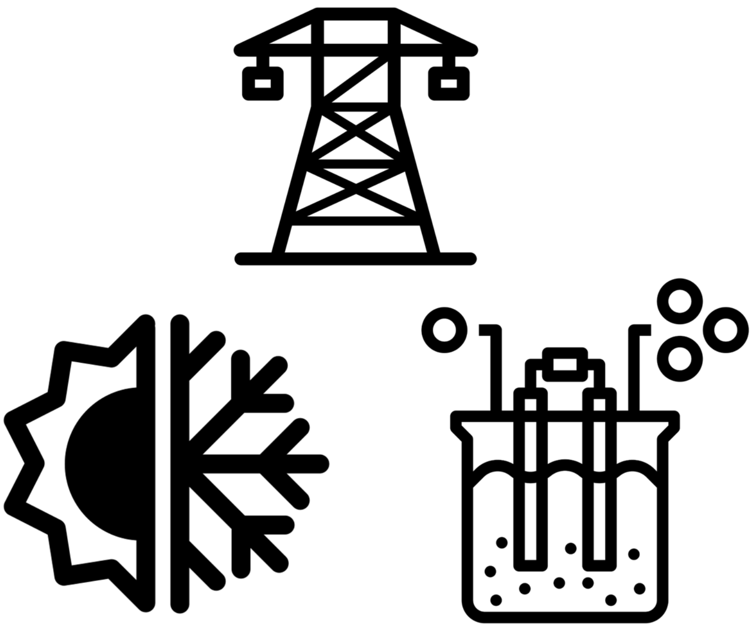
Technology Collaboration Programme
by iea

INTERNATIONAL ENERGY AGENCY
TECHNOLOGY COLLABORATION PROGRAMME ON
**DISTRICT HEATING AND COOLING**



**IEA DHC ANNEX TS3: HYBRID ENERGY NETWORKS**

# APPENDIX D
# COUNTRY REPORT GERMANY

This page is empty on purpose.

**Disclaimer notice (IEA DHC):**

This project has been independently carried out within the framework of the International Energy Agency Technology Collaboration Programme on District Heating and Cooling (IEA DHC).

Any views expressed in this publication are not necessarily those of IEA DHC. IEA DHC can take no responsibility for the use of the information within this publication, nor for any errors or omissions it may contain.

Information contained herein has been compiled or arrived from sources believed to be reliable. Nevertheless, the authors or their organizations do not accept liability for any loss or damage arising from the use thereof. Using the given information is strictly your responsibility.

**Disclaimer Notice (Authors):**

This publication has been compiled with reasonable skill and care. However, neither the authors nor the DHC Contracting Parties (of the International Energy Agency Technology Collaboration Programme on District Heating and Cooling) make any representation as to the adequacy or accuracy of the information contained herein, or as to its suitability for any particular application, and accept no responsibility or liability arising out of the use of this publication. The information contained herein does not supersede the requirements given in any national codes, regulations or standards, and should not be regarded as a substitute.



**Image Source (Frontpage):**

thenounproject.com (Yazmin Alanis, Symbolon, PenSmasher)

**Citation:**

Please refer to this report as:

Dennis Cronbach: IEA DHC Annex TS3 Guidebook, Appendix D Country Report Germany, 2022

# CONTENT

# 1 INTRODUCTION

This Appendix is part of the IEA DHC Annex TS3 guidebook. The full guidebook is available at https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts3

*Author: Dennis Cronbach (Fraunhofer IEE)*

# THE OVERALL PICTURE

Germany's goal for 2050 is to transform into a low-emission society. In 2020 however, fossil fuel sources still contribute significantly to the energy system. The share of renewable energy in total primary energy consumption was 16,8% in the last year. The largest share of renewable energy sources is formed by wind energy plants, which supply 27% of the total electricity demand. In the whole, 50,5% of the total electricity demand was covered by RES.

Regarding the heating sector, only 11,5% of the total heating energy consumption was covered by renewable sources in 2016. The largest part was covered by natural gas (44,5%). Sector coupling technologies contribute with 12,5% for direct usage of electrical power and district heating energy with 7,1%. It is, however, expected that the share of district heating energy and direct usage of electrical power will rise in the future, due to the increasing amount of installed heat pump systems.

The electrification of the heating sector is stated as an important near term goal (2030) by several studies, alongside with the electrification of traffic. It is also mentioned that incentives and subsidies are necessary in order to achieve this goal (BDEW, 2021) (ISE, 2021) (Agora Energiewende, 2017).

| | |
|---|---|
| 1 | **Increasing share of renewable energy sources.** A mixture of wind, solar and water power is used to cover ~ 50% of electricity demand. Note that nuclear power is not included. |
| 2 | **Heating sector still relies heavily on fossil fuels. Only 11,5% of the heating demand were covered by renewable sources in 2020.** |
| 3 | **Ambitious 2030 and 2050 renewable energy targets.** Comparable to other European countries like denmark, Germany has ambitious goals for the future energy system. 80 % of electricity demand shall be covered until 2050. |

## A.1.1 KEY STATISTICS

The origins of the current German energy system and the initiation of the transformation of the energy system date back to the 1970's. Because of the oil crisis and public concerns about the utilization of nuclear energy, many countries began to change energy politics and economy. In the 1990's, the "Stromeinspeisegesetz" was created, which was a large catalyst for renewable energy sources. With this law, grid operators had to feed in the energy produced by renewable plants with a high priority. During the following years, renewable power systems like wind and solar power systems began to expand.

