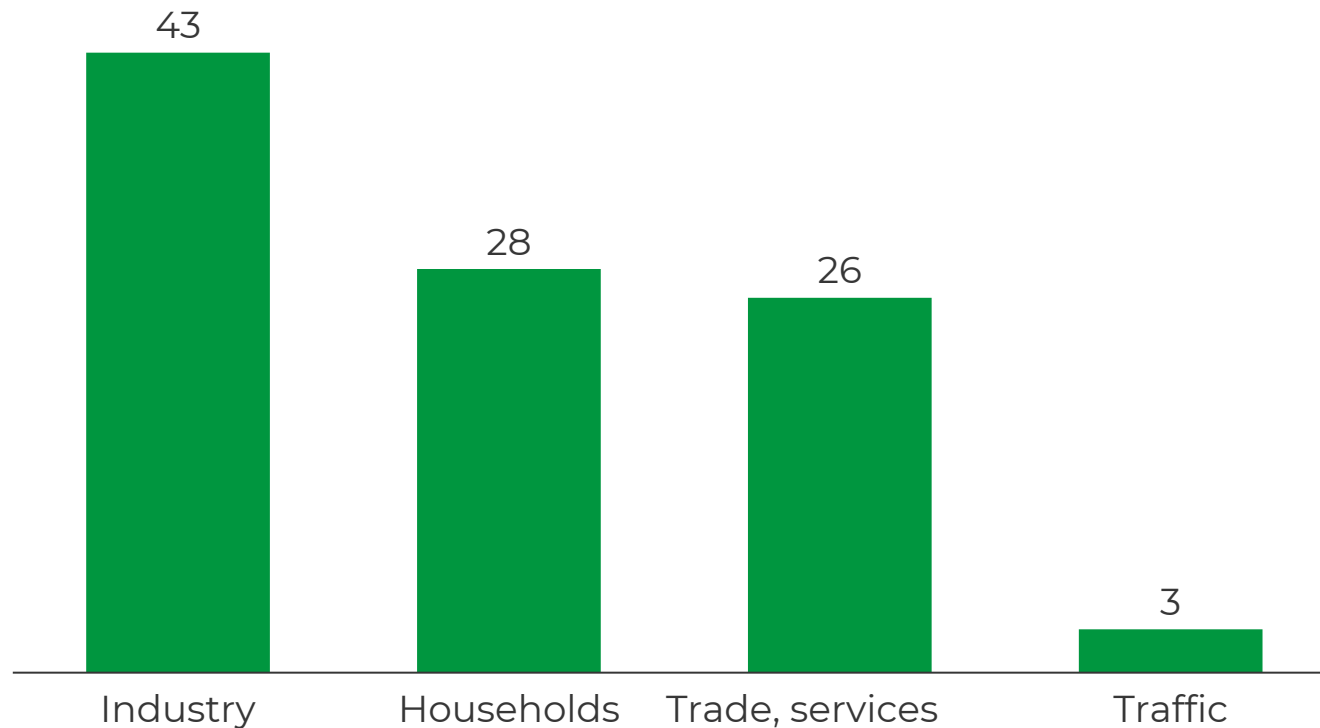
Quelle: eigene Berechnungen auf der Grundlage von Eurostat-Daten

The European energy market allows for increased system stability. Each country has a different energy mix. 12 countries are using nuclear power in the European Union. France is the front runner in nuclear power generation.

