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Activity A.T2.2: Infrastructure analysis

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The potential for exploitable organic residue for each participating country listing key aspects such as location, amount, transport options and costs.

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Version	Date	Author	Organization	Description
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v5-1	26.02.2022	Kiril Raytchev	BSERC	Secondary market regulation info has been marked as not mandatory, but nice to have,

1. METHODOLOGY

For the infrastructure database, the locations, owner address and technical data such as power and electricity consumption have been collected. The data was collected for the area of Germany and for the following technologies:

- Wind power plants
- Photovoltaic plants
- Biogas plants
- Industrial plants
- Gas grid connection points
- Transport hubs (Rail-road, Water-rail-road)
- Transnational links (gas and electricity grids links between Bavaria – Austria, Bavaria – Czech Republic)

The data was achieved through publicly available sources.

The Energy Atlas Bavaria¹ provides information on renewable electricity plants, heat and grids in Bavaria. The data is publicly available and can be downloaded.

Information on gas connection points were calculated based on the grid information provided by Energienetze Bayern and Schwaben Netz, two of the major gas distribution grid operators in Bavaria. The connection points for electrical grids could not be found. However, the electricity grid is vast in Germany, and in every populated area, it is expected to find a close electrical connection point.

For the information on transport hubs, the biggest ports and rail freight stations were identified. Bayernhafen as the operator of six big ports in Bavaria provides public information on their website². Information on rail freight stations are provided by Deutsche Bahn³. The transport costs were calculated for train transport according to a price list by DB Cargo⁴. Since transport costs are provided in €/t, it is the same for every item. Transport costs by truck were estimated based on information provided by logistic

¹ Energieatlas Bayern, <https://www.karten.energieatlas.bayern.de/start/>

² <https://www.bayernhafen.de/>

³ https://www1.deutschebahn.com/ecm2-duss/terminals_uebersicht

⁴ <https://www.dbcargo.com/resource/blob/5742980/f1152ec5e0fc55d24df3ddc70f2d0ca3/DB-Cargo-Preisliste-2021-SuwB-data.pdf>

companies and might vary depending on the real transport distance (lower €/t for larger distances).

Transport prices	
Train transport	0.9 €/t/km
Road transport by truck	1.5-2.4 €/t/km

2. BRIEF DESCRIPTION OF GERMAN INFRASTRUCTURE LANDSCAPE

Germany has a large amount of renewable electricity plants. In Bavaria, especially PV power is installed. However, the expansion is not yet big enough to cover the electricity consumption. Further investments in renewable electricity plants is needed in order to gain enough surplus renewable electricity to use for P2G hubs. The plans of the German and the Bavarian governments include the fast augmentation of renewable power production.

P2G hubs can already provide a viable solution for the increase of renewable electricity production and usage. At the moment, almost all German wind power plants are not operating consistently due to the lack of storage possibilities. This surplus renewable electricity could already be used for green hydrogen production in P2G hubs. With further expansion of the installed capacity of renewable electricity, prices are expected to drop, thus making P2G hubs more likely to be profitable.

At the moment, a large amount of the renewable energy production comes from crop biomass plants (mostly heat, but also electricity in cogeneration plants). State funding for those plants is going to end in the near future. This might lower the amount of existing renewable electricity, threatening the expansion of renewable electricity production, but it can be substituted with PV and wind power. The end of state funding also bears the potential to start new business models around an existing biogas plant. Possibilities here are the construction of a PV power plant next to the biogas plant and subsequent creation of a P2G hub with methanation. Thus, the end of state funding for biogas plants can be both a threat and an opportunity for the expansion of P2G hubs.

The grid infrastructure is quite well established in Germany. Almost everywhere, a near connection point to the gas, electricity and water grid can be found, resulting in low connection costs.

