The German primary energy consumption – status and trends

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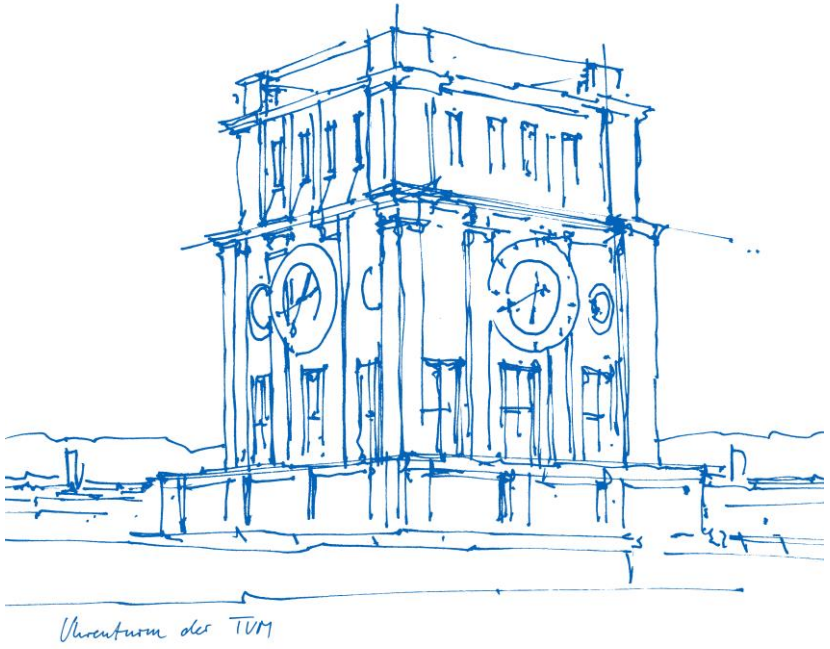

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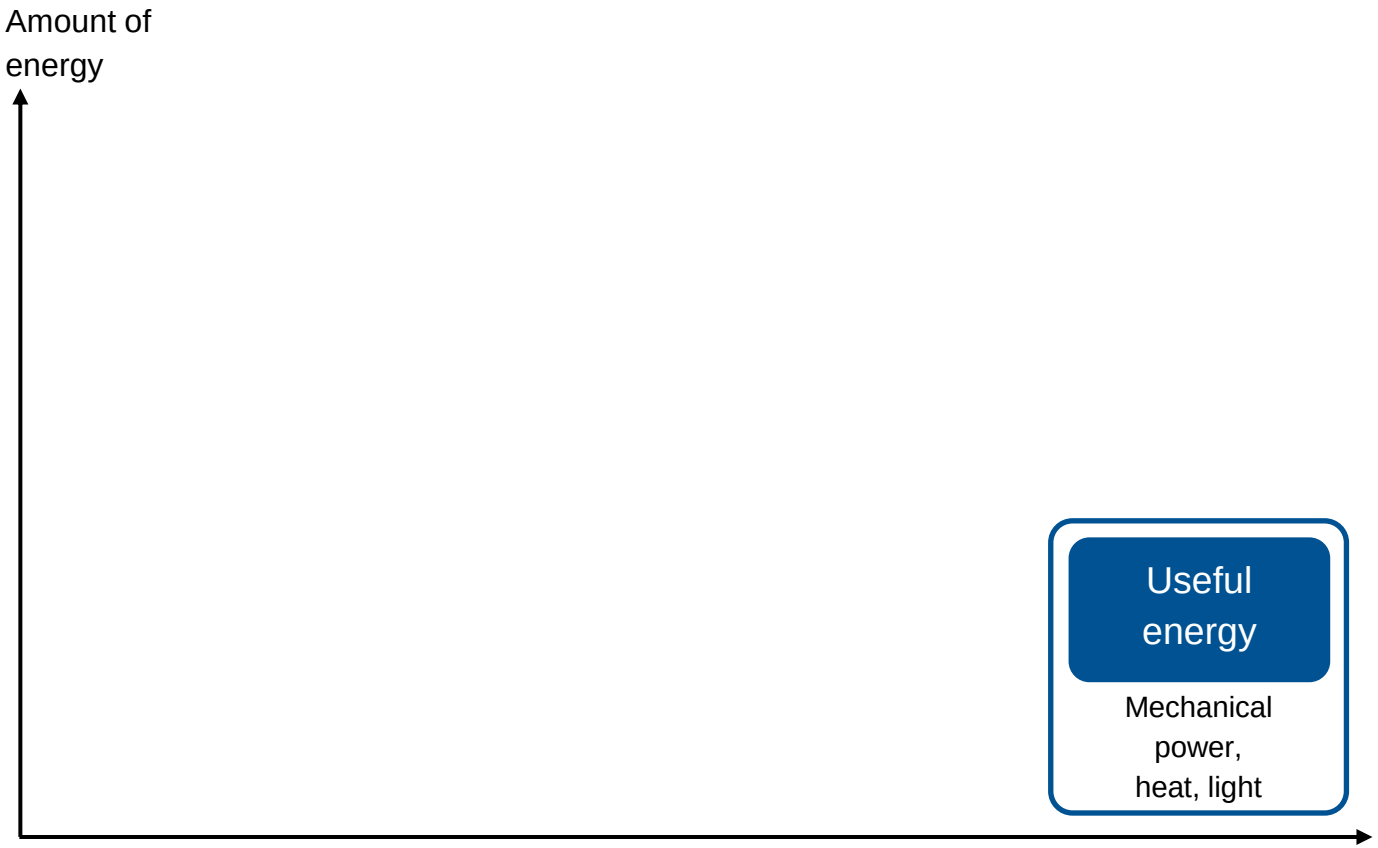
Introduction

How is primary energy consumption characterized?



Own representation based on Kaltschmitt (2013)

Definition of the term "energy“

Energy can be defined as the ability of a system to produce external effects. Useful energy is for example demanded as *mechanical power, heat and light*. Depending on the required form, energy conversions are necessary.

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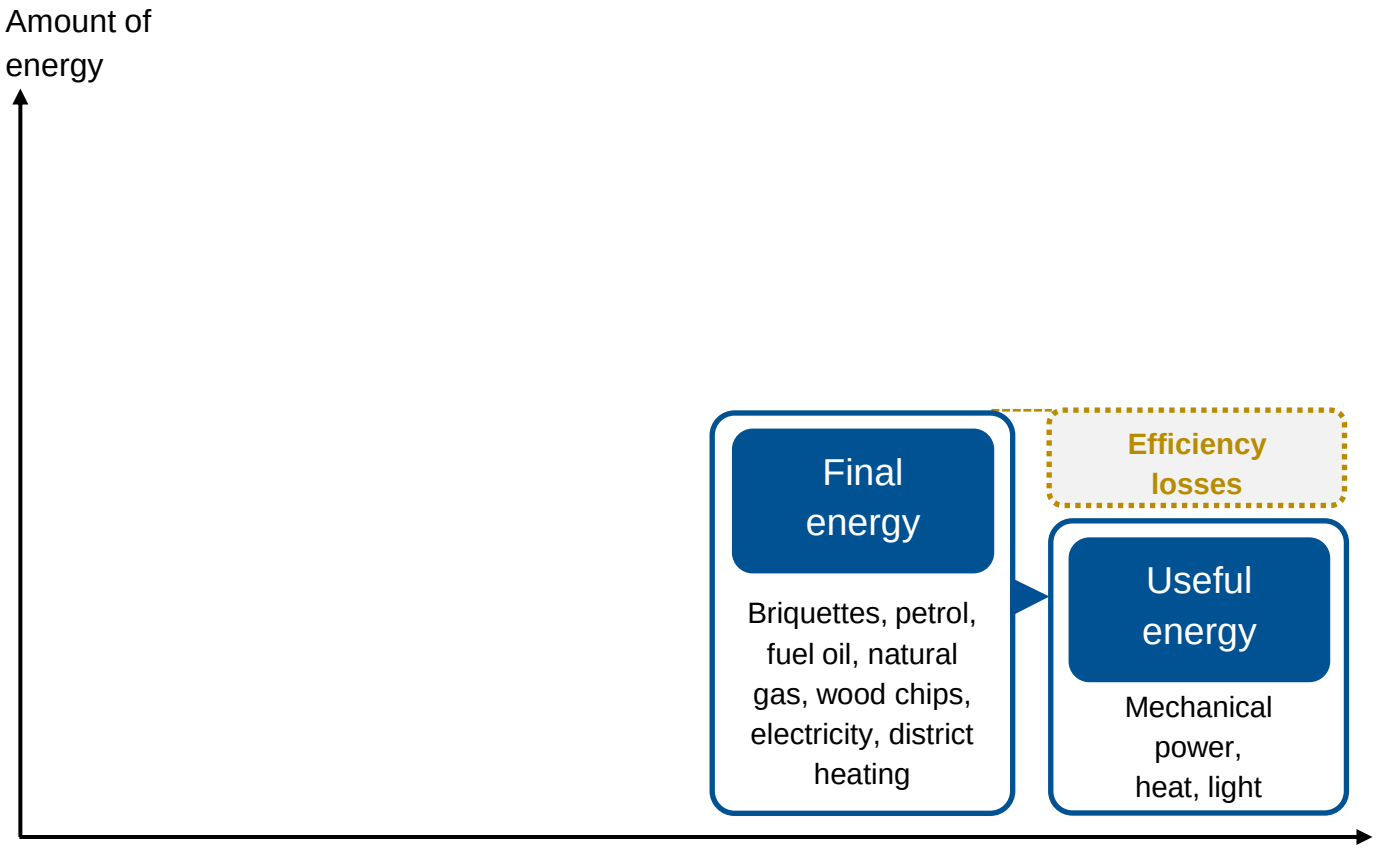