INDUSTRIAL COMPANIES ARE THE BIGGEST GROUP OF ELECTRICITY CONSUMERS IN GERMANY

Electricity consumption in Germany by sector in 2023

● ————— Share of electricity consumption in Germany in 2023 in % ————— ●

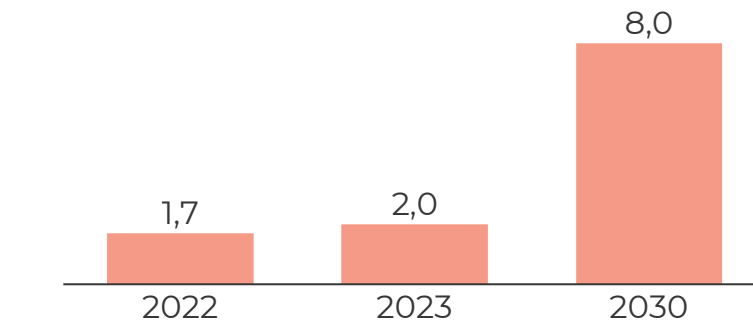


Remarks

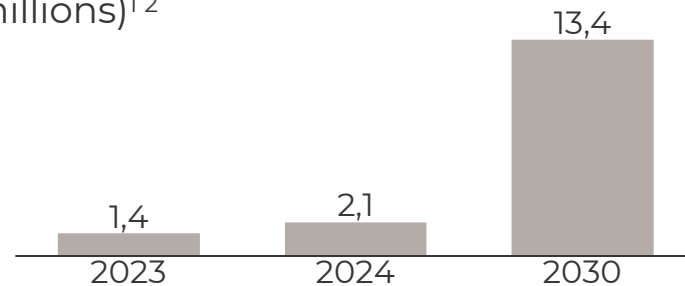
- Industrial consumers represented the biggest group of electricity consumers in Germany.
- Especially chemical, metal companies and companies producing glass or ceramics are power hungry as they need a lot of energy for the production. These companies normally have individual energy systems ²
- Industrial companies benefit from lower electricity prices

AN INCREASED NUMBER OF APPLICATION AREAS ARE ELECTRIFIED

Projection of heat pumps and EVs in Germany



Forecast: Heat pumps in Germany (in millions)^{1 2}



Forecast: Number of EVs in Germany (in millions)¹

Remarks

- More and more areas are electrified:
 - Industry: Industrial heat pumps, etc.
 - Households: heat pumps, wall boxes, solar panels, acs, etc.
 - Trade, services: Server, digitization, AI, etc.
 - Traffic: EVs, trains, etc.
- The German government supports electrification to reduce the CO2 consumption
- New consumption sources are created (e.g. data centers, bitcoin, air conditioning) leading to additional load on the energy grid

THE GERMAN ENERGY SYSTEM IS FACING HUGE CHALLENGES

Why does the energy information matter:

- Germany is currently transforming its energy system. This development has huge impacts on the economy and how consumers and producers are consuming from and feeding into the energy grid.
- In the past, we had rather big power plants (e.g. nuclear power plants, coal power plants) to generate Germany's energy supply. By 2045, Germany wants to become climate-neutral. Therefore, the German government decided to phase out of nuclear and coal energy. Instead, we should use renewable energy sources such as wind, sun, water and biomass.²
- Overall, Germany's energy system is facing increased complexity. Reliable predictions on production and consumption become more important.