<p>Strengths</p> <ul style="list-style-type: none"> • Comparably high amount of renewable electricity plants with plans for further expansion • Unused potential of electricity production in wind power plants • Well established gas, electricity and water grids 	<p>Weaknesses</p> <ul style="list-style-type: none"> • Not enough REP to cover electricity consumption • End of state funding for biogas plants • Not enough funding for green hydrogen production/P2G and methanation • Low CO₂ prices
<p>Opportunities</p> <ul style="list-style-type: none"> • P2G hubs can already be installed due to existing infrastructure • Make use of surplus electricity from wind power (cheap, increased efficiency) • New business models for existing biogas plants 	<p>Threats</p> <ul style="list-style-type: none"> • Expensive renewable electricity in the near future • Biogas plants go unused due to lack of funding for new business models • Unprofitability of P2G hubs due to high investment costs • Green hydrogen/renewable natural gas not competitive against blue/grey hydrogen and fossil natural gas

2.1 ELECTRICAL ENERGY SECTION

2.1.1 ELECTRICITY PRICES

The price for electricity in Germany consists of the production and supply costs (35.6%), network charges (23.4%) and taxes, other levies (41%).⁵ The electricity prices without taxes and levies has risen over the last years. In February 2022, electricity prices reached the highest level of 18.17 ct/kWh on 24.02.2022 and decreased to 15.11 ct/kWh on the 28.02.2022.

For end consumers, electricity prices are ranging between 25 ct/kWh and 37 ct/kWh for existing clients of the basic supplier. For new costumers, prices might be a lot higher. Private electricity providers are currently increasing their prices. Many of them have lost rentability and quit the contracts with their clients.

⁵ Numbers stating 01/2022, <https://strom-report.de/strompreise/strompreisentwicklung/>

The high electricity prices in Germany are influenced by high taxes. Additionally to VAT (19% of the electricity price including all other price components, average of 6 ct/kWh), consumers have to pay the so called “electricity tax” (“Stromsteuer”) of 2.05 ct/kWh. Other minor levies add up to around 2-3 ct/kWh.⁶

Network charges depend on the federal state where the electricity is consumed. In Bavaria, they vary between 4.13 and 11.82 ct/kWh. In the long run, network charges have increased from average 5.81 ct/kWh in 2010 to 7.52 ct/kWh in 2021.⁷ In 2022, network charges are expected to rise by 4%.⁸

All end users pay a special levy, the so called “Renewable Energy Levy” (“Umlage nach dem Erneuerbare-Energien-Gesetz”, short “EEG-Umlage”) which is a financing instrument to advance the expansion of renewable energies in Germany. The levy has decreased from 6.5 ct/kWh in 2021 to 3.7 ct/kWh in 2022. As of the 1st of July 2022, the EEG levy will be removed completely. However, experts doubt that this will strongly influence the electricity prices and relieve end consumers.⁹

Influences of day/night time and weekends¹⁰

Wholesale electricity prices rise from 5:00, reaching peak at 8:00/9:00, and from 17:00, reaching peak at around 20:00-22:00 during the weekdays. The lowest prices can be observed between 13:00 and 15:00 and between 1:00 and 4:00, while the afternoon prices are usually a little lower than the night prices.

The medium prices are usually lower on weekends. The lowest electricity prices can be obtained on weekends during the afternoon hours (in April 2022 up to 0,00-0,08 €/MWh; 17 April, 14:00 and 23 April, 13:00).

In April 2022, electricity prices ranged from 0 €/MWh (17 April, 14:00) to 295 €/MWh (19 April, 8:00) and 301 €/MWh (13 April, 20:00).

⁶ <https://www.finanztip.de/stromvergleich/strompreis/>,
<https://www.stromauskunft.de/verbraucherservice/strompreise-2022/>

⁷ <https://www.stromauskunft.de/strompreise/netzentgelte/>

⁸ <https://www.stromauskunft.de/service/energienachrichten/19806647.strom-und-gaspreise-2022-netzentgelte-steigen/>

⁹ <https://www.stromauskunft.de/service/energienachrichten/19807869.energiepreiskrise-alle-einzelheiten-zum-entlastungspaket-der-bundesregierung/>