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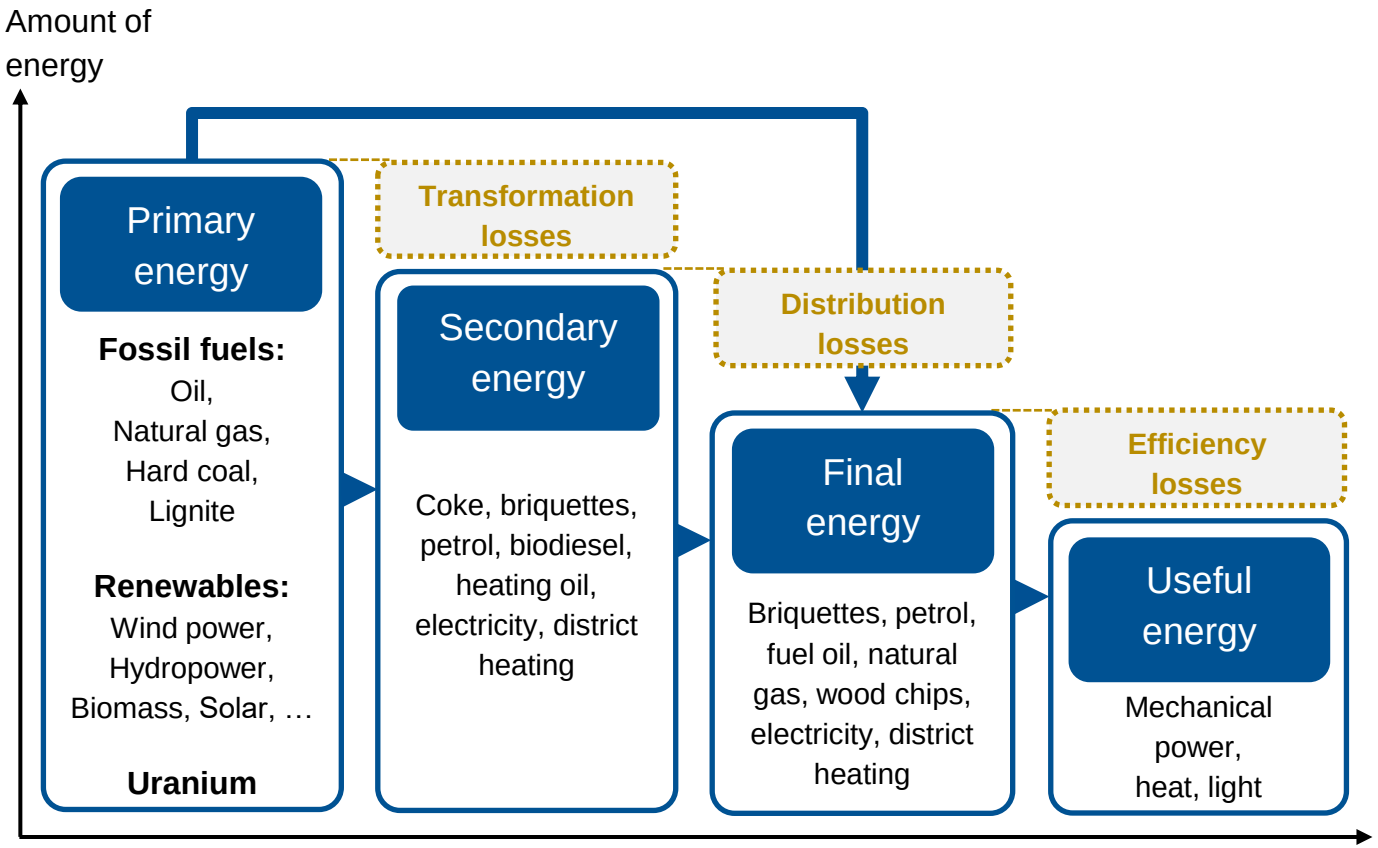

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Primary energy is the energy contained in primary energy sources that have not yet been processed. Secondary energy can be obtained directly or through one or more transformations from primary energy carriers.

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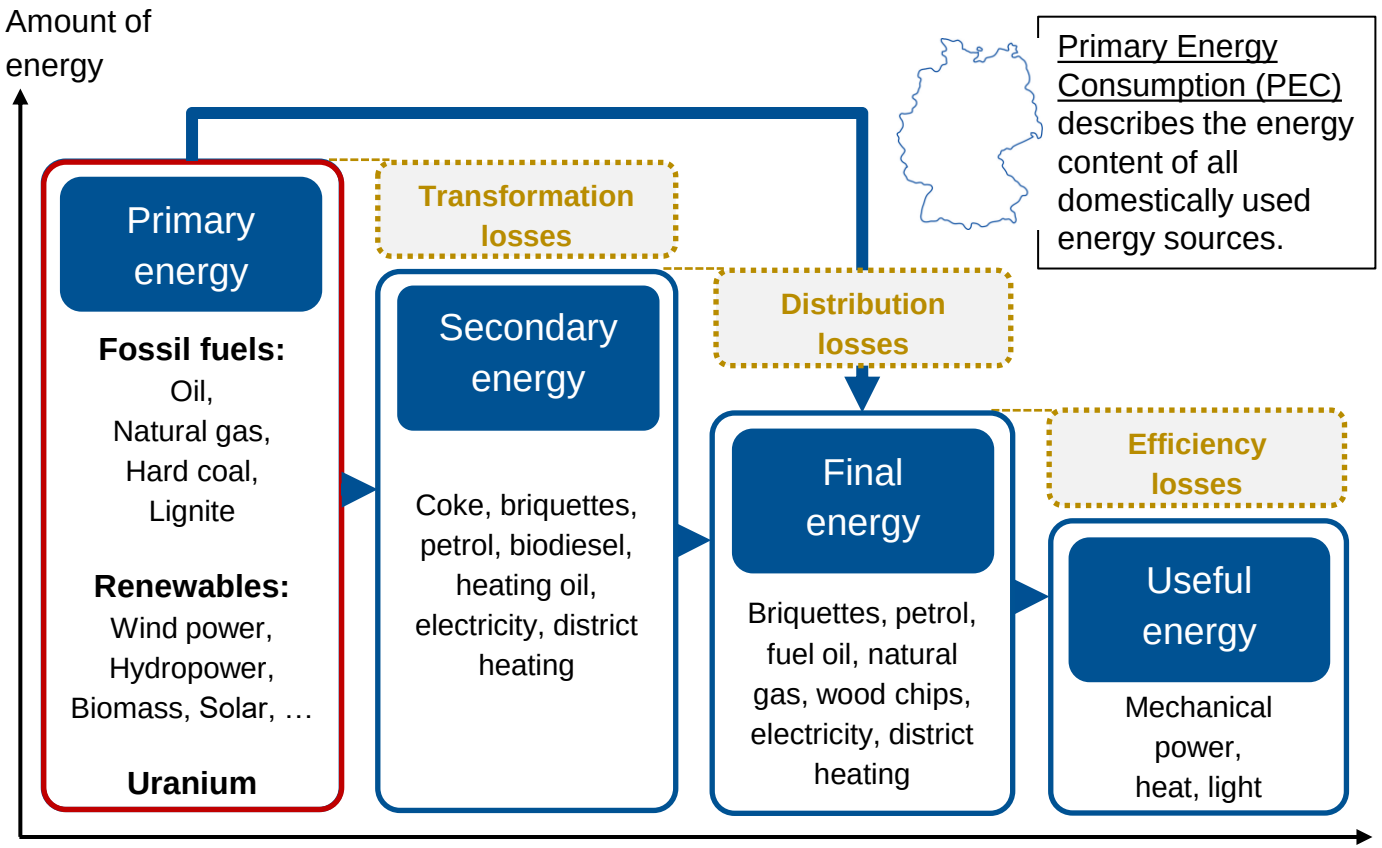