THE GERMAN ENERGY SYSTEM IS FACING HUGE CHALLENGES



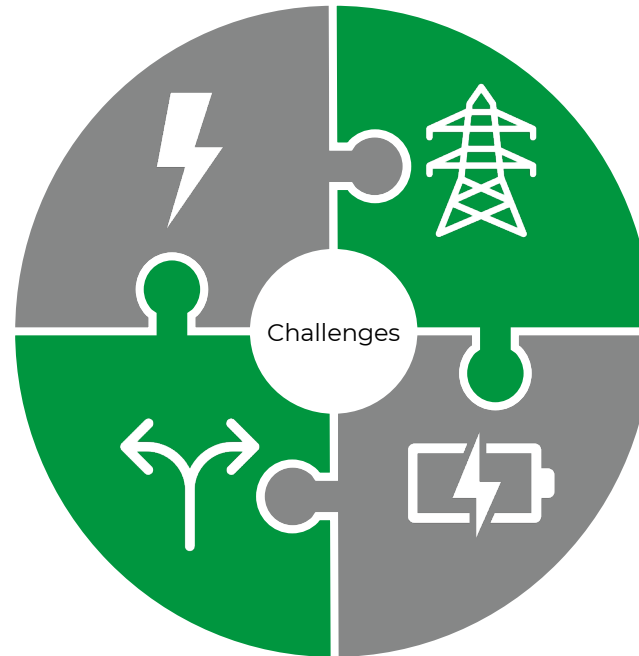
Production

Volatile Production due to renewable energy sources



Distribution

System stability challenged due to decentral production



Transmission

High investments into the grid infrastructure necessary

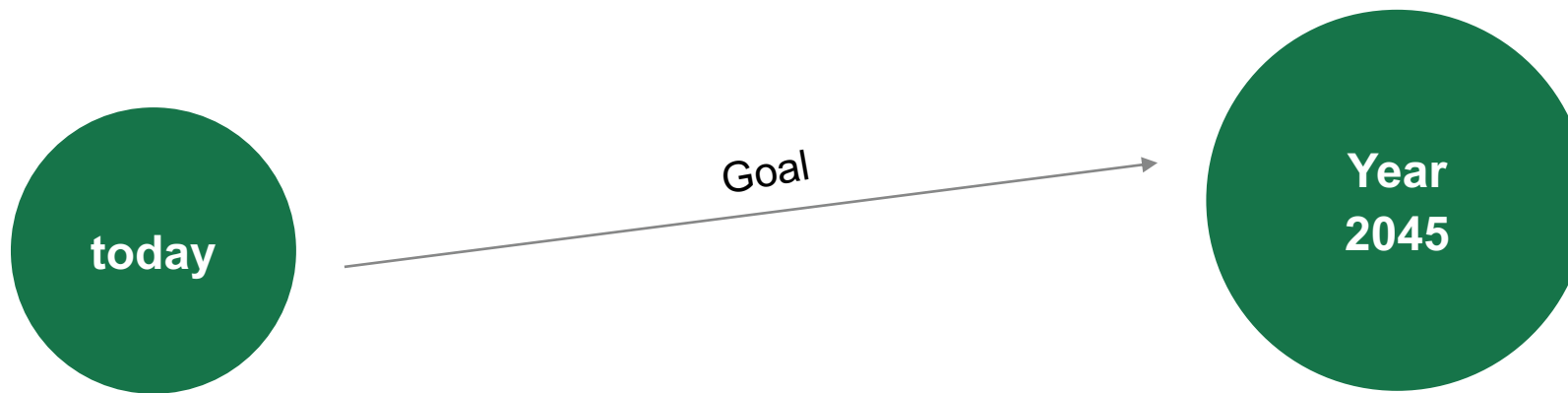


Usage

High costs in comparison to other countries

GERMANY IS UNDERGOING AN ENERGY TRANSITION TO MEET THE 1.5 DEGREE GOAL

Plans of the German government¹



Laying the foundation to cover the German energy need with renewable energy

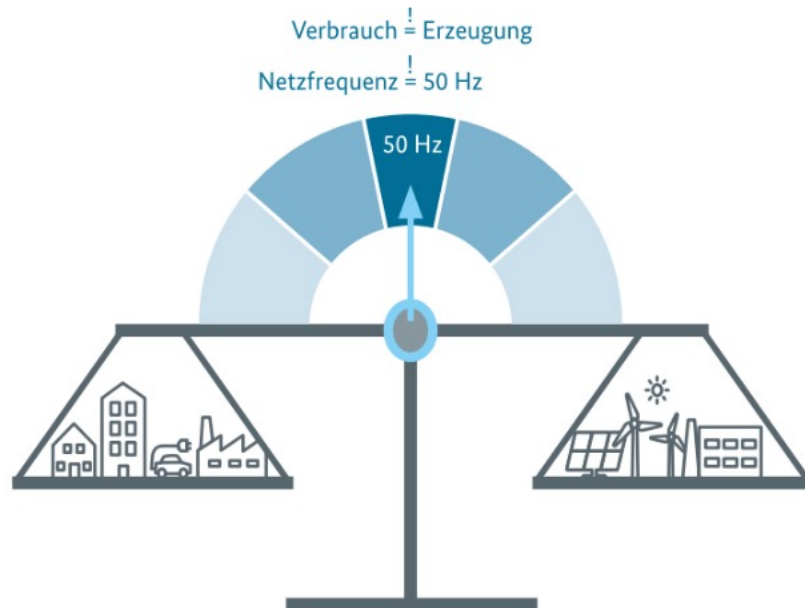
- Phasing out of nuclear power in 2023
- ~ 57% of the electricity consumption is covered with renewable energy sources
- Regulatory requirements were defined, e.g. with the Klimaschutzgesetz (KSG), Klimaanpassungsgesetz (KAnG), Wind-an-Land-Gesetz
- Massive expansion of the electricity infrastructure, especially in the electricity grid