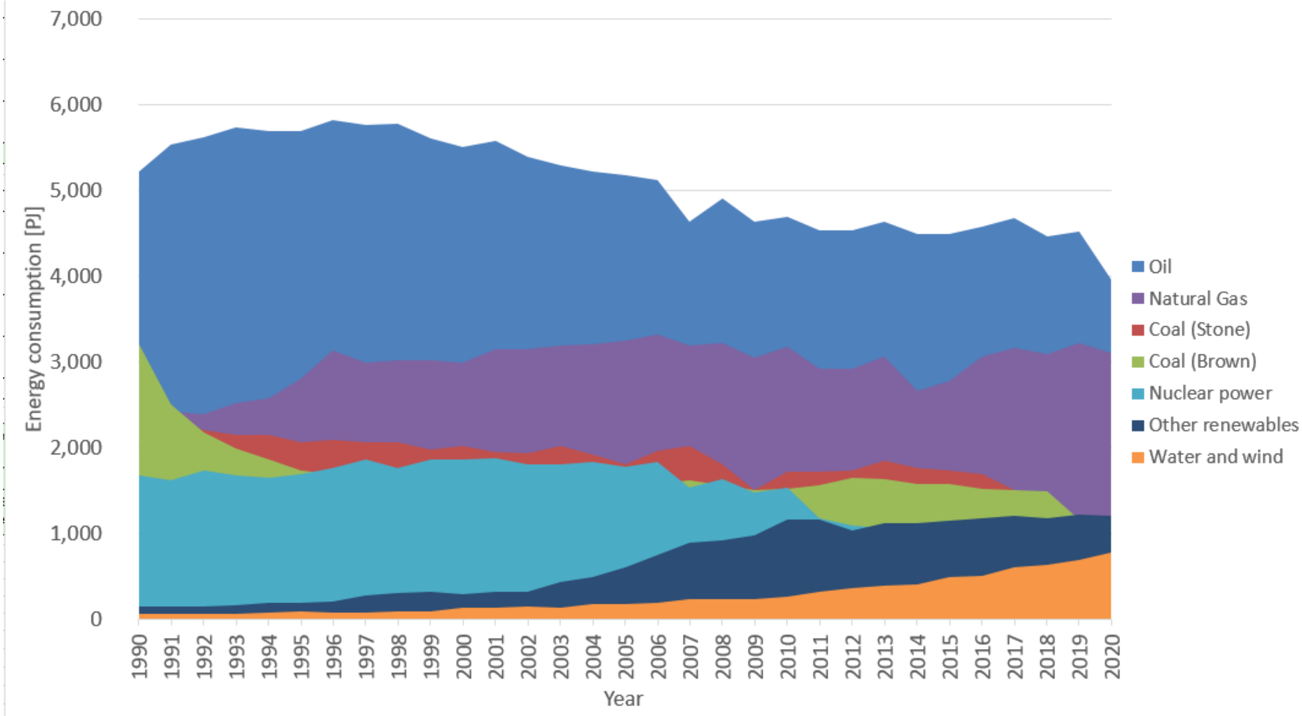



*Figure 1: Gross energy consumption (Bundesministerium für Wirtschaft und Energie, 2021).*

This trend is still ongoing (figure 1) and has to increase even more, if the climate goals for 2030 shall be achieved. The expansion of wind power plants began to decrease, however, in 2020. This has several reasons, for example low incentives or new regulations, like a higher prescribed distance a wind power plant has to have from households. Since 2017, new plants have to be part of a tender process, which also delays further expansion. In 2020, companies agreed to build 770 new wind power plants. In 2015, 40% more plants were built.

The development of $CO_2$-emissions can be seen in Figure 3. Since 1990 the $CO_2$-emissions have decreased, mainly due to a shift in fuel consumption from oil and coal to natural gas, and due to the increasing use of renewable energy.

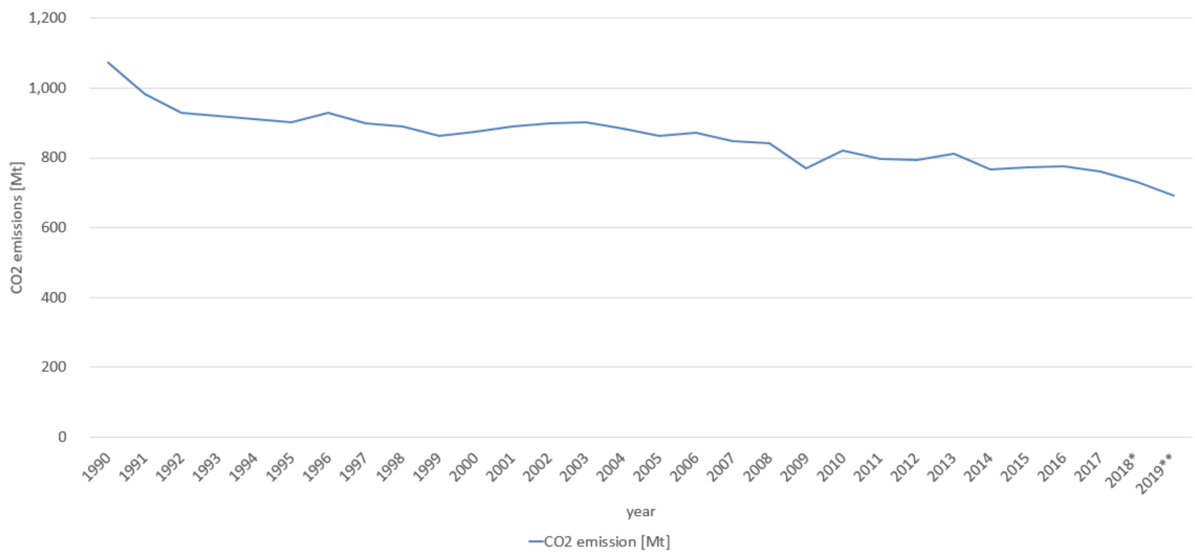



*Figure 2: Total $CO_2$ emissions (Bundesministerium für Wirtschaft und Energie, 2021).*

# POLICS AND STRATEGY

Germany is part of the European Union (EU) and therefore contributes to the common greenhouse gas reduction target of 40% in 2030. For 2030, the german government decided to choose a more ambitious target of a reduction of 65% compared to the emissions in 1990. A target of 100% emission reduction was set for 2045. This chapter elaborates on the purpose and definition of these targets, and the past and present energy policies related to the fulfilment of these targets. Finally, the chapter summarizes obstacles for the introduction of sector coupling technologies and lists trends regarding new business models.

## A.1.2 POLITICAL GOALS AND AGREEMENTS

In June 2021, the German government decided to reduce the GHG emissions to 35% of the emissions in 1990. This goal is included in the novel “Bundes-Klimaschutzgesetz (KSG)”, or climate protection law. The climate law does not contain concrete steps towards the goals. Instead, a council was created, which observes the yearly progress. It was also decided to publish more detailed climate reports every years.

Some of the steps the government will take are summarized in the following

- Incentives: The government increases subsidies for green heating technologies. Subsidies for solar power plants are extended.
- Increasing costs for usage of fossil fuels. Reduction of EEG levy.
- Transformation of district heating networks. These will be supplied by renewable energy sources.
- “Reallabore”. These are dedicated areas for testing devices and regulations.