¹⁰ <https://www.smard.de/home>

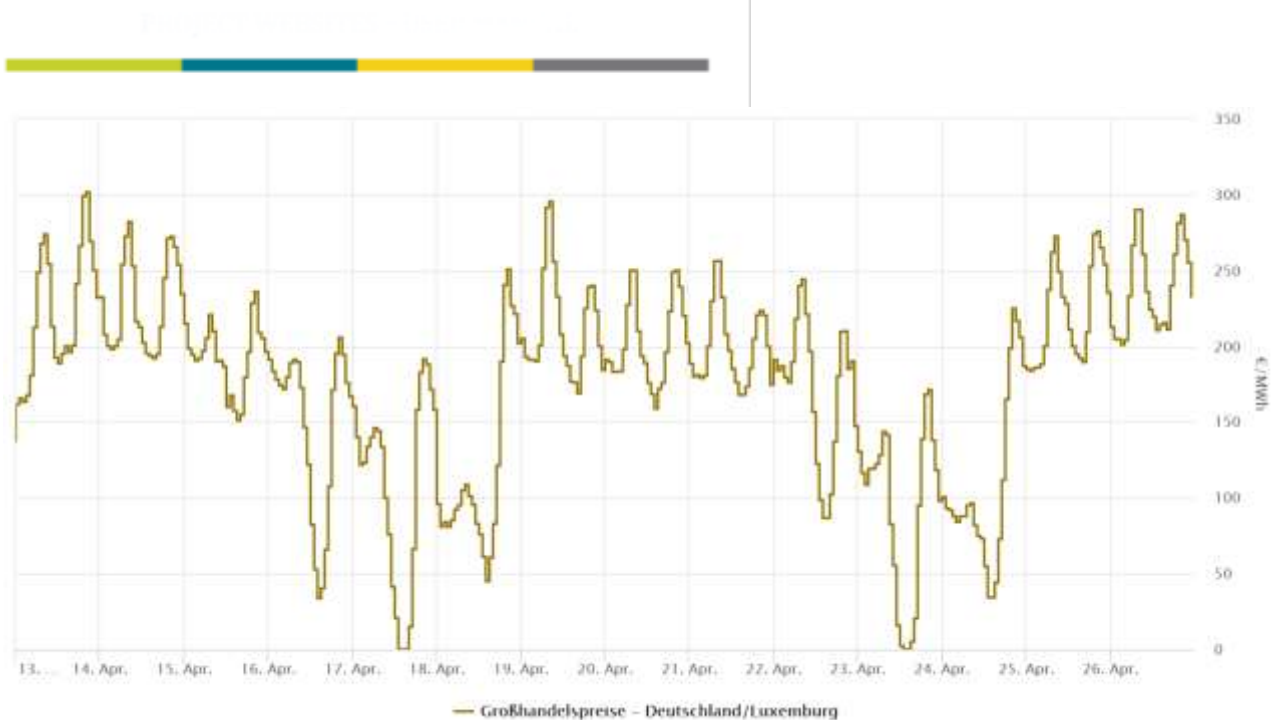


Figure 1: Hourly electricity prices April 2022, Source: Smard

Prices for consumers

As P2G hubs might be classified as end-consumers by the German law, they have to pay the same electricity prices as private households if they consume electricity from the grid (sometimes, certain taxes and levies can be reduced or reimburse, see “Legal framework” for Germany). That means, the P2G hub operator has to pay the wholesale price plus all levies, taxes and network charges (as explained above).

The consumer of electricity can decide between a fixed electricity price and a dynamic tariff.¹¹ The latter does not change the levies and network charges, but influences the price due to the changes on the daily electricity price fluctuations, thus making it more profitable to consume electricity when it is cheap (afternoon and night time during the week). It is even possible to profit from negative electricity prices.

Electricity prices from self-production

¹¹ <https://www.finanztip.de/stromtarife/variable-stromtarife/>

In light of high and rising electricity prices, the construction of a renewable electricity plan alongside the P2G hub seems to be an attractive option to lower operational costs. In Germany, the self-consumption is free of taxes and levies (except EEG-surcharge, which will become obsolete on 1 July 2022 and will thus not be explained in more detail here). The electricity price is thus as high as the production price (currently around 40-70 €/MWh for ground-mounted PV plants and 60-120 €/MWh for rooftop PV plants, both depending on plant size and solar radiation).¹²

Electricity price components	
Electricity price peak hours (~7:00-9:00 and 19:00-21:00)	~200-300 €/MWh
Electricity price bottom hours (~13:00-15:00 and 1:00-4:00)	~0-20 €/MWh
Network charges	~0.32 ct/kWh for industry clients ~1.28 ct/kWh for commercial clients ~1.59 ct/kWh for household clients
VAT	19%
Concession fee	1.61 ct/kWh (2018, average)
Electricity tax	2.05 ct/kWh (fixed price)
KWKG levy (Law for cogeneration)	0.254 ct/kWh (2021)
StromNEV levy (Electricity network ordinance)	0.432 ct/kWh (2021)
Offshore grid levy	0.395 ct/kWh (2021)
Levy on switchable loads	0.009 ct/kWh (2021)