Climate neutrality to limit the temperature increase to 1.5 degree celsius (Paris Climate Accords)

- Phasing out of coal for electrification (until 2038)
- Investment of 460 billion € in the electricity grid
- Energy consumption will be completely covered with renewable energy
- Maximum electrification (e.g. transport, heating) as electricity uses less CO₂

PREDICTIONS ARE VITAL TO FORESEE IMBALANCES IN THE ELECTRICITY GRID AND THUS AVOID OUTAGES

System stability between electricity consumption and generation



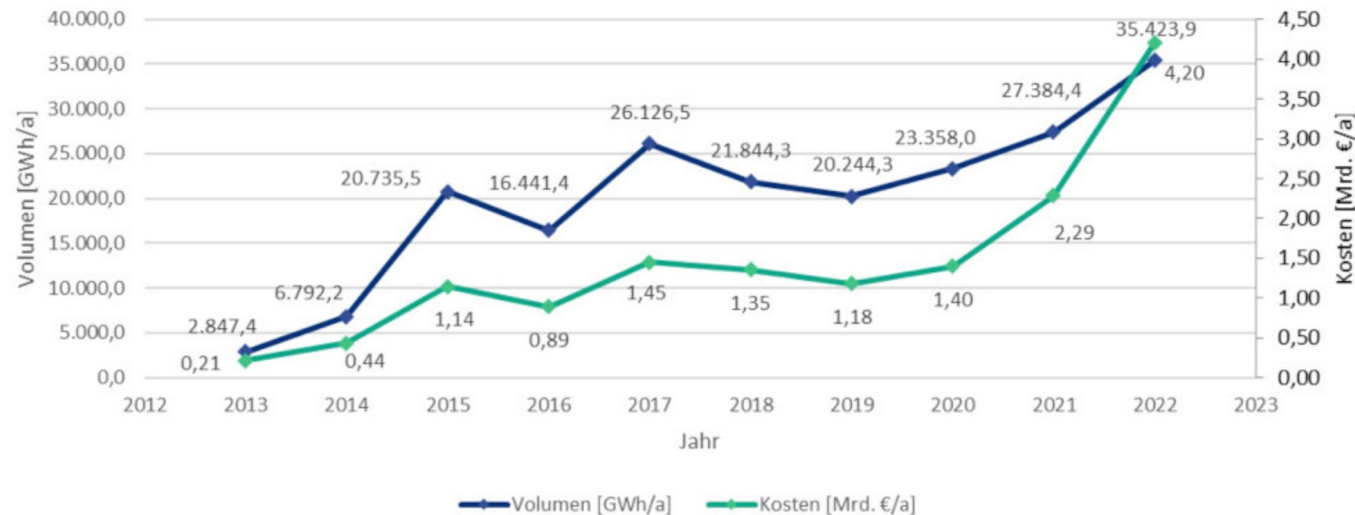
© BMWE, Frequenzhaltung als Waage zwischen Erzeugung und Verbrauch

Remarks

- Due to the big changes in electricity consumption and generation, the electricity grid is facing big changes
- In Europe, the grid frequency always needs to be at 50 Hertz. Otherwise, the grid can face outages (e.g. outage in Spain)
- Consumption and generation thus have to be balanced
- Predictions are an important tool to avoid such outages; if oversupply, undersupply, overdemand or underdemand are predicted, manual interventions into the grid are necessary (redispatch)