## A.1.3 ENERGY PRICE STRUCTURE

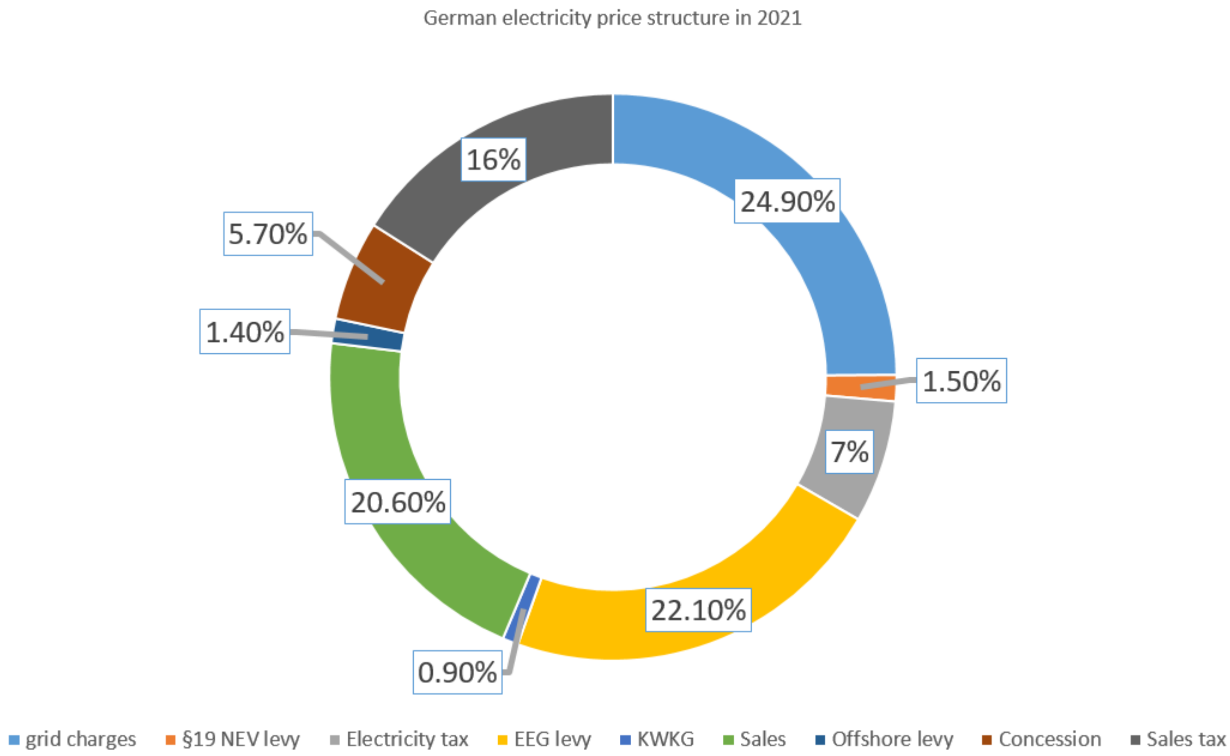



*Figure 3: Structure of the German electricity price in 2021. Source: (Verivox, 2021)*

According to different sources, the current structure of the electricity price is the reason for different obstacles regarding the expansion of sector coupling technologies. As shown in Figure 3 , the amount of taxes and levies have a high share on the total price. There are currently discussions ongoing if the price structure could be changed in order to support the consumers. A smaller electricity price could lead to an expansion of sector coupling technologies like heat pumps or electric vehicles. On the other hand, if part of the taxes and levies are transferred to fossil fuels, it would probably decrease the usage of these. As can be seen from Figure 4, the share of taxes is much lower compared to electricity. However, there are no concrete plans available yet on how to relieve the consumers.

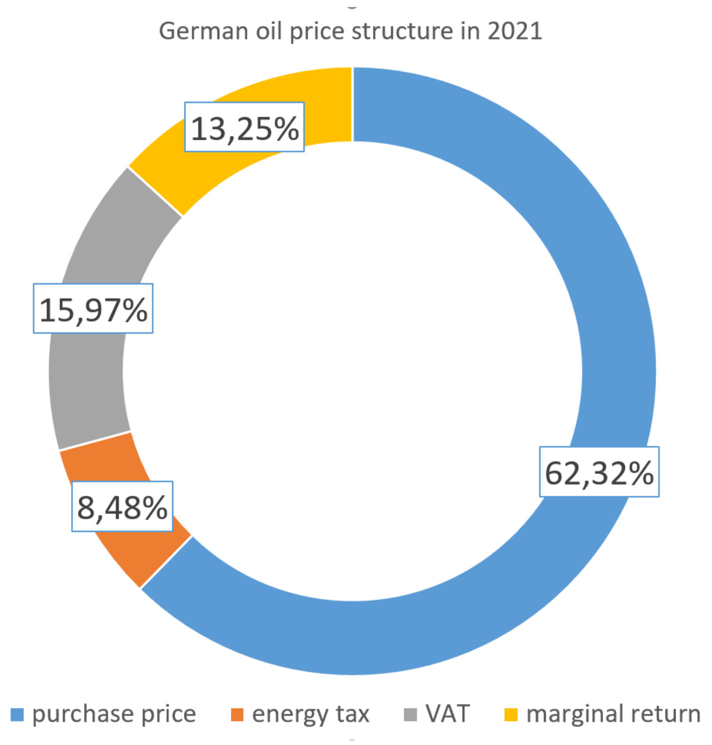



*Figure 4: Structure of the german oil price in 2021*

## A.1.4 SUBSIDIES AND LEVIES

The EEG (Renewable energies act) is based on the Stromeinspeisungsgesetz. As already mentioned, this law was an important advance towards the expansion of renewable energy sources in Germany, as it guaranteed producers of renewable energy a fixed price.

This is also a problem for the grid operators, as they have to pay a high price for the produced energy. The EEG power has to be offered on the electricity spot market and is sold there usually for a lower price. In order to avoid losses, the consumers have to pay the difference between the guaranteed feed-in tariff and the spot market price. This difference is the EEG levy.

Although some politicians want to fade out the EEG levy and replace it by payments financed of taxes, the future of the EEG levy is still discussed. A tax replacement of it would be a significant financial burden, which would be especially difficult to implement after the corona pandemic in 2020.

## A.1.5 KNOWN PROBLEMS ARISING FROM ENERGY PRICE STRUCTURE AND SUBSIDIES

As (Agora Energiewende, 2017) reports, the future energy system will rely on sector coupling technologies like heat pumps, which lead in the whole to a better efficiency of renewable energy sources, as these devices may flexibly create demand in times where there is excess power available.

The major obstacle which can be identified for the expansion of sector coupling technologies related to the energy price structure is already shown in figure [3]. The high electricity tax rate and also the EEG levy increase artificially, making some business strategies inefficient.

Problems, arising from this price structure are, e.g. mentioned in the final report of the Orpheus project.