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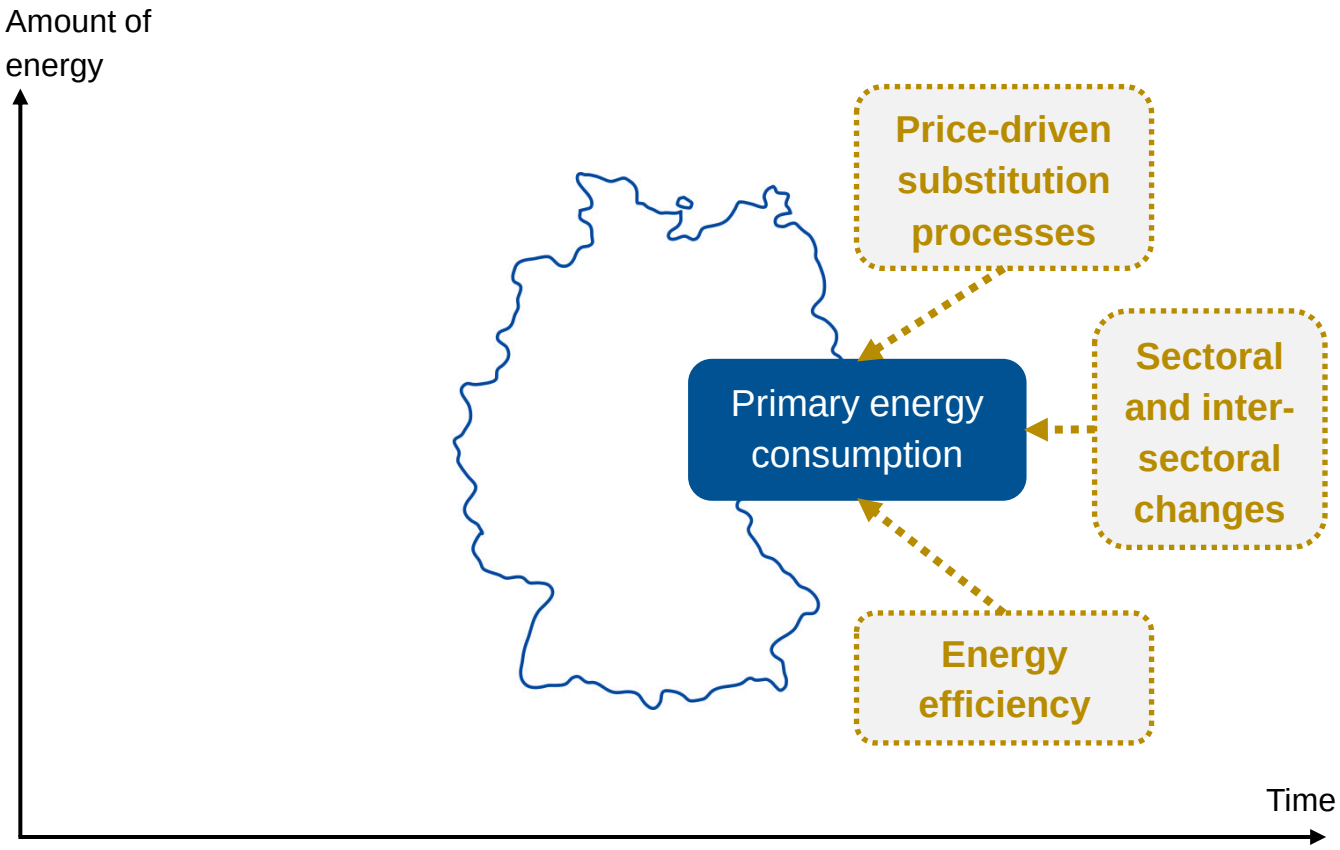

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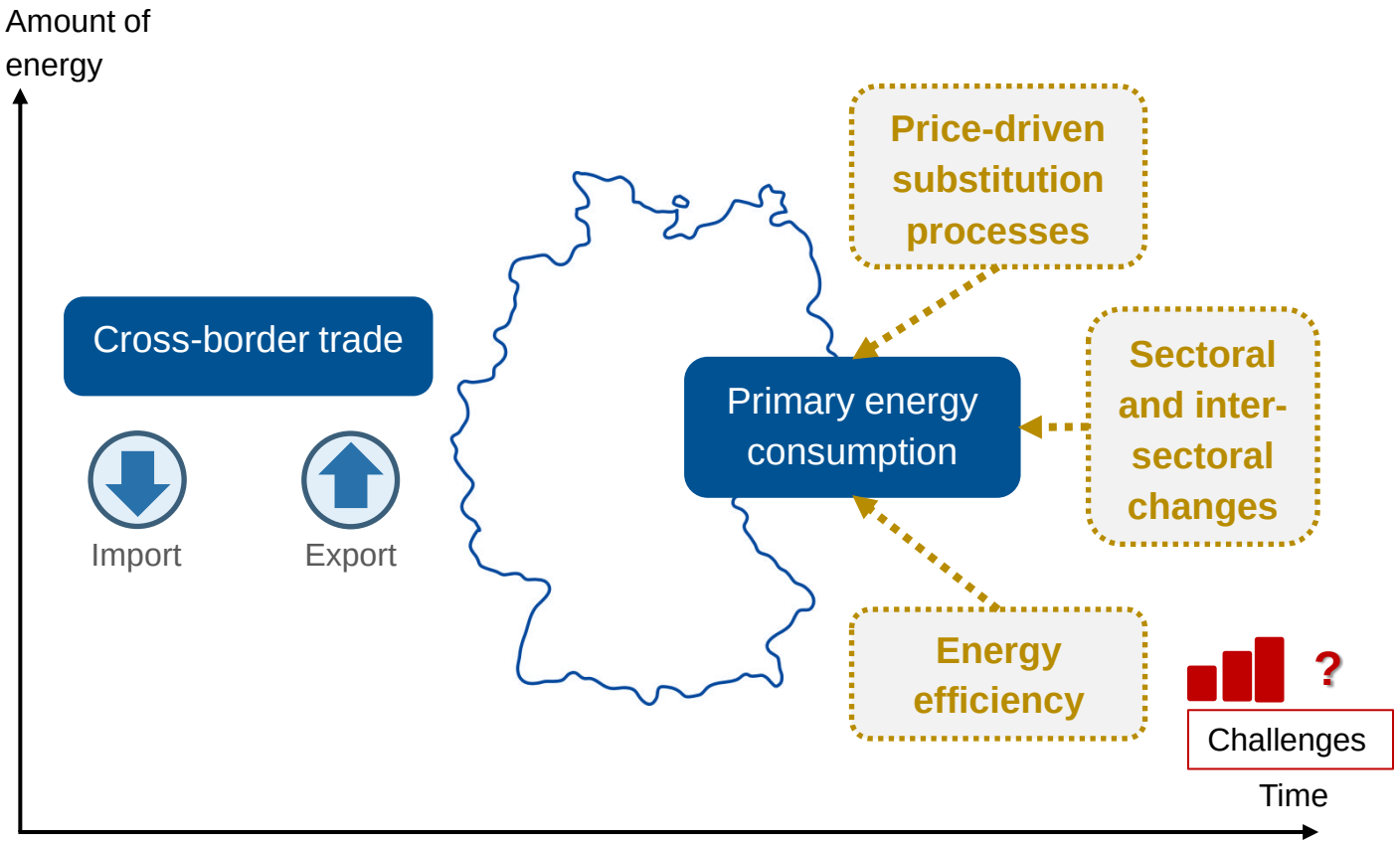

- We summarize the:
  - composition of PEC in Germany,
  - how cross-border trade of primary energy is structured and
  - which challenges in the field of energy supply Germany is likely to face in the future.

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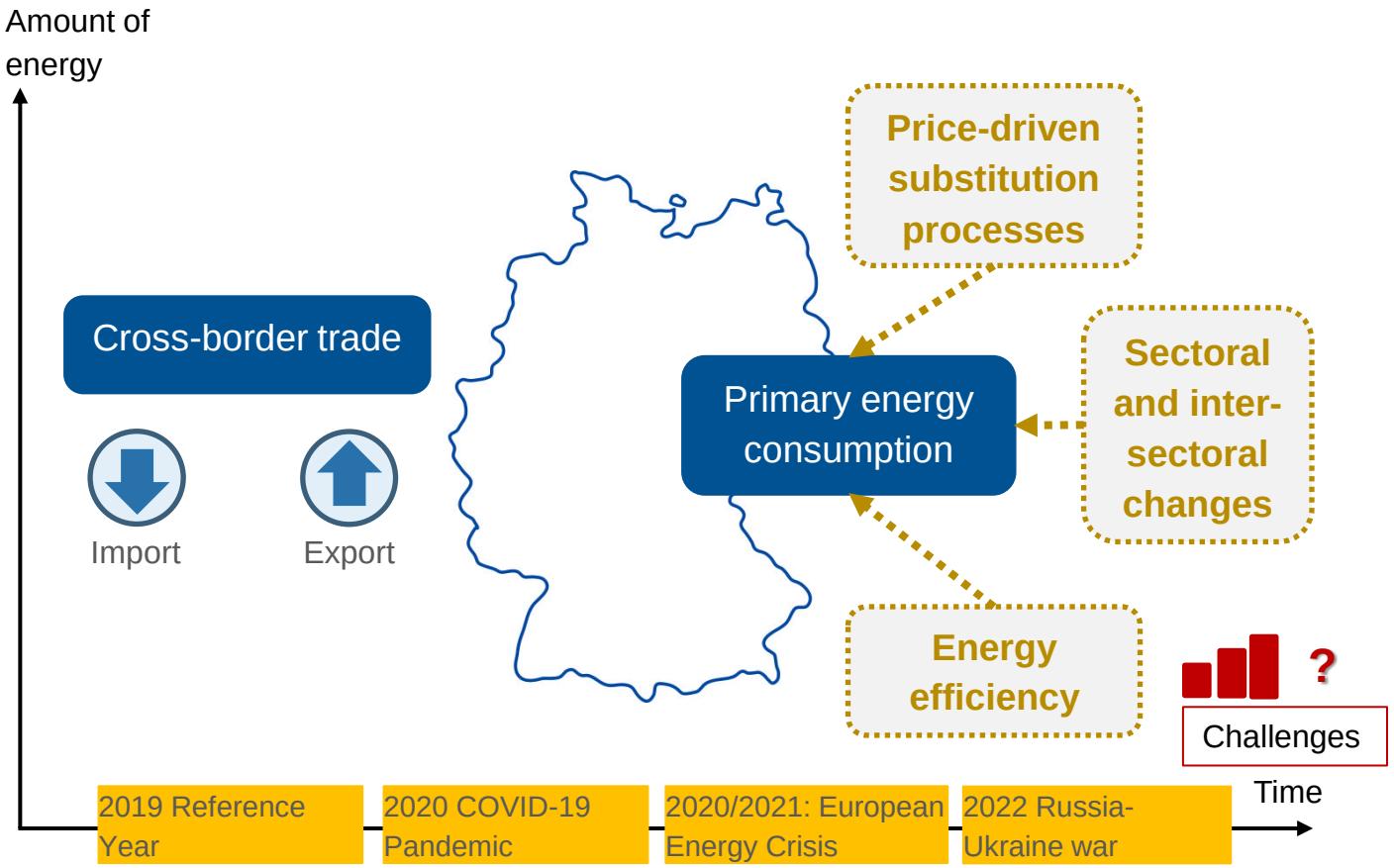