THE NUMBER OF REDISPATCH MEASURES INCREASED SUBSTANTIALLY, LEADING TO HIGHER COSTS FOR ELECTRICITY

Redispatch measures between 2013 and 2023



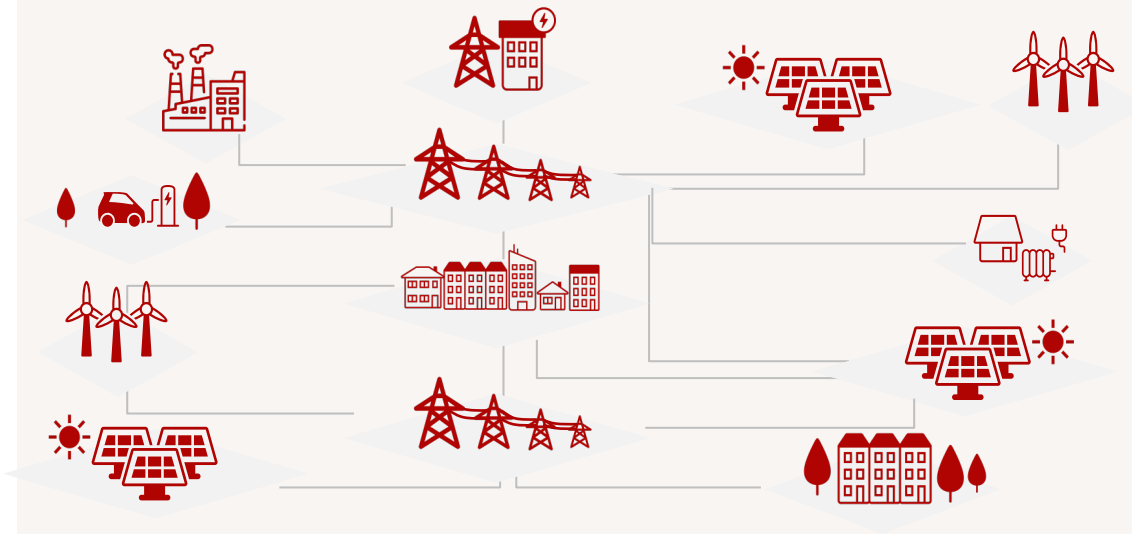
Quelle: (BDEW 2022; Bundesnetzagentur 2023c)

Remarks

- Redispatch describes a short-term change in the power plant production
- The procedure is manual to avoid outages in the grid
- The number of redispatch measures increased in the past, mainly due to the energy transition
- Redispatch costs have skyrocketed and are paid by the end consumer
- Huge amounts of energy is also wasted as it is used for redispatch measures

DIGITALIZATION ADDRESSES THE INCREASING COMPLEXITIES OF THE ENERGY SYSTEM OF THE FUTURE

The energy system is becoming more decentralized, volatile and connected with fast growing complexities...



- Supply structures more decentral, small-scale and volatile

...Digitalisation is the answer to address the growing complexity of the energy system.

- Manage increasing share of volatile power generation and new customer requirements
- Observe and control network assets to maintain security of supply
- Offer flexibility on different network levels
- Manage increasing electricity consumption due to more application areas such as EVs, heat pumps, data centers, etc. (electricity consumption rose by 2.2% in 2025 worldwide)

That's why reliably predicting the electricity consumption is important.

THE FUTURE ELECTRICITY CONSUMER WILL BOTH BE A PRODUCER AND CONSUMER (PROSUMER)

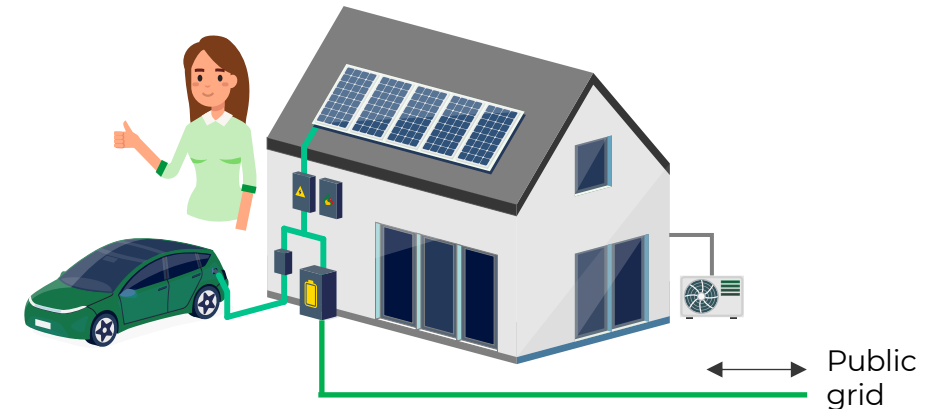
There will still be customers who are "only" looking for an electricity contract...