In the future, it will become inevitable to view the different energy sectors as one unit, leading to a restribution of the tax burden to other sectors as well. The C02 tax introduced in 2021 in Germany might be a first step in this direction and may be a way to start the fade out process of the EEG levy.

However, in june 2021 it turned out that a very fast transformation of the tax system may not be accepted by the Germans: Annalena Baerbock, candidate for chancellor of the political party “Die Grünen”, suggested to raise the price for gas up to 16 ct./l. As the media reported, this other members of political parties and also some members of her own party, did not agree with this increase (taz, 2021). An increase of gas would lead to a more difficult situation for people who live in rural areas and are dependent on their car. It might be helpful to introduce further incentives for people to invest in electric vehicles, new heating systems and a better connectivity of public transportation first. In this way, more people would benefit from a redistribution of electricity taxes.

## A.1.6 KNOWN OBSTACLES FOR THE INTRODUCTION OF NEW OPERATION AND BUSINESS STRATEGIES FOR HYBRID NETWORKS FROM A REGULATORY POINT OF VIEW

In section 5.2.2 of the annex, an article of IKEM was mentioned, which emphasized suggestions for a regulatory transformation with respect to sector coupling technologies. These are probably valid for several European countries, but as they were originally intended for Germany, they are summarized here again:

Reduction of grid charges: Currently, batteries and Power-to-Gas plants connected to a grid do not have to pay grid charges. A suggestion is to include all kinds of coupling points, e.g. heat pumps.

Reduction of EEG levy: A reduction of the EEG levy is proposed. This could be an incentive for new sector coupling technologies.

Reduced costs for flexibility providing plants: If a coupling point is able to provide flexibility for the connected grid, costs, e.g. grid charges, could be reduced.

Unified framework for electricity tax reduction: It is mentioned that some devices have the possibility to pay a reduced electricity tax. One example are batteries, which only have to pay taxes as long as they are discharged. It is suggested to unify these different regulations in order to provide fair conditions for all types of coupling points.

## A.1.7 TRENDS FOR NEW BUSINESS STRATEGIES

Trends in Germany show that the study created by IRENA in (International Renewable Energy Agency, 2019) identified the correct trends for business models for future energy systems.

In the end of June 2021, the concept of energy communities described in two directives by the European Union shall be transferred into national law in each member state. Unfortunately, no information regarding the current progress of this transfer could be found, but it is clear by the directives that consumers will have access to new ways of energy trading and that there will be a closer connection between the different energy sectors.  According to the IRENA study, there are also projects taken place which examine the possibilities of peer-to-peer energy trading approaches. These measures might introduce the current consumer as a new actor in business model concepts, leading to better sector coupling business strategies.

Another approach which is used in Germany is the one using aggregators to accumulate demand flexibility of small devices which is then offered at the balancing market. Aggregators also make it possible to control a set of sector coupling devices, which also enables new operational and hence business strategies. If no aggregator is involved, network operators alone are typically not allowed to control coupling devices due to unbundling regulations.

# CURRENT ENERGY SYSTEM IN GERMANY

This chapter provides an overview of the primary energy production technologies and energy demands in Germany, with an outlook towards how the future energy system is expected to develop and how technologies should be integrated across different sectors and energy grids. Scenarios for the future German energy system are described more in chapter 4.

As can be seen in Figure 5, the German energy consumption is fairly equally distributed across the industry, transportation and household sectors. It can also be noted that in the past 30 years, the amount of consumed energy did not change a lot in these sectors.

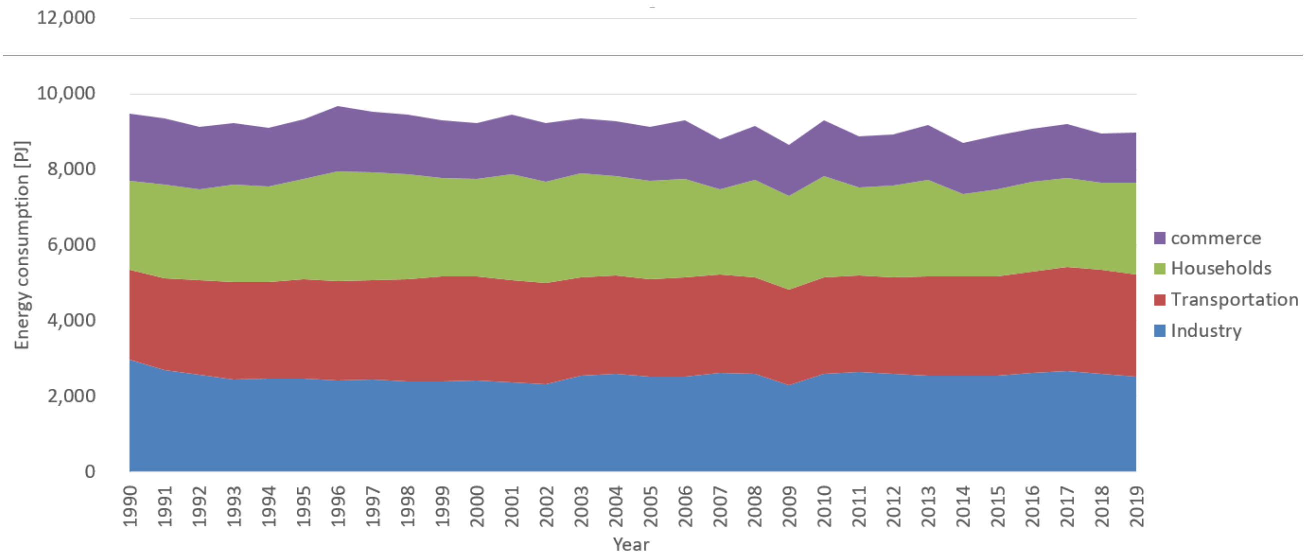



*Figure 5: Energy consumption per sector* [3].

## A.1.8 PRODUCTION OF ELECTRICITY, DISTRICT HEATING AND DISTRICT COOLING

An overview of the German energy production can be seen in Figure 7. The share of stone and brown coal decreased significantly in the past 30 years. As a replacement, renewable energy sources were added. However, besides an increased amount of RES, also the share of wood, waste and waste heat production grew significantly. Unfortunately, the source did summarize these three positions into one, but probably wood forms the largest share. The image shows that there is still energy produced by coal power plants. It is planned to shut down these in 2038. With respect to the climate goals of Germany, this is very late. Interestingly, in 2020 there was also a new coal power plant set into operation because of economical reasons (Datteln 4) (Endres, 2020).