2.1.2 GRID CONNECTION PRICES

There are no determined prices for grid connection. The grid operator has to calculate the connection costs and the building costs separately and provide the calculations to the connecting party.¹³

¹²

https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/DE2018_ISE_Studie_Stromgestehungskosten_Erneuerbare_Energien.pdf

¹³ <https://www.bundesnetzagentur.de/DE/Vportal/Energie/Netzanschluss/start.html>

Usually, plants (producers and consumers) are connected to the middle voltage grid. In case of small plants, a connection directly to the low voltage grid is possible.

The grid connection has to be conducted by the grid operator. The connecting party bears the costs, which are usually calculated as a lump-sum by the operator.¹⁴ Further, the grid operator can demand a construction cost subsidy from the connecting party. This only applies for connections above 30 kW power and can also be calculated as a lump-sum.¹⁵

The prices for both grid connection and construction cost subsidy are provided by the individual network operators, mostly upon concrete request. According to expert opinion, the costs for the connection cable vary from 60 – 160 €/m, depending on the environment in which the cable has to be installed (grass, asphalt etc).

2.1.3 ELECTRICITY CONSUMPTION IN GERMANY

The annual amount of net electricity consumption in Germany ranges between 480 and 550 TWh. In the last years, the consumption dropped from 527 TWh in 2017 to 488 TWh in 2020.¹⁶ The gross electricity consumption did not change much in the last years, ranging from 580 TWh to 624 TWh since 2000. In 2021, the gross electricity consumption was 565 TWh.¹⁷ Germany has higher electricity exports than imports and the gap is becoming wider since the early 2000s.¹⁸

¹⁴ § 9 NAV, <https://www.gesetze-im-internet.de/nav/BJNR247710006.html>

¹⁵ § 11 NAV, <https://www.gesetze-im-internet.de/nav/BJNR247710006.html>

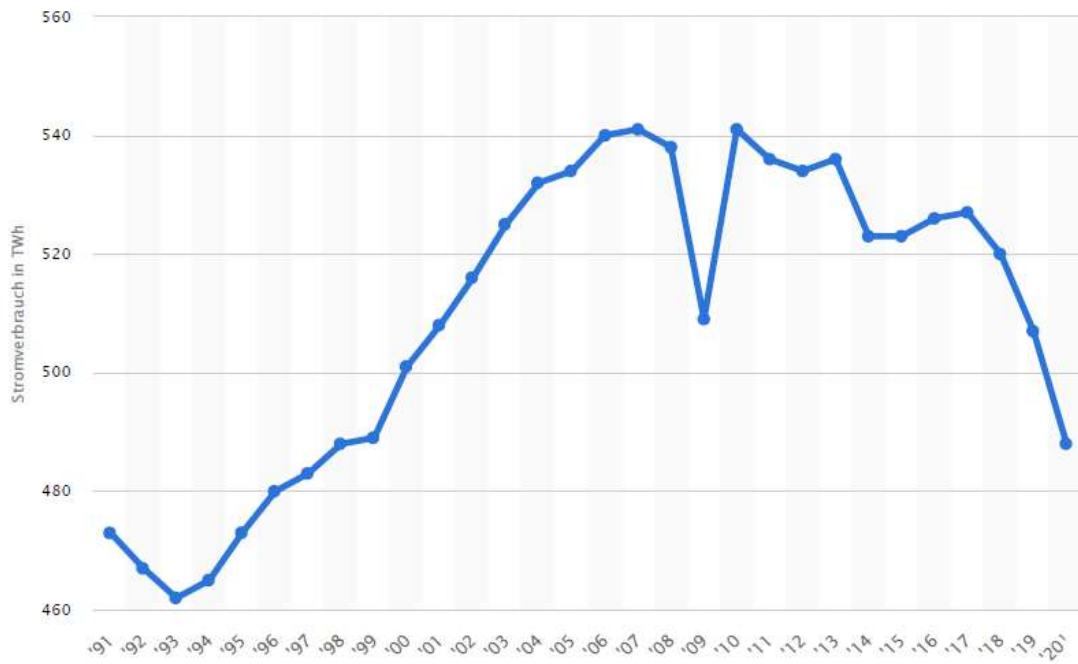
¹⁶ <https://de.statista.com/statistik/daten/studie/164149/umfrage/netto-stromverbrauch-in-deutschland-seit-1999/>