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  - composition of PEC in Germany,
  - how cross-border trade of primary energy is structured and
  - which challenges in the field of energy supply Germany is likely to face in the future.
- We are comparing current data with data from 2019 due to the serious and sometimes temporary shifts in the international raw materials and energy markets:
  - in 2020 as a result of the COVID-19 pandemic and
  - 2022 due to the Russia-Ukraine war

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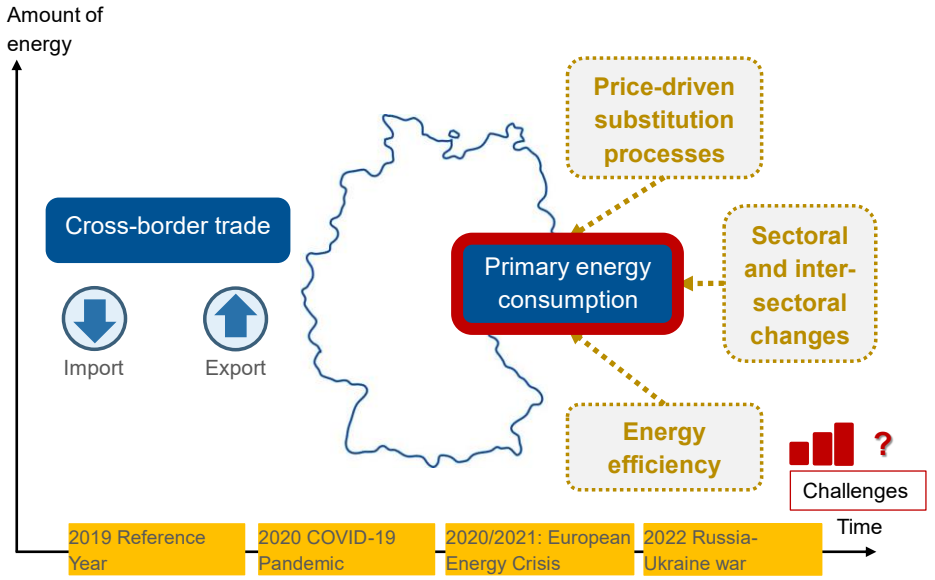

The primary energy consumption in Germany

Energy flow chart

Energy flow chart, 2021 (2019);
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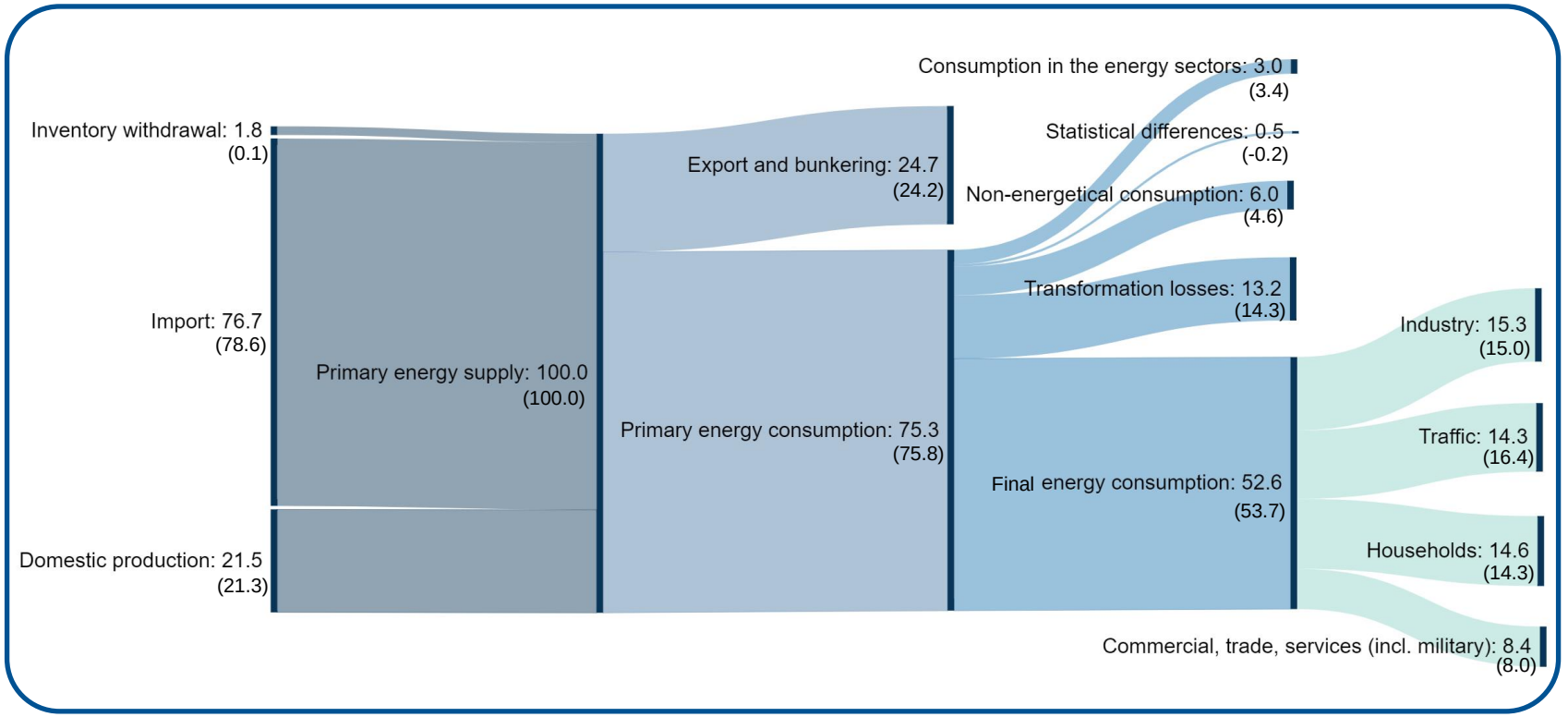

Own representation based on AGEB (2022e)
Primary energy supply: 16,492 PJ (16,855 PJ); Deviations in the totals are due to rounding

Germany, 2021:

- The Primary energy supply was 16.492 PJ. (AGEB, 2022e)
- 77% (12.644 PJ) of primary energy supply was covered by imports, 22% (3.548 PJ) by domestic primary energy production and 2% (300 PJ) by inventory withdrawal. (AGEB, 2022e)
- 25% (4.078 PJ) was exported and bunkered. (AGEB, 2022e)
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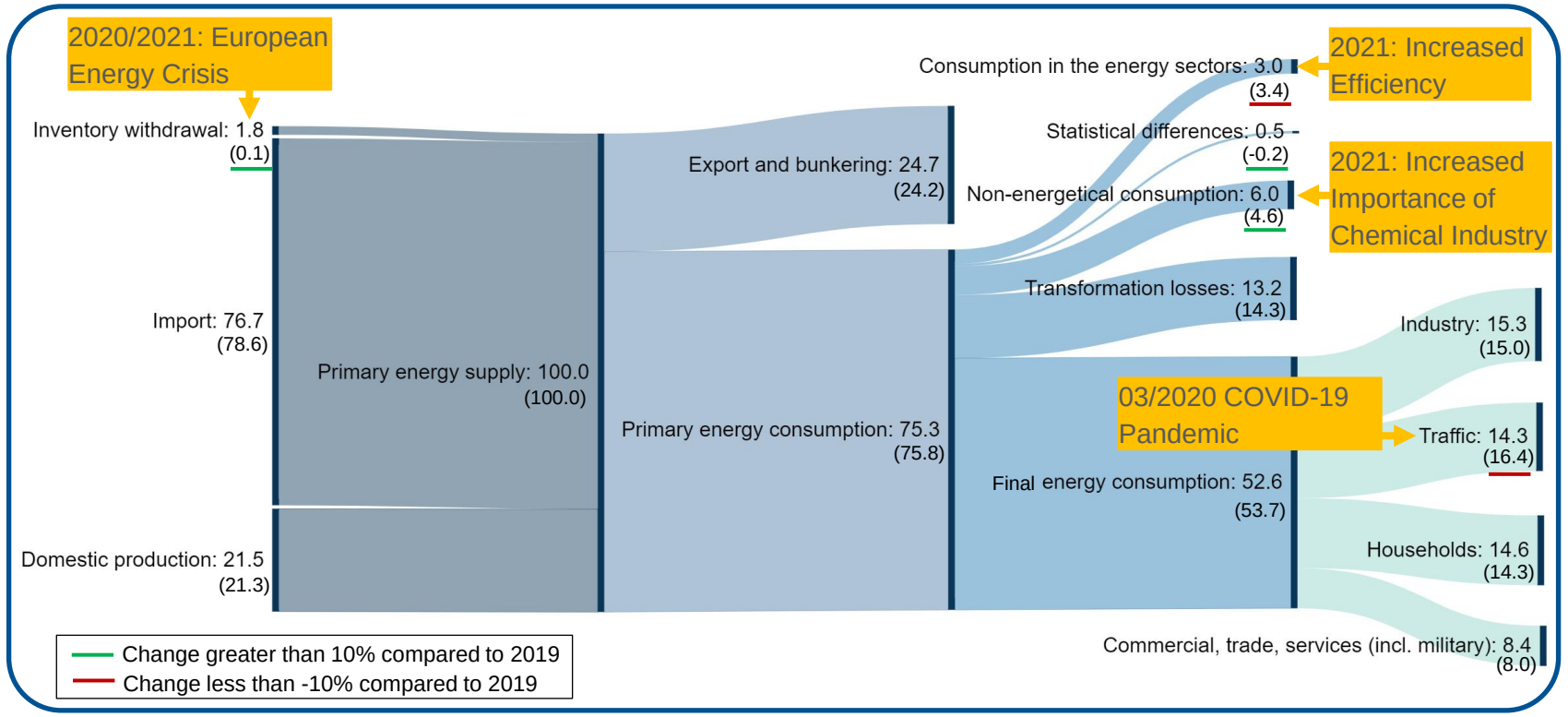