On the other hand, the expansion of wind power decreases as shown in Figure 5. The decrease is because of limited space for new plants and a complicated approval procedure. Small improvements regarding the procedure were made during the last months, but in general, the decrease in wind power expansion is contradictory to the climate goals, especially because also in Germany there are many projects ongoing to support sector coupling technologies like e-mobility or heating technologies like heat pumps. Without a sufficient amount of renewable energy sources covering this demand, sector coupling technologies are meaningless with respect to the german climate goals.

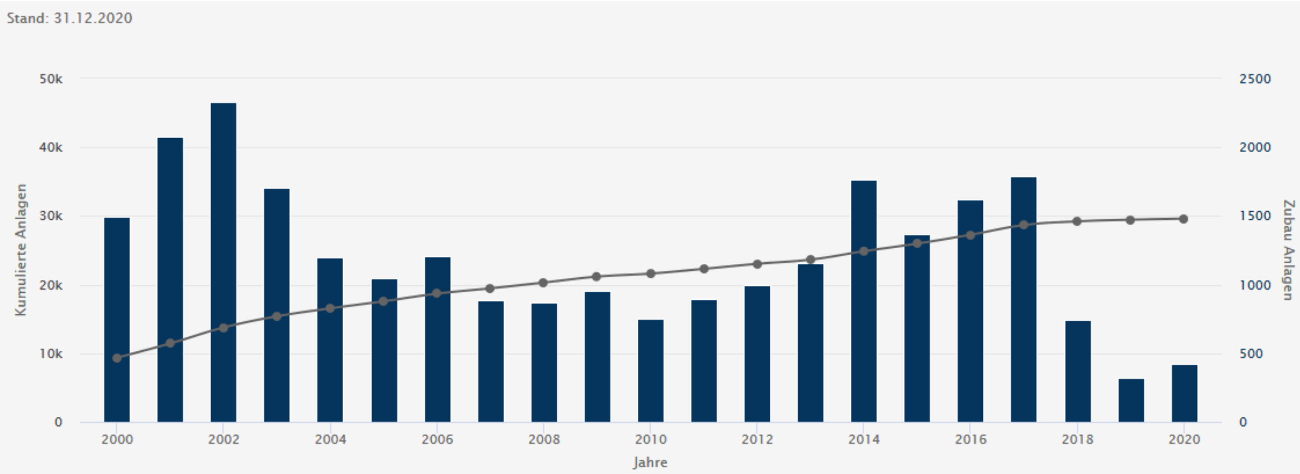



*Figure 6: Amount of wind power plants in Germany. The line graph shows the accumulated value of wind power plants, while the bar plot shows the amount of new plants in the corresponding year (Bundesverband für Windenergie, 2020).*

Especially the sharp decrease of new plants between 2017 and 2018 has to be noted.

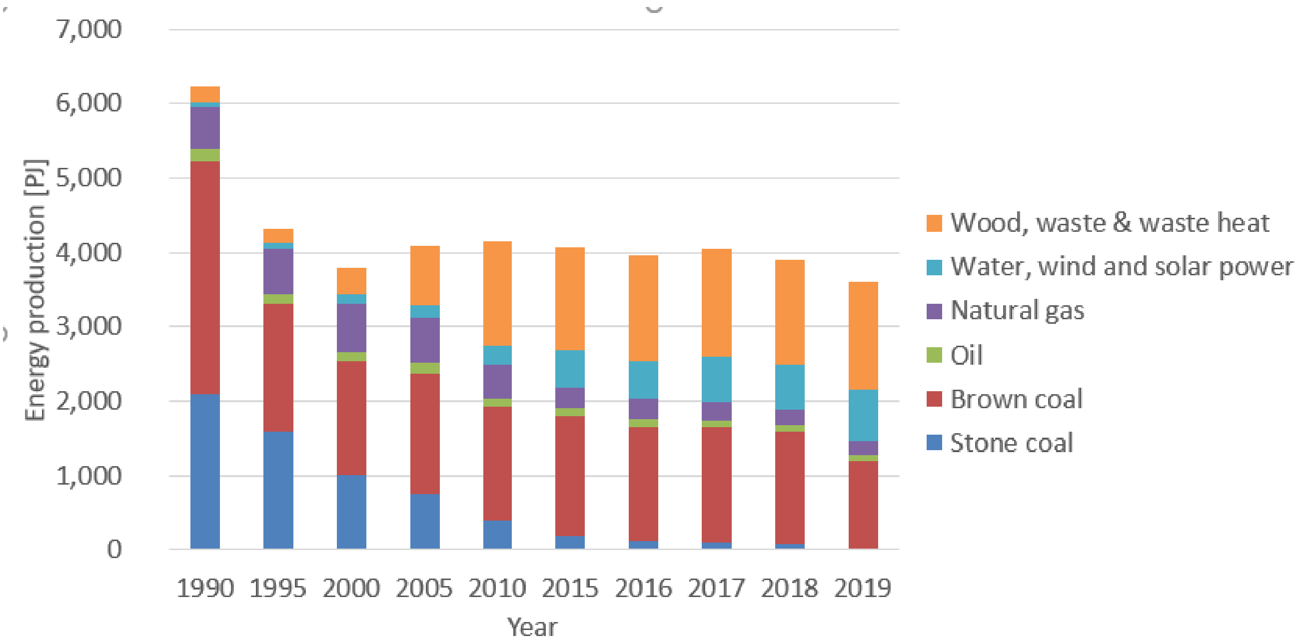



*Figure 7: Total production of energy by fuel* [3]

The electricity system in Germany is well-connected to neighboring countries by electricity transmission lines. The amount of imported and exported power during the last 30 years is shown in Figure 8, although no export data for the last years was available. However, it is clear that Germany increased the amount of exported energy during the last years, while the amount of imported power could be reduced. In the frame of the low expansion rates of renewable energy systems the high amount of exported power is especially interesting.