¹⁷

https://www.umweltbundesamt.de/sites/default/files/medien/384/bilder/dateien/2_abb_bruttostromverbrauch_2022-01-17.pdf

¹⁸ <https://de.statista.com/statistik/daten/studie/164150/umfrage/stromeinfuhr-und-ausfuhr-von-und-nach-deutschland-seit-1999/>

Nettostromverbrauch in Deutschland in den Jahren 1991 bis 2020
 (in Terawattstunden)



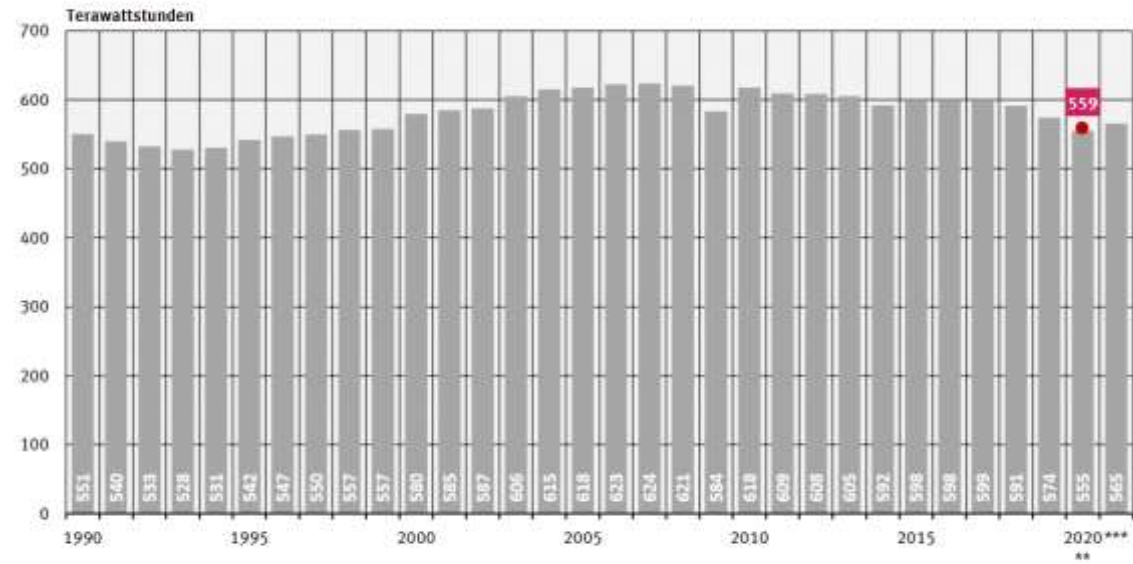
Details: Deutschland; 1991 bis 2020; 1 Vorläufig.