1/3 of our customers continue to rent and as Commodity-only customers are facing rising living cost - attractively priced, flexible, green electricity tariffs will remain a cornerstone of the electricity business in the future, customer loyalty remains a key success factor

The need for new propositions (e.g., dynamic tariffs) will also increase for these segments

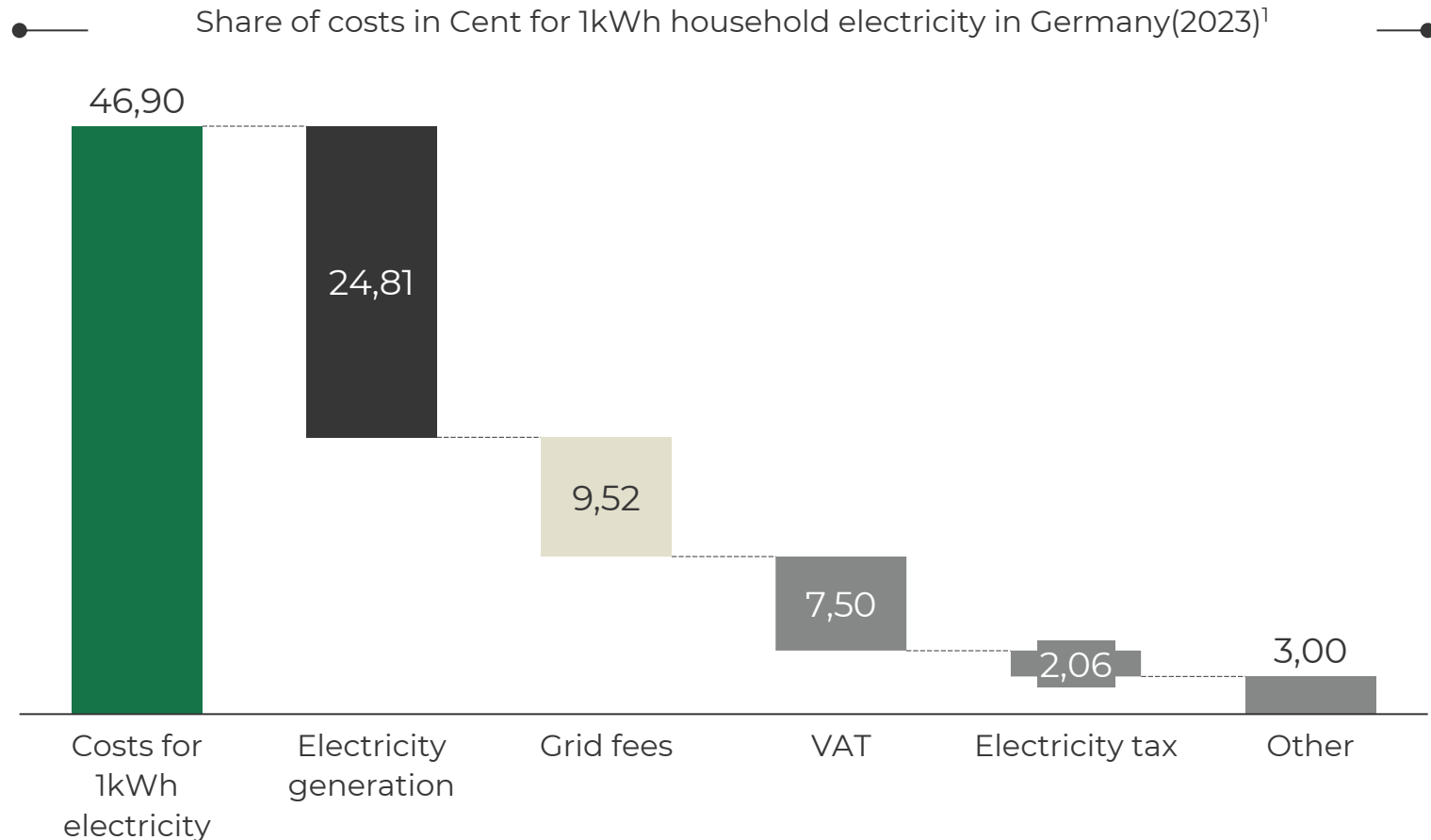
But the majority of our customers are shifting...