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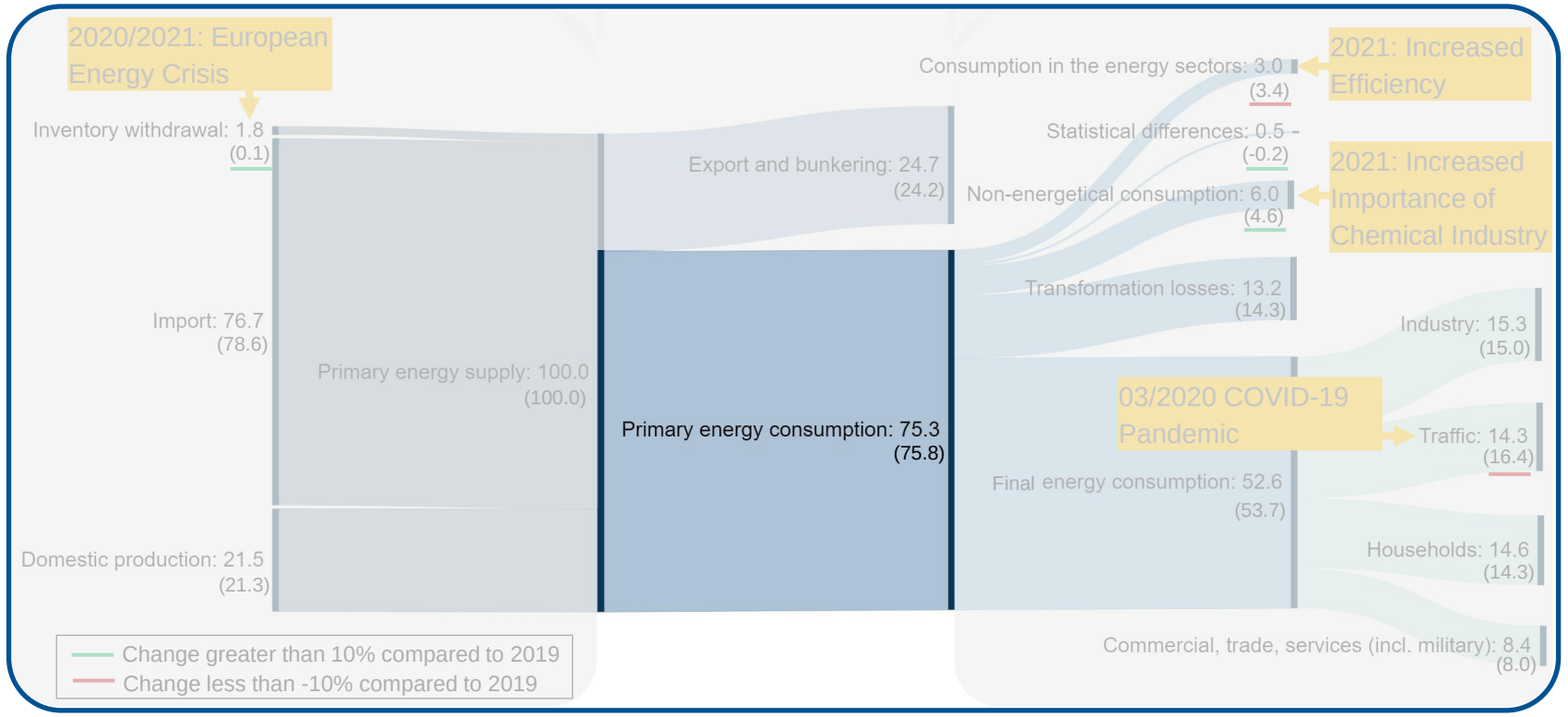

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Development of the consumption and composition

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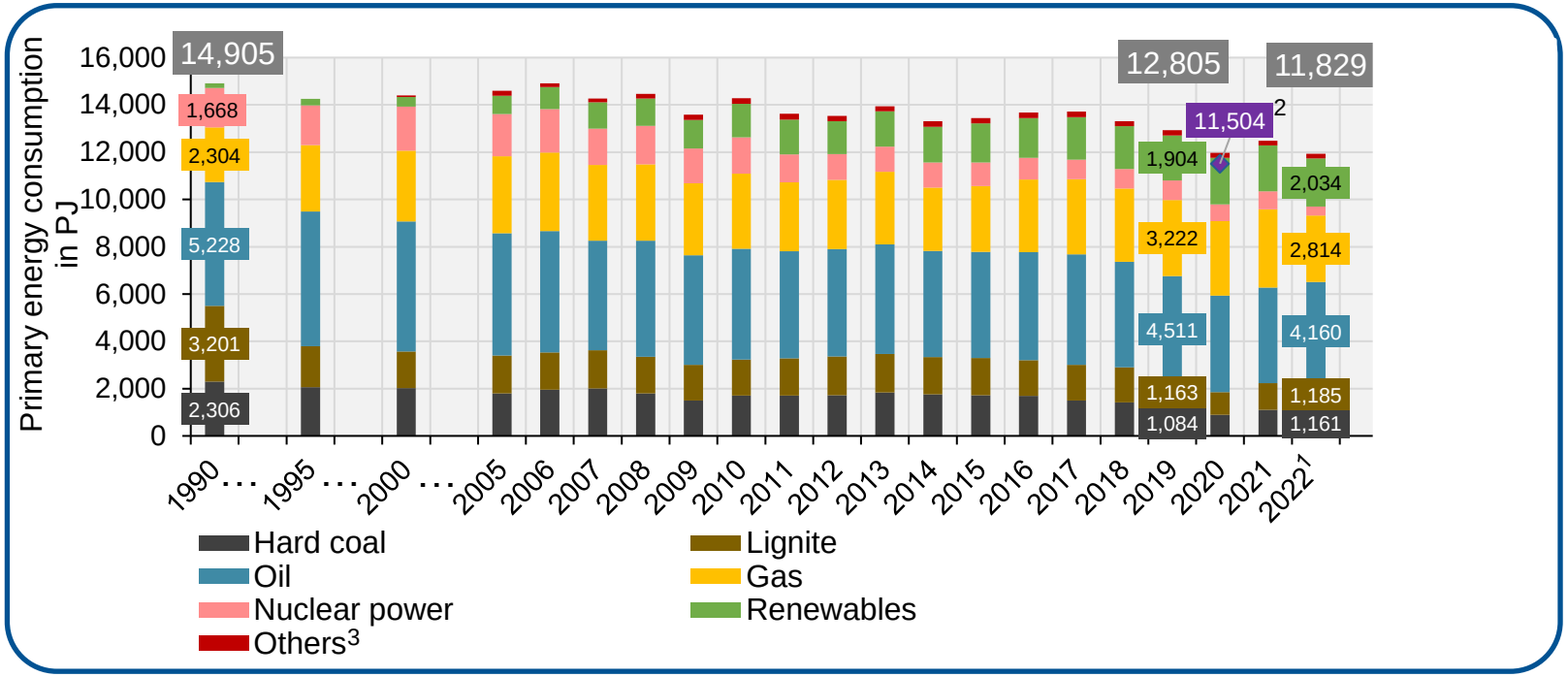

Own representation based on AGEB (2022a), AGEB (2022b) and BMWK (2019)
[1] Preliminary
[2] Federal goverment's energy efficiency target
[3] Mine gas, non-renewable waste and heat as well as electricity external trade balance

- The corona pandemic caused a special effect on PEC in 2020. (Agora, 2020)
- The federal government has set itself the goal of reducing primary energy consumption by 20% by 2020 and by 50% by 2050 compared to 2008 levels. In 2020, the 20 percent target was missed by 2.7 percent. (BMWK, 2019)
- PEC falls to lowest level since 1990s (14,905 PJ) in 2022 (11,829 PJ). Some of the reasons are changes in consumer behavior, energy efficiency investments and production cuts in individual economic sectors. (AGEB, 2022c)