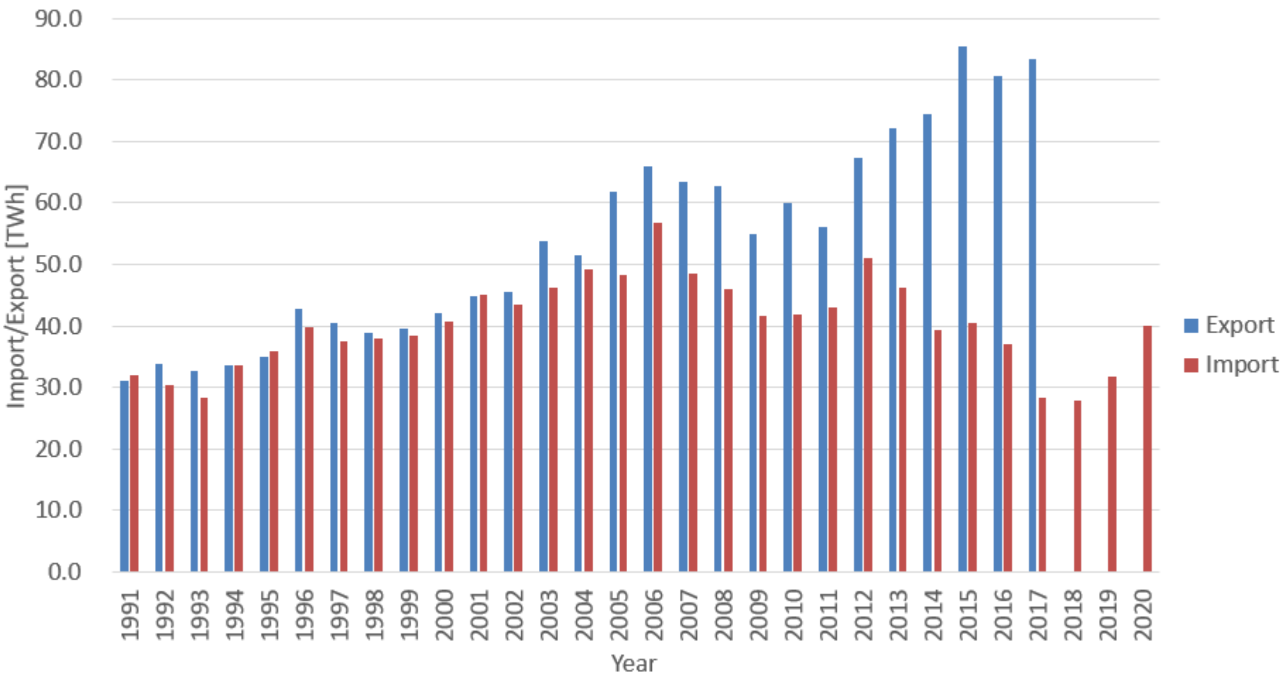



*Figure 8: Import and export of electricity from Germany.*

In comparison to other countries like Denmark, district heating systems are not as common.

. The biggest district heating systems can be found in Hamburg, Berlin and Mannheim. The largest amount is created with CHP plants. As can be seen from Figure 8, there is no district heating system which is fuelled using renewable energy sources. Instead, there is still a large amount produced by coal power plants. The biggest share of district heating energy is natural gas with 42%.

An alternative to the mentioned fuels is heat created by biomass plants. These plants are already used for smaller district heating systems and in order to achieve the climate goals, these plants are also subsided by the German government.

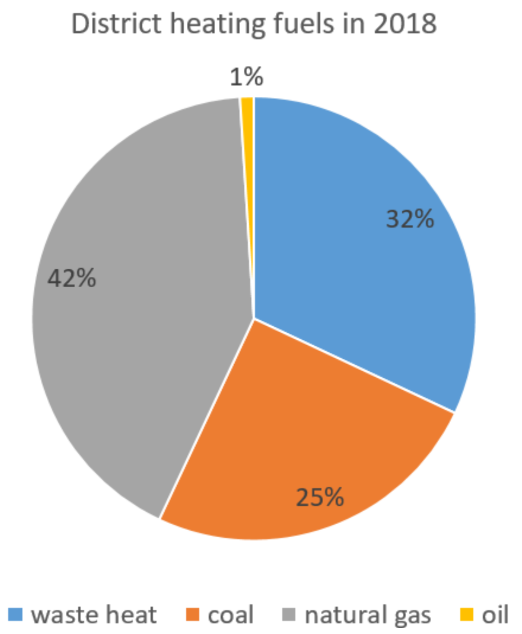



*Figure 9: District heating production* [3].

## A.2 FUTURE SCENARIOS FOR THE ENERGY SYSTEM

Many studies are available which show different scenarios for the German energy system in the years to come. These studies have been created by different institutions. In the following sections, the results of (Fraunhofer ISE, 2020) and (Agora Energiewende, 2017) are summarized.

### A.2.1 NECESSARY DEVELOPMENTS UNTIL 2030

The scenario for 2030 of the Bundesverband Erneuerbare Energien declares a goal of a reduction of 65% in carbon dioxide emissions. The main measures to reduce the emissions evaluated by the Bundesverband are (Bundesverband Erneuerbare Energie e.V., 2021):

1. The renewable energy production has to be expanded to 1084 TWh. In 2019, the production from RES sources was at 455 TWh according to the study. This means that in 2030, the RES energy has to be increased by a factor of 2,4.
2. The study mentions sector coupling technologies as an important pillar for the emission reduction. The usage of sector coupling technologies will lead to an increase of electricity demand.
3. The main lever to increase RES production is the expansion of wind and solar power. It may be possible to increase the share of renewable energy to 77%.
4. Besides the increasing RES production for electricity, it is very important to use renewable energy sources for heat production as well. One way to do this might be to use more biomass plants.
5. Usage of PTX technologies.

A very important aspect is the increasing electricity demand in the transport sector due to electric vehicles, although the study also assumes that more bio energy is used and that PTX technologies will be set into operation to fuel ships and airplanes.

The increasing amount of electric vehicles may help to reduce the problem of volatility of renewable energy sources. The study mentions that 40 TWh may be lost if there are not enough storages available to store generated power during peak production times.

According to (Agora Energiewende, 2017), gas grids will be extended by Power-to-gas-plants. Gas grids are also prepared for the reduction of gas demand. Instead, district heating grids will be extended and be driven by a low temperature. At the same time, oil heating devices will be replaced by heat pumps.

## A.2.2 GERMAN ENERGY SYSTEM IN 2050

There are several studies available which outline the path towards a 100% emission free energy system in 2050. These paths require significant changes in the current energy system. The main transformation aspects are summarized in (Brandes, et al., 2020):

- It is assumed that the required power in 2050 will be at 1250 – 1570 TWh. This number does not include the required power to cover the sectors mobility and heat. This means that the amount of wind power parks and solar power plants has to increase accordingly. In 2050, 240-300 GW of wind power and 340-450 GW of solar power have to be installed.
- Because of the volatile energy source, storages will be necessary
- It is important that in 2030, a share of 30 % electromobiles is available.
- The biggest transformation takes place in the heating sector. It is expected that in 2050, 90% of the heating supply is covered by heat pump and district heating systems. To achieve this goal, a continuous transition is necessary as outlined in Figure 10.