Majority of our customers will gradually shift to Prosumers - with high energy mgmt. optimization potential. Prosumers will consume and also feed into the energy grid.

This segment is increasingly looking for **integrated energy solutions consisting of optimized generation and consumption** that are seamlessly interlinked. The flexibility also decreases the load on the energy grid

THE ELECTRICITY PRICE IS MAINLY DRIVEN BY THE ELECTRICITY GENERATION AND GRID FEES



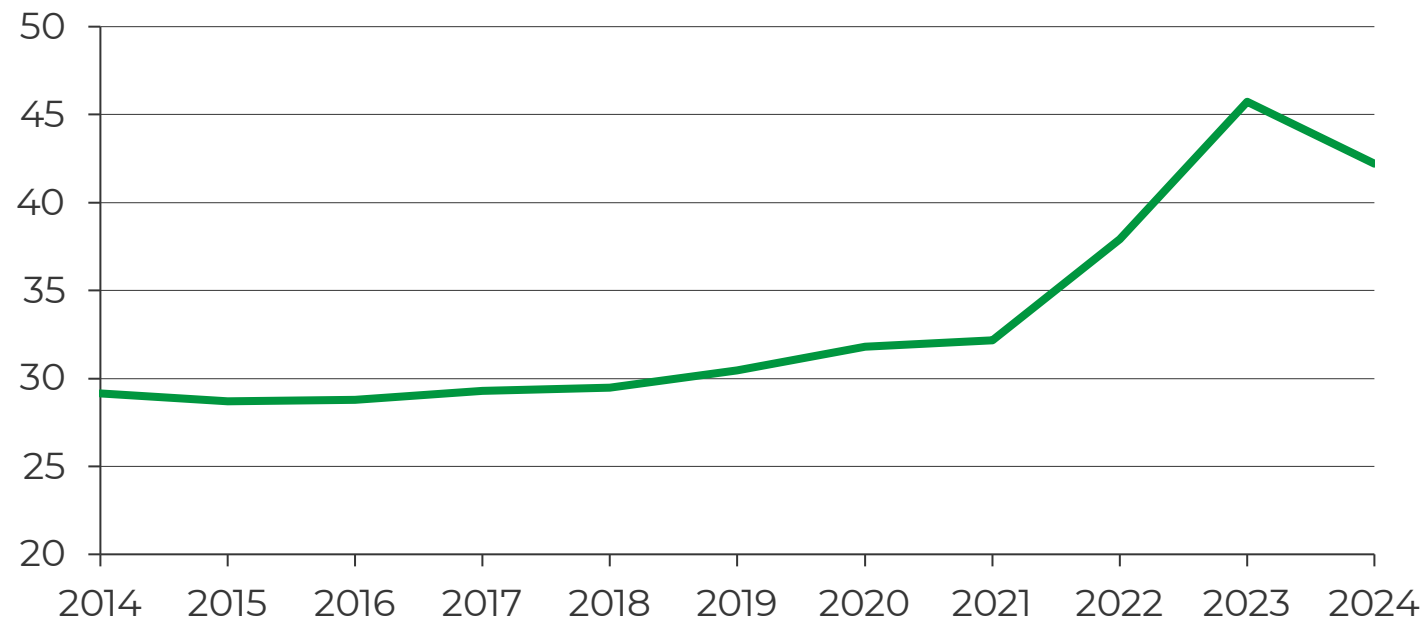
Remarks

- For a 2-person household, an average annual consumption of 2,500 kWh is assumed
- The grid fees include metering & operations
- 26.8% of electricity costs are caused by taxes
- Other levies include concessions, sheddable loads for nuclear energy, combined heat and power plants (KWKG) surcharge, electricity grid fee regulation (StromNEV), and offshore grid surcharge
- The electricity generation price has eased, meaning 1 kWh currently costs 38.44 cents from the default provider in Nuremberg²