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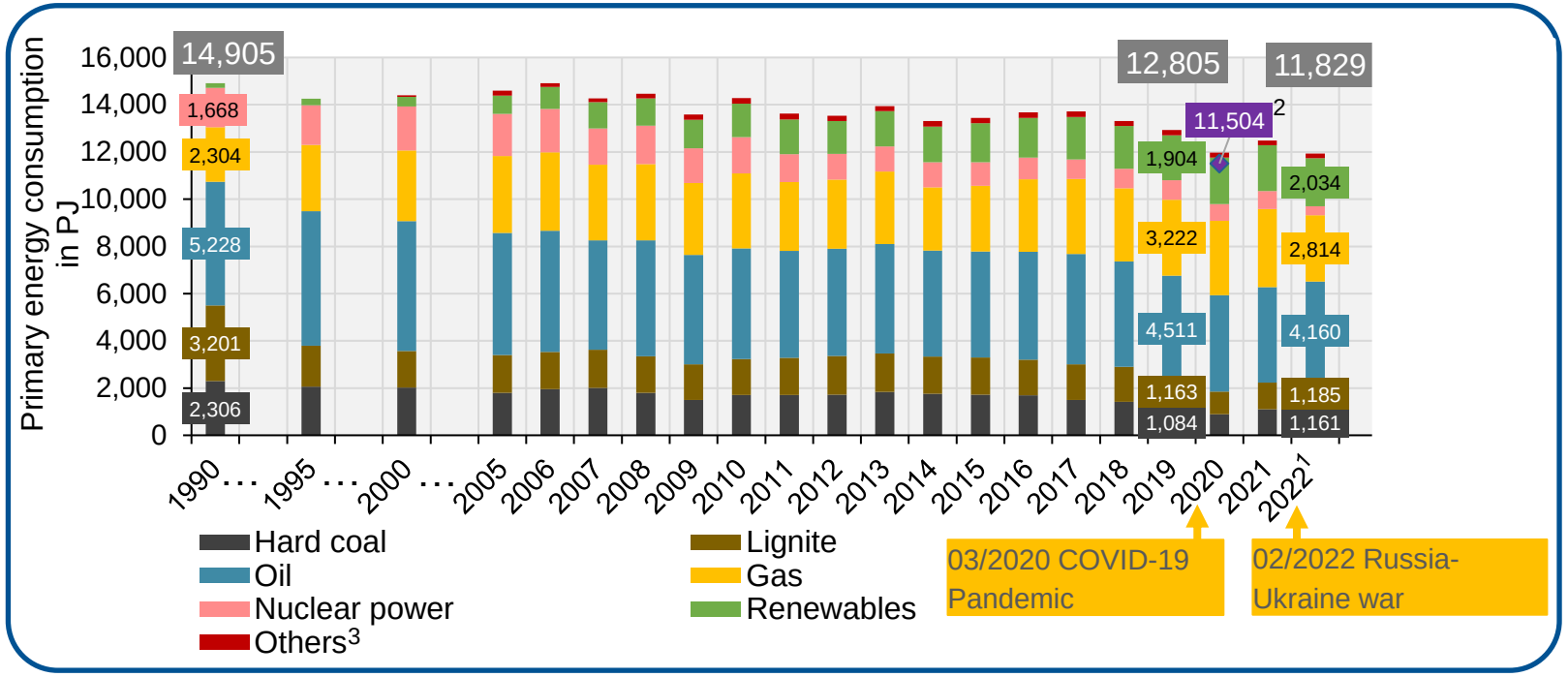

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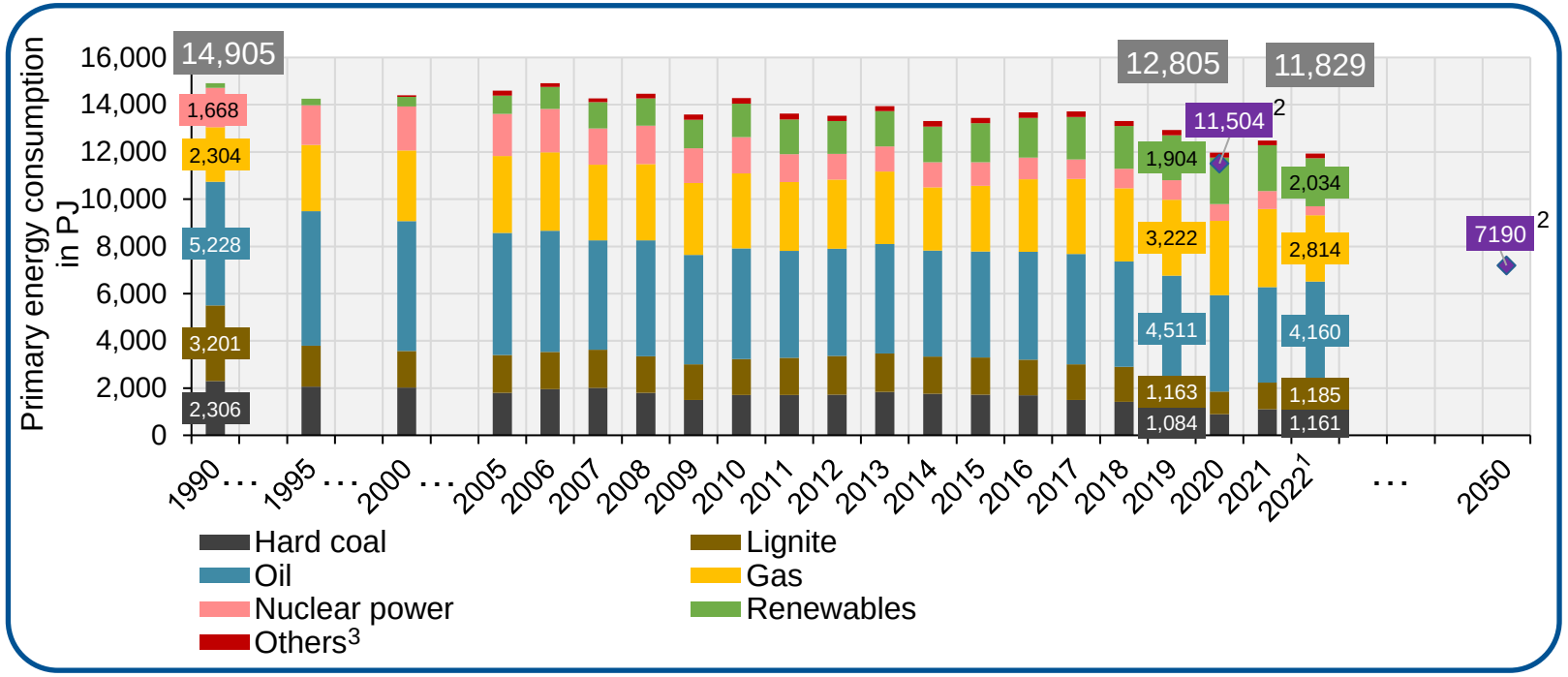

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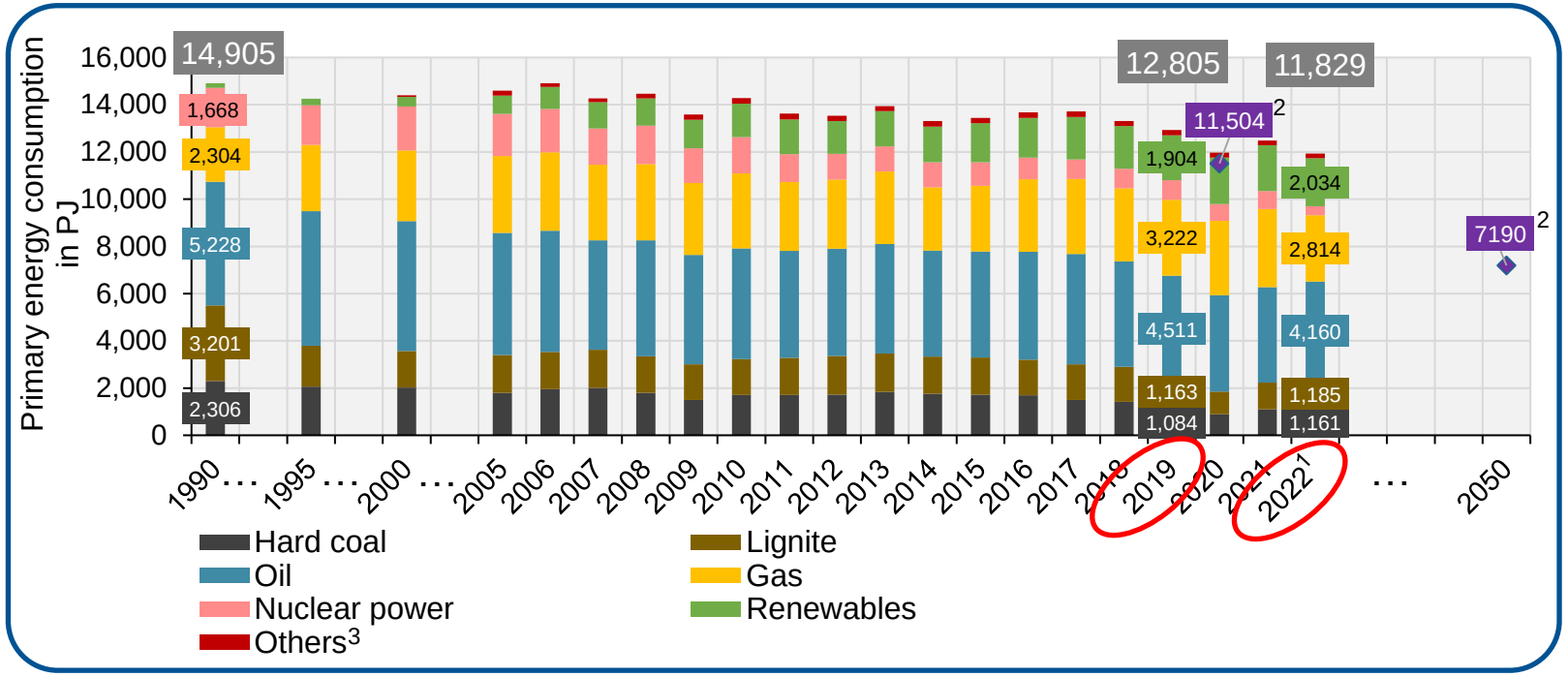