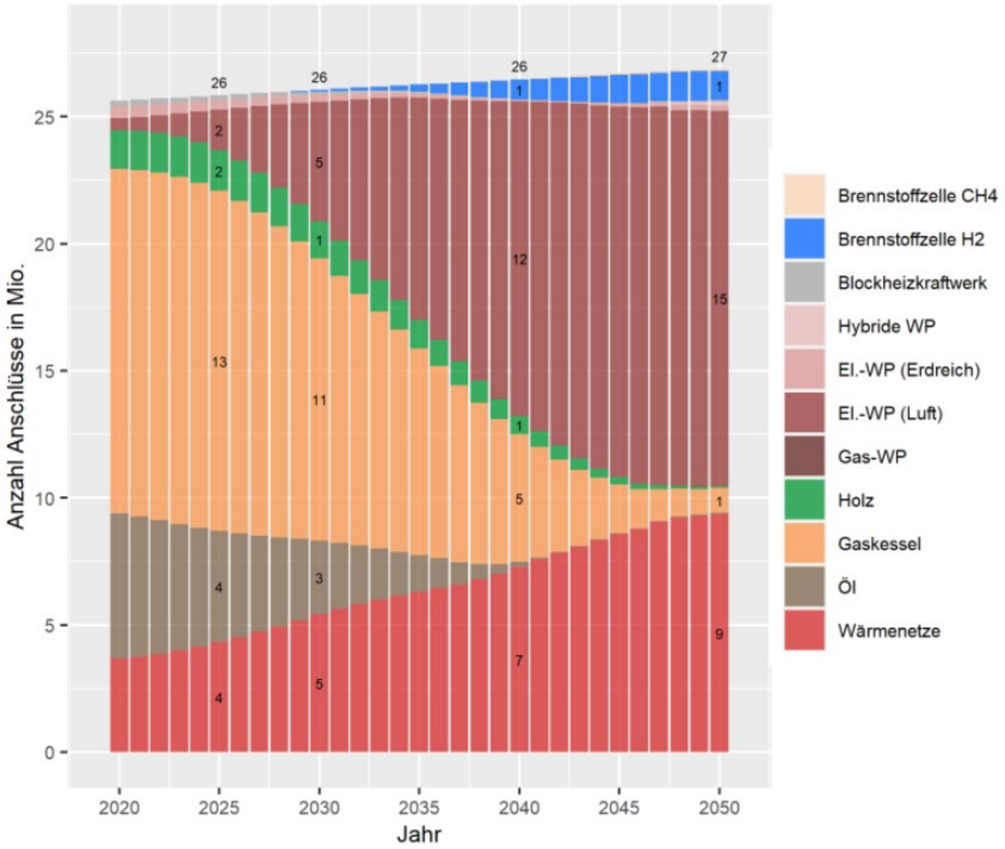



*Figure 10: Transition of heating supply until 2050. The y axis shows the number of household connections in millions. As shown, the amount of gas infrastructure has to decrease, while at the same time the number of district heating grids and heat pump systems has to increase.*

However, there are also studies available, which state that the heat pump will not play a major role in the future German energy system. Instead, also the gas system, will take part in supplying heat energy. As gas producers, one can think of hydrogen or biomass production.

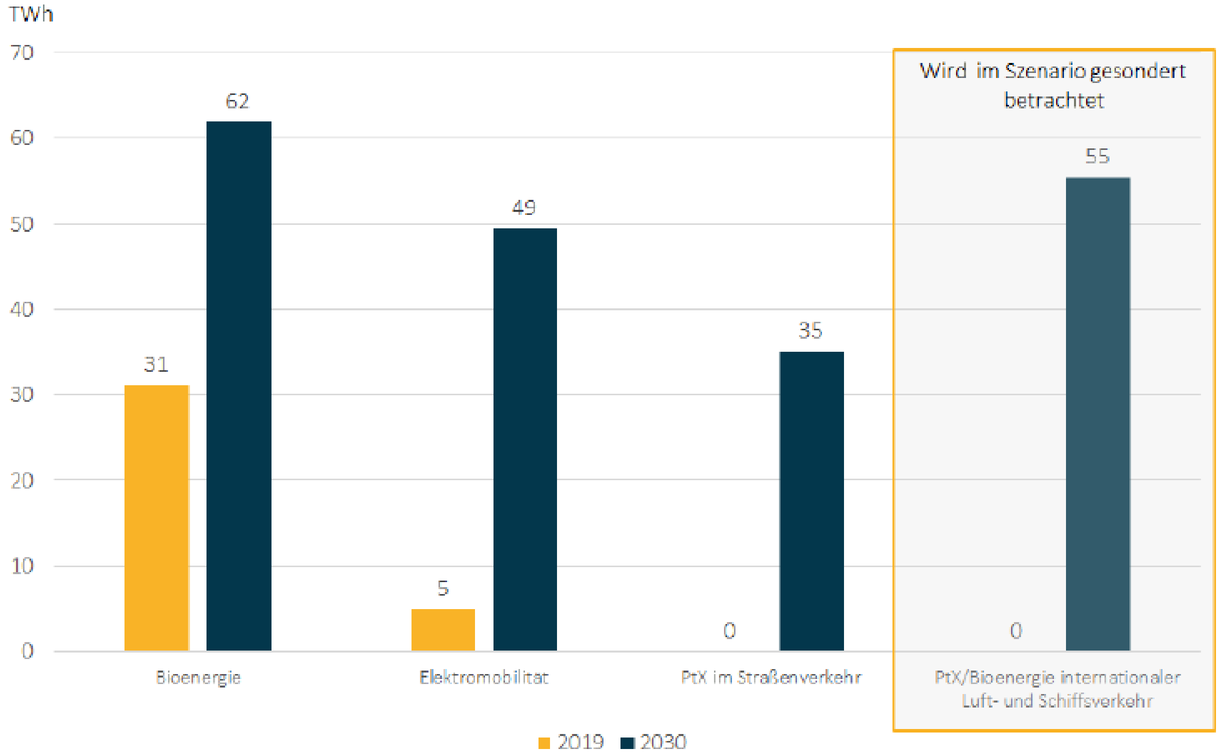



*Figure 11: Required energy in the transport sector in 2019 and 2030. From Left to Right: Bio energy, electromobility, PTX for traffic, PTX for ship and air traffic.*

# 2 LITERATURVERZEICHNIS

Agora Energiewende. (2017). *Energiewende 2030: The big picture.*

Austrian Institute of Technology. (2019). *Sondierung zur Realisierung des Wärmepumpenpooling für städtische Wärmenetze.* Bundesministerium für Verkehr, Innovation und Technologie.