© Statista 2022

Figure 2: Net electricity consumption



Bruttostromverbrauch*

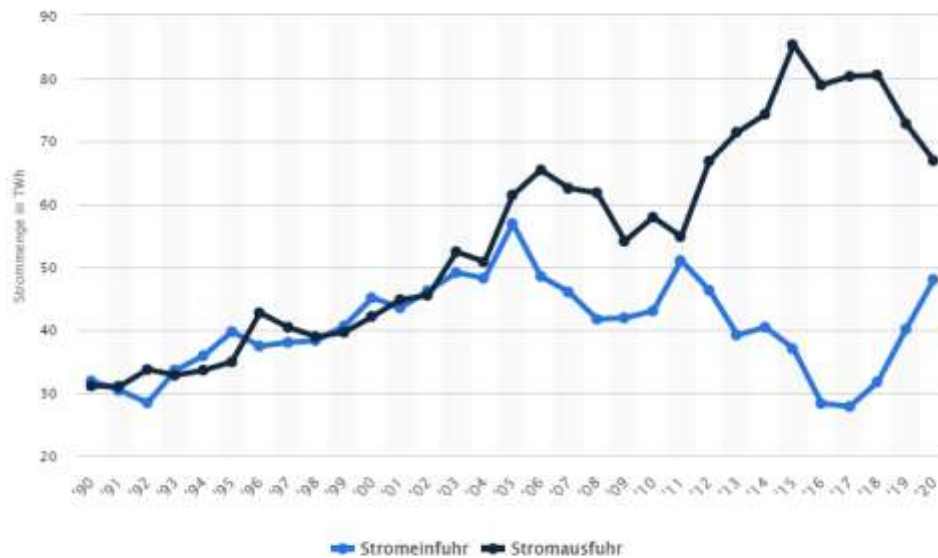


* ausschließlich Erzeugung aus Pumpspeicherkraftwerken, Retoverkäufen, Eigenverbrauch, Stromerzeugung aus Pumpspeichern und Stromhandelssaldo
 ** Ziel 2020, Energiekonzept der Bundesregierung 2010: Senkung des Bruttostromverbrauchs um 10 % gegenüber 2008
 *** vorläufig

Quelle: Umweltbundesamt auf Basis AG Energiebilanzen, Tabelle Bruttostromerzeugung in Deutschland, Stand 12/2021

Figure 3: Gross electricity consumption

Stromeinfuhr und -ausfuhr von und nach Deutschland in den Jahren 1990 bis 2020
 (in Terawattstunden)



Details: Deutschland; 1990 bis 2020

© Statista 2022

Figure 4: Import and export of electricity

The share of renewable electricity has increased significantly since 2000. In 2020, the share of renewable electricity in gross electricity consumption reached 45%. Several laws and goals of the government are aiming to further increase this share in the next years.

Anteil erneuerbarer Energien am Bruttostromverbrauch

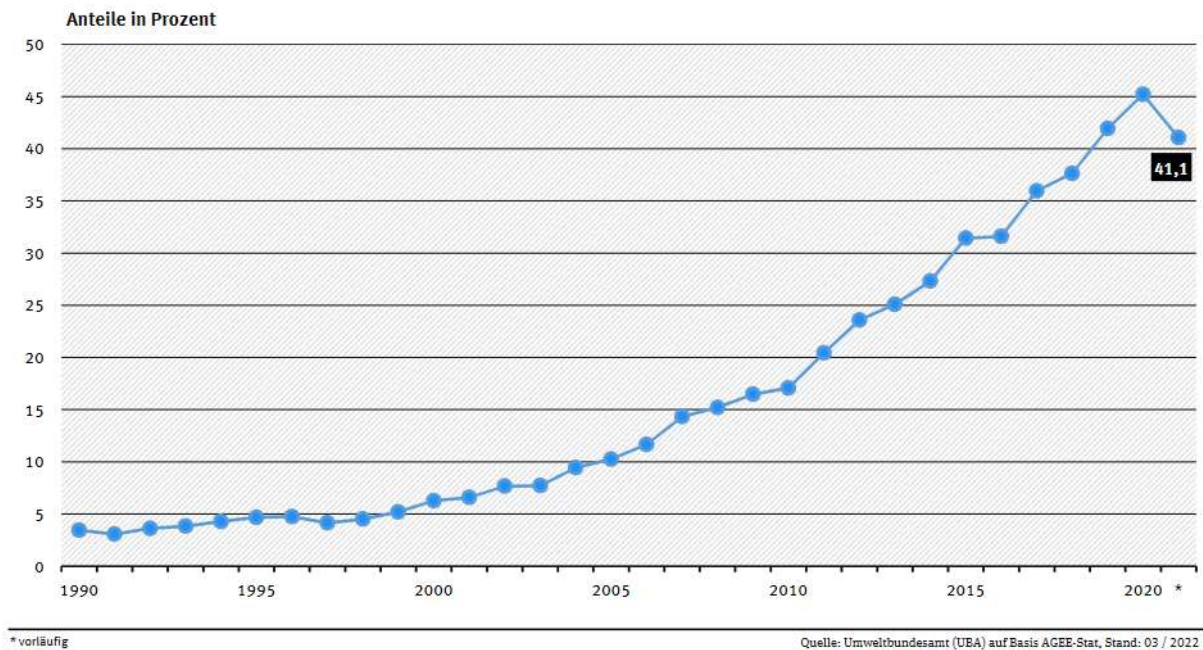


Figure 5: Share of renewables in gross electricity production

At the moment, the highest share within renewable electricity production is generated through wind power (38.3% offshore and 10.4% onshore), followed by biomass (21.6%) and PV (21.4%). The remaining 8.2% are produced via hydropower. The total amount of renewable gross electricity production cumulated to 233.6 TWh in 2021.¹⁹

2.2 NATURAL GAS ENERGY SECTION

2.2.1 GAS PRICES

As for the electricity price, the gas price consists of the costs for production and supply (~49%), network charges (~25%) and taxes/levies (~26%).²⁰ For gas, a CO₂ price has to be paid additionally. Beginning in February 2022, the costs of gas supply increased and reached a share of around 62% of the total end consumer price.