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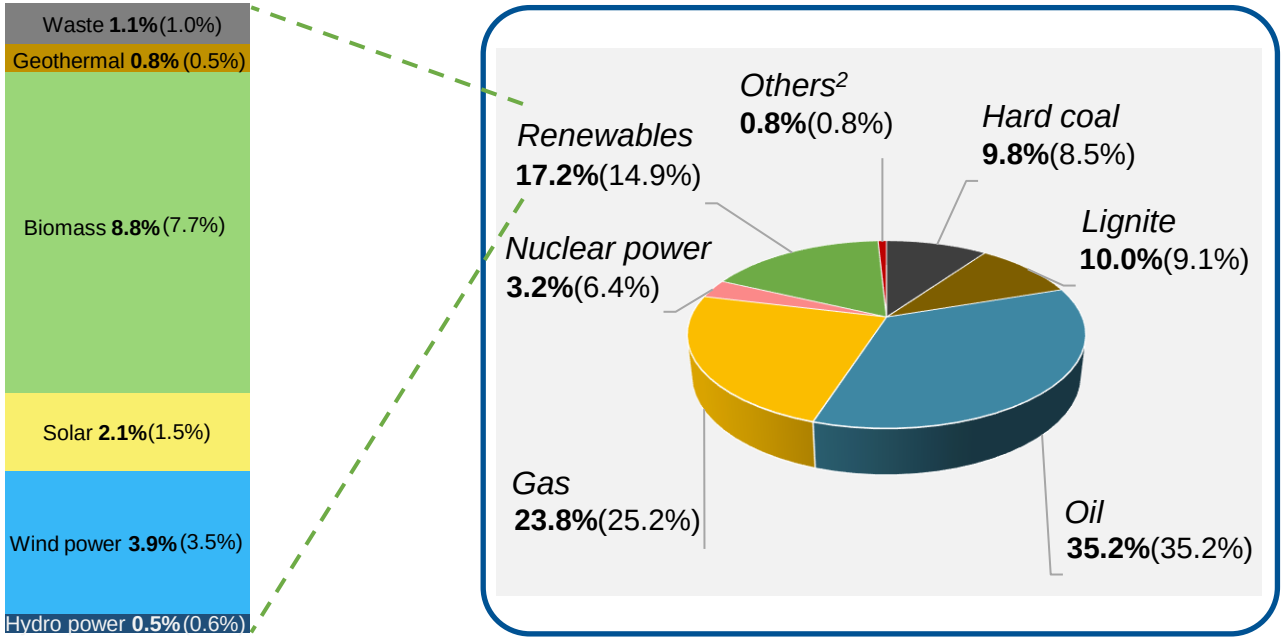
Development of the consumption and composition

Primary energy consumption by energy source, 2022[1] (2019);
In %



- The shares of the various energy sources in the German energy mix have shifted in 2022 compared to 2019. (AGEB, 2022a/b/d)
- Halving the share of nuclear energy is offset by increases in renewables, hard coal and lignite. Natural gas recorded a decrease. (AGEB, 2022a/b/d)
- In 2022, 17.2% of the PEC was provided by renewable energies. This corresponds to 2,034 PJ and an increase of 7% compared to 2019. (AGEB, 2022a/b/d)

Own representation based on AGEB (2022b) and AGEB (2022d), based on unit PJ
Primary energy consumption: 11,829.4 PJ (12,804.5 PJ); Deviations in the totals are due to rounding
[1] Preliminary, own calculations
[2] Incl. electricity external trade balance

The primary energy consumption in Germany

Structure of energy consumption by sector

Energy flow chart, 2021 (2019);
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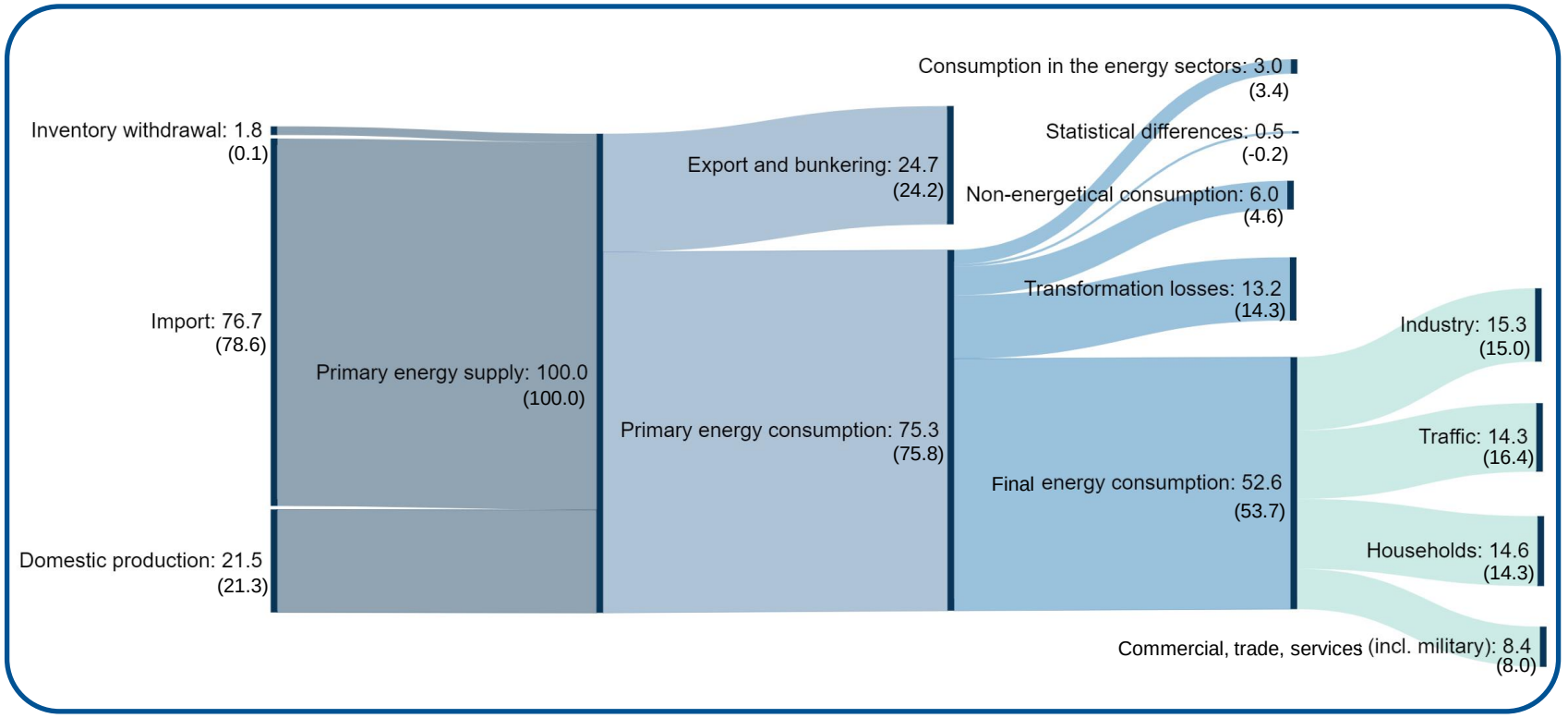