BDEW. (2021). *BDEW - Primärenergieverbrauch.* Abgerufen am 25. 01 2022 von https://www.bdew.de/energie/primaerenergieverbrauch-in-deutschland-nach-energietraegern-2020/

Brandes, J., Haun, M., Senkpiel, C., Kost, C., Bett, A., & Henning, H.-M. (2020). *Wege zu einem klimaneutralen Energiesystem.* Fraunhofer ISE.

Bundesministerium für Wirtschaft und Energie. (5. 3 2021). *Zahlen und Fakten: Energiedaten.* Abgerufen am 1. 6 2021 von http://www.bmwi.de/Navigation/DE/Themen/energiedaten.html

Bundesverband Erneuerbare Energie e.V. (2021). *Das BEE-Szenario 2030.*

Bundesverband für Windenergie. (2020). *Deutschland in Zahlen.* Abgerufen am 18. 06 2021 von https://www.wind-energie.de/themen/zahlen-und-fakten/deutschland/

Caramizaru, A., & Uihlein, A. (2020). *Energy communities: An overview of energy and social innovation.* JRC Science for Policy.

Doderer, H., Schäfer-Stradowsky, S., Antonis, J., Metz, J., Knoll, F., & Borger, J. (2020). *Sinteg-Windnode: Denkbare Weiterentwicklungsoptionen für die umfassende Flexibilisierung des Energiesystems.* IKEM.

Endres, A. (29. 01 2020). *Dieser Ausstieg ist ein klarer Betrug am Steuerzahler.* Abgerufen am 21. 06 18 von https://www.zeit.de/politik/deutschland/2020-01/kohleausstieg-gesetz-kai-niebert-deutscher-naturschutzring/komplettansicht?utm_referrer=https%3A%2F%2Fde.wikipedia.org%2F

Energiteknologisk Udviklings- og Demonstrationsprogram). (2019). *Ecogrid 2.0 - Main results and findings.*

Ester, T., Pober, M., Kerschbaumer, M., Ziegler, M., Terreros, O., Spreitzhofer, J., . . . Schmidt, R. (2020). *Electricity market options for heat pumps in rural district heating networks in Austria.* Energy.

eurelectric powering people. (2019). *Citizens Energy Communities: Reccomendations for a successful contribution to decarbonisation.*

European Union. (2018). *Directive (EU) 2018/2001 of the European Parliament and of the council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast).* Official Journal of the European Union.

European Union. (2019). *Directive (EU) 2019/944 of the European Parliament on common rules for the internal market for electricity and amending Directive 2012/27/EU.*

Eurostat. (2020). *eurostat data explorer*. (eurostat) Abgerufen am 21. 01 2021 von http://appsso.eurostat.ec.europa.eu/nui/setupDownloads.do

Fraunhofer ISE. (2020). *Wege zu einem klimaneutralen Energiesystem 2050.* Freiburg.

Fraunhofer ISI, consentec, zsw. (2020). *Auswirkungen klima- und energiepolitischer Instrumente mit Fokus auf EEG-Umlage, Stromsteuer und CO2-Preis.* Karlsruhe.

Greisen, C. e. (2019). *Energy Lab Nordhavn - Results from an Urban Living lab.*

Hvelplund, F., Ostergaard, P. A., & Meyer, N. I. (2017). Incentives and barriers for wind power expansion and system integration in Denmark. *Energy Policy*, S. 573-584.

International Renewable Energy Agency. (2019). *Innovation Landscape for a renewable-powered future.*

ISE. (2021). *Fraunhofer ISE.* Abgerufen am 25. 01 2022 von https://www.ise.fraunhofer.de/de/presse-und-medien/news/2020/nettostromerzeugung-in-deutschland-2021-erneuerbare-energien-erstmals-ueber-50-prozent.html

ISI, Fraunhofer; Consentec;Stiftung Umweltenergierecht. (2020). *Auswirkungen klima- und energiepolitischer Instrumente mit Fokus auf EEG-Umlage, Stromsteuer und CO2-Preis.* Karlsruhe.

Jorgensen, J. M., Sorensen, S., & Behnke, K. (2011). Ecogrid EU - A prototype for European Smart Grids. *2011 IEEE Power and Energy Society General Meeting.* IEEE XPlore.

Klimaatakkoord. (2019). *Climate Agreement*. Abgerufen am 25. 01 2021 von https://www.klimaatakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands

Komusanac, I., Brindley, G., & Fraile, D. (2020). *Wind Energy in Europe in 2019.* Wind Europe.

Maxwell, V., Sperling, K., & Hvelplund, F. (2015). Electricity cost effects of expanding wind power and integrating energy sectors. *International Journal of Sustainable Energy Planning and Management*, S. 31-48.

NIBE Systemtechnik GmbH. (2022). *NIBE - Die Co2-Steuer für Heizungen*. Abgerufen am 14. 01 2022 von NIBE - Die Co2-Steuer für Heizungen: https://www.nibe.eu/de-de/support/artikel/co2-steuer

Schwabeneder, D., Auer, H., & Burgholzer, B. (2017). *OPtimising Hybrid Energy grids for smart citiesS: Technical, Economical and Social Benefits.* Seventh Framework Programme.

Stephanos, C. e. (2018). *Coupling the different energy sectors - options for the next phase of the energy transition.* Leopoldina - Nationale Akademie der Wissenschaften, acatech - Deutsche Akademie der Technik Wissenschaften.

taz. (04. 06 2021). *Alle gegen Baerbock.* Abgerufen am 16. 06 2021 von https://taz.de/Streit-ueber-Benzinpreis-Erhoehung/!5776408/

Umweltbundesamt. (2019). *Integration erneuerbarer Energied durch Sektorkopplung: Analyse zu technischen Sektorkopplungsoptionen.*

Ventury GmbH, Fraunhofer IEE, Voß Wärmepumpen, BBH Consulting AG, Stadtwerke Neuburg an der Donau, Institut für Klimaschutz, Energie und Mobilität, Fraunhofer IEE. (2020). *Innonex - Final Report.*

Verivox. (2021). *Verivox.* Abgerufen am 09. 06 2021 von https://www.verivox.de/strom/themen/strompreiszusammensetzung/

Wang, J., Yi, Z., You, S., & Traeholt, C. (2017). A review of Danish integrated multi-energy system flexibility options for high wind power penetration. *Clean Energy*, S. 1-13.

Zong, Y., Böning, G., & Santos, R. (2017). Challenges of implementing economic model predictive control strategy for buildings interacting with smart energy systems. *Appl. Thermal Eng.*