THE ELECTRICITY PRICE WAS EXTREMELY VOLATILE IN THE PAST AND REACHED A PEAK IN 2023

● — Price development for household electricity between 2014 and 2024 — ●

Average electricity price
in Ct/kWh

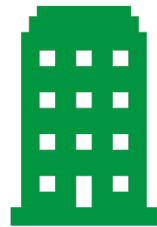


Remarks

- The electricity price grew by 45% in the last decade
- In 2014, an average two person household paid 728.5€ per year for electricity. In 2023, the number rose to 1.143.25€
- The electricity price is influenced by many factors:
 - Dependence on energy imports: Ukraine war in 2022 or Iran war 2026
 - Regulations: price halts in 2023 or EEG Umlage, change in energy mix
 - Demand shocks: Covid pullback in 2021
 - Grid expansion: grid fees necessary for energy transition

COMPANIES HAVE DIFFERENT ELECTRICITY PRICES: COMMERCIAL AND INDUSTRIAL PRICES

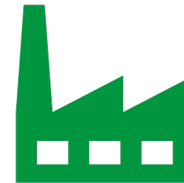
Commercial price¹



For companies



Average price in August 2024:
25.03 Ct per kWh electricity



Can be used if demand is
between 160.000 & 20 Mio. kWh
electricity; Consumption is
captured in 15 minute intervals



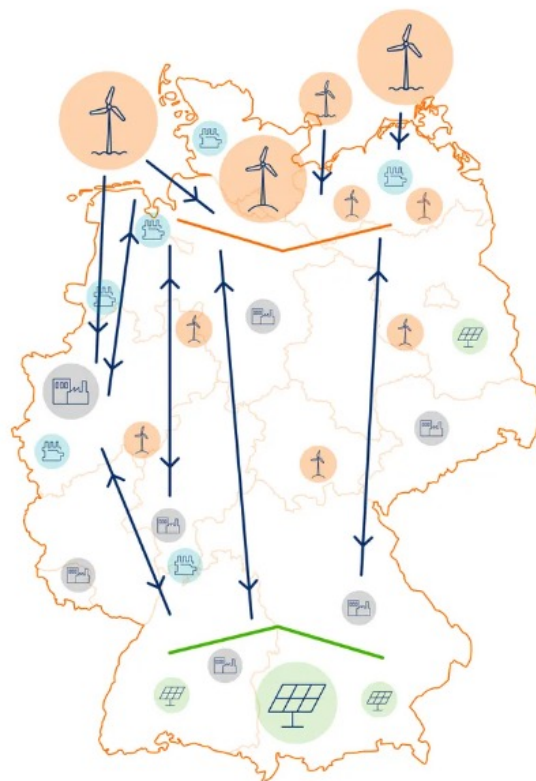
Average price in August 2024:
16.65 Ct per kWh electricity

Companies benefit from lower electricity prices as they have to pay less taxes. The industrial price is far below the household price. However, Germany's electricity prices are very high in comparison to other countries! There are different markets in Germany: the futures market for longterm purchases (up to 6 years), spot market (day ahead until 5 minutes before delivery), system stability market (to ensure the frequency balance) and the Over-the-counter market (between two different parties)

MOST RENEWABLE ENERGY IS GENERATED IN THE NORTH OF GERMANY, WHEREAS IT IS CONSUMED IN THE SOUTH

Grid of the future¹

Neue Netzstruktur: Produktion, Bedarf und Transport



Remarks

- The South currently consumes more electricity than the North due to industrial landscape¹
- Demands were previously covered by local power plants
- Wind energy is produced primarily in the North and must now be transported to the South, which leads to energy loss
- Energy cannot currently be reasonably stored locally with batteries
- Production is more difficult to control due to the weather
- Reliable predictions are important as grid expansion is extremely expensive (costs of copper and commodities, equipment such as transformers, regulation, etc.)

IN THE GROUP WORK, YOU SHOULD PREDICT THE FUTURE ELECTRICITY DEMAND AS RELIABLY AS POSSIBLE

Now it's up to you:

- Analyze the data set and find interesting facts in the data
- Create a Machine Learning model to predict the future demand on a daily and hourly basis
- Assess the performance of your model by using a held out data set; Use a suitable KPI
- Find additional data sources that might help you to get better results
- Create artifacts that are reusable and scalable. We will highlight what reusable code looks like in the following sessions

LEARNING GOALS

After today's lesson, you got familiar with the following topics:

- Requirements for the group work
- Electricity foundations
- Current state of electricity energy system in Germany
- Importance of electricity consumption predictions



**THANK YOU FOR
YOUR ATTENTION!**