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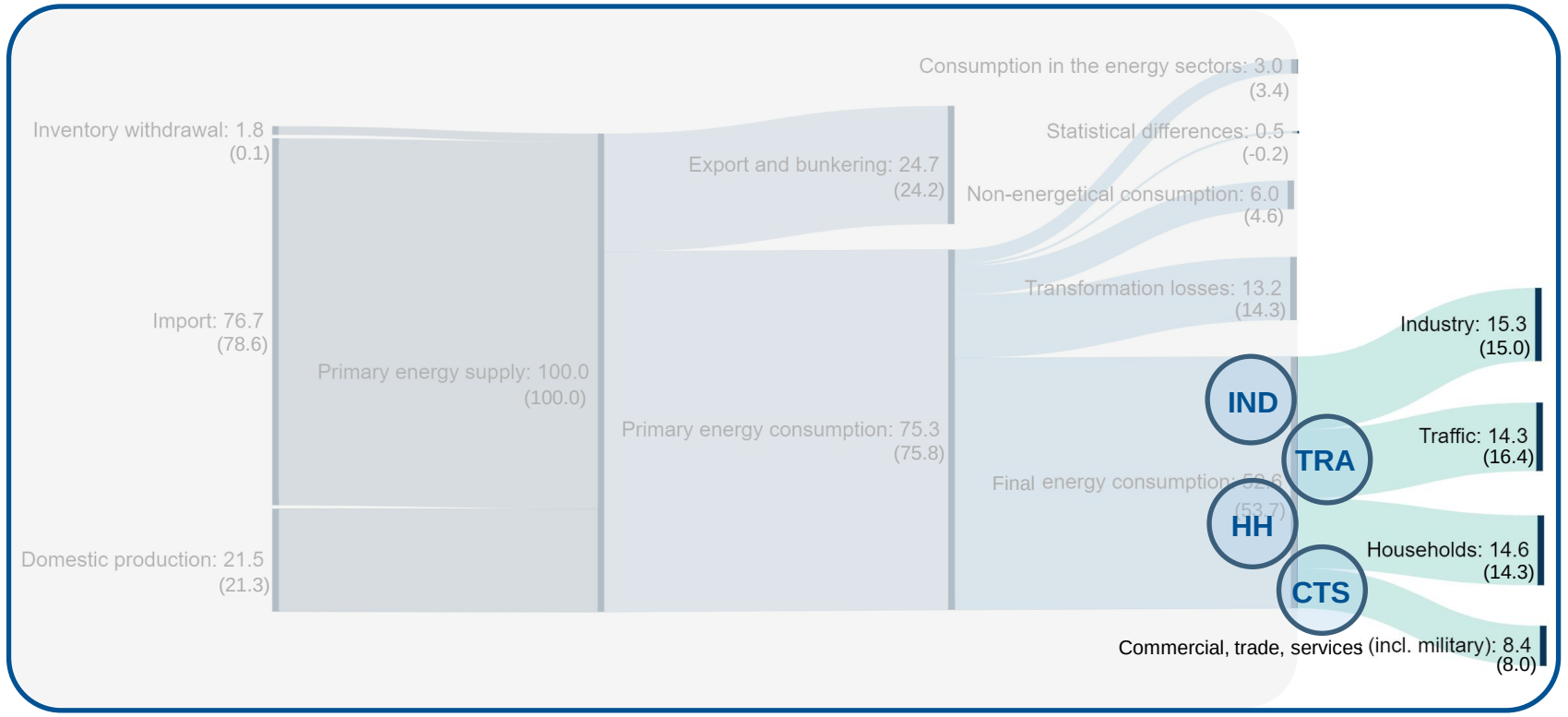

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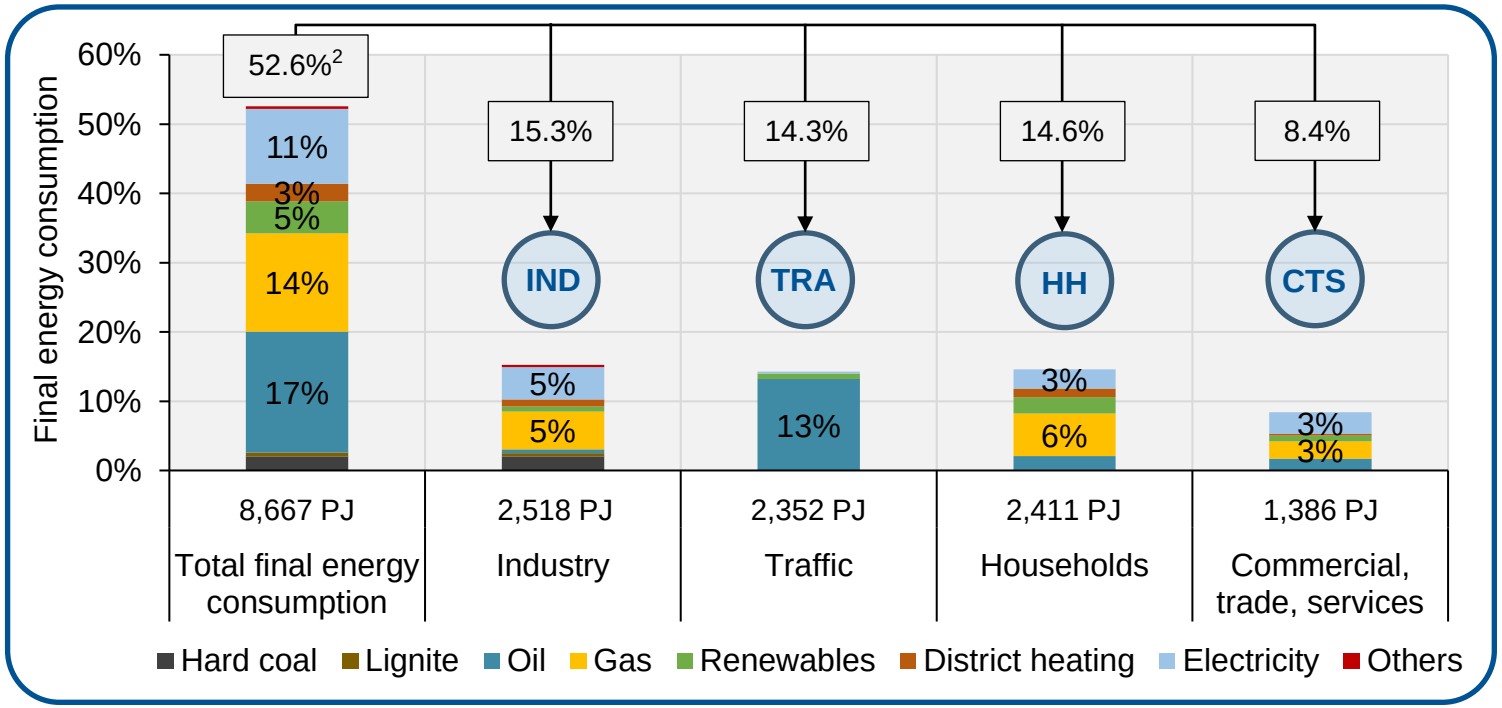

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Germany, 2021

- Industry (IND):
  - 5% of the primary energy supply is allocated by industrial needs in form of gas, 5% in form of electricity.
  - Hard coal is only used in the IND sector.
- Traffic (TRA):
  - Mineral oils in TRA allocate 13 % of the primary energy supply.
  - Share of renewable energies is 1%.
- Households (HH):
  - 15% of the primary energy supply covers the HH energy demand, 6 % in form of gas, 2% oil, 3% electricity and 1% district heating consumption.
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- Commercial, trade, services (CTS):
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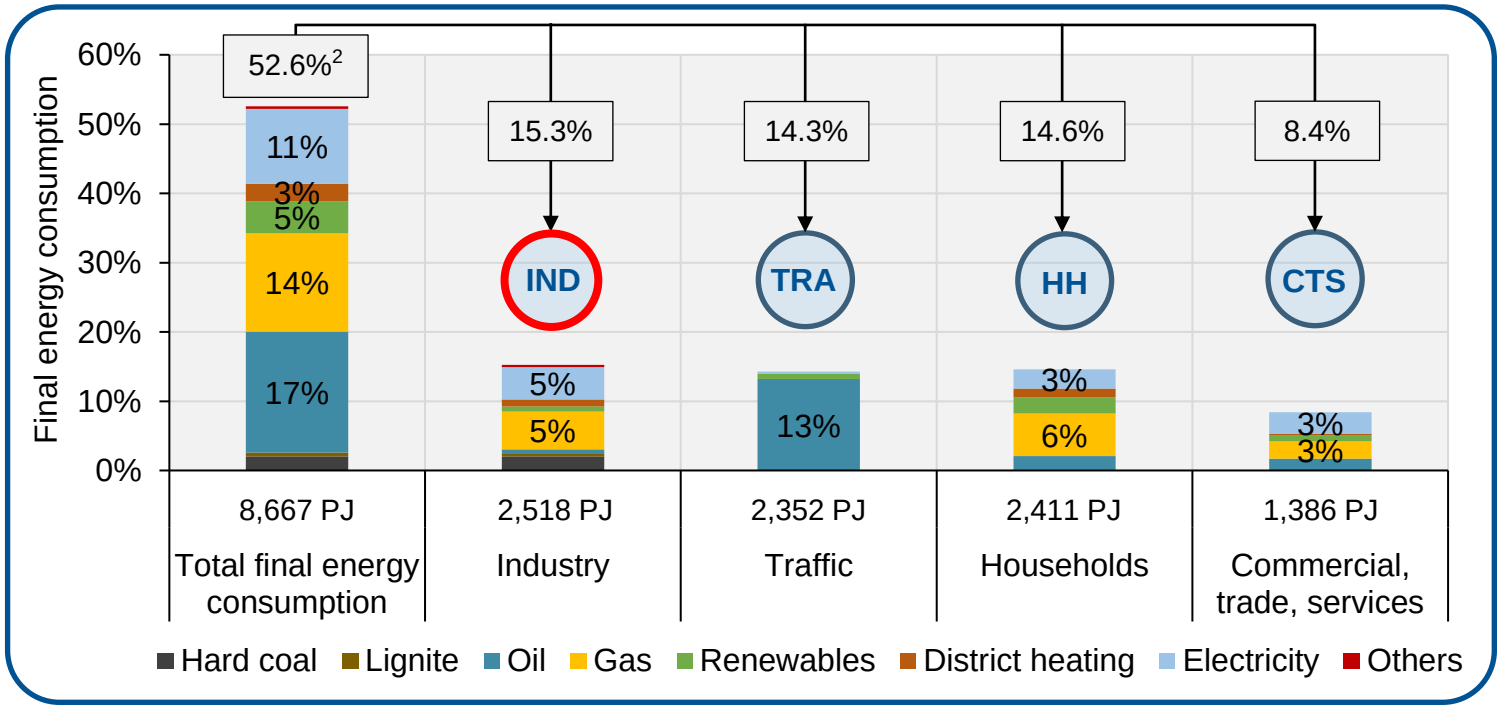

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