¹⁹ <https://www.umweltbundesamt.de/themen/klima-energie/erneuerbare-energien/erneuerbare-energien-in-zahlen#strom>

²⁰ <https://www.bmwi.de/Redaktion/DE/Artikel/Energie/gaspreise-bestandteile.html>

The total gas price depends on the consumed amount. For households, the average gas price was 6.13 ct/kWh in 2020. For industries, the gas price varied from 3.75 ct/kWh (more than 1.1 Mio. MWh) to 5.59 ct/kWh (less than 278 MWh) depending on the consumed amount in 2021 including all taxes and levies.²¹ In 2022, gas prices increased significantly to an average of 11.84 – 12.21 ct/kWh for households. Taxes and levies also increased due to higher VAT (19% of the total price, including supply, network charges, taxes and levies) and increased CO₂ prices (from 25€/t CO₂ in 2021 to 30€/t CO₂ in 2022). Network charges increase by 1.2% to 1.34 – 1.66 ct/kWh.²²

The gas price was more or less constant over the last years, ranging from 45.40 €/MWh in 2017 to 47.40 €/MWh in 2021 (without taxes and levies)²³ (6.11 €/MWh (2017) to 6.20 €/MWh (2020) including taxes and levies)²⁴. However, gas prices are expected to rise in the future due to the reduction of natural gas imports from Russia and the increase of the CO₂ tax. In 2022, gas prices climbed up to over 120 €/MWh.²⁵

Gas price components	
Gas price	~46 €/MWh (increasing to around 100 €/MWh)
Network charges	~0.32 ct/kWh for industry clients ~1.28 ct/kWh for commercial clients ~1.59 ct/kWh for household clients
VAT	19%
Concession fee	0.08 ct/kWh (average, 0.03-0.93 ct/kWh)
Gas tax	0.55 ct/kWh

2.2.2 GAS GRID CONNECTION

The costs of connection to the gas grid consist of the construction costs and the connection costs. The grid connection costs typically range from 1,000 to 2,500 € for households, depending on the distance to the next gas grid connection point and the characteristics of the area. Thus, connection points for facilities such as P2G hubs might

²¹ <https://www-genesis.destatis.de/genesis/online?operation=previous&levelindex=1&step=1&titel=Ergebnis&levelid=1646656058352&acceptscookies=false#abreadcrumb>

²² <https://www.bdew.de/service/daten-und-grafiken/bdew-gaspreisanalyse/>

²³ https://ec.europa.eu/eurostat/databrowser/view/nrg_pc_202/default/line?lang=de

²⁴ <https://www.enbw.com/energie-entdecken/energiewirtschaft-und-politik/energiewirtschaft/gasmarkt.html>

²⁵ <https://efi-net.de/energiemarktbericht-vom-31-maerz-2022/>

be higher, if the selected location is further away from established infrastructure. The price of the grid construction is around 15-25 €/m.

The grid connection costs have to be provided by the grid operator, separating construction and connection costs.

2.3 BIOCHAR SUPPLY SECTION

In Germany, biochar is produced in small amounts and usually for agricultural purposes. The prices range from ~300 to 450 €/t.²⁶ Specific prices have to be identified by contacting the biochar producers directly.

Transport prices range between 0.3-3 €/t/km, depending on the transport mode (train, truck), the distance and the weight/amount of transported load. However, transport prices are expected to rise in the near future due to higher fuel and electricity costs. For the costs for ship transport, shipping companies/ports have to be contacted directly.

2.4 WATER SUPPLY SECTION

The water price in Germany including the cost for waste water lies at around 4 €/m³.

²⁶ https://www.kompost.de/fileadmin/user_upload/Dateien/HUK-Dateien/2017/Q1_2017/Biokohle_fuer_die_Landwirtschaft_H_K_Q1_2017.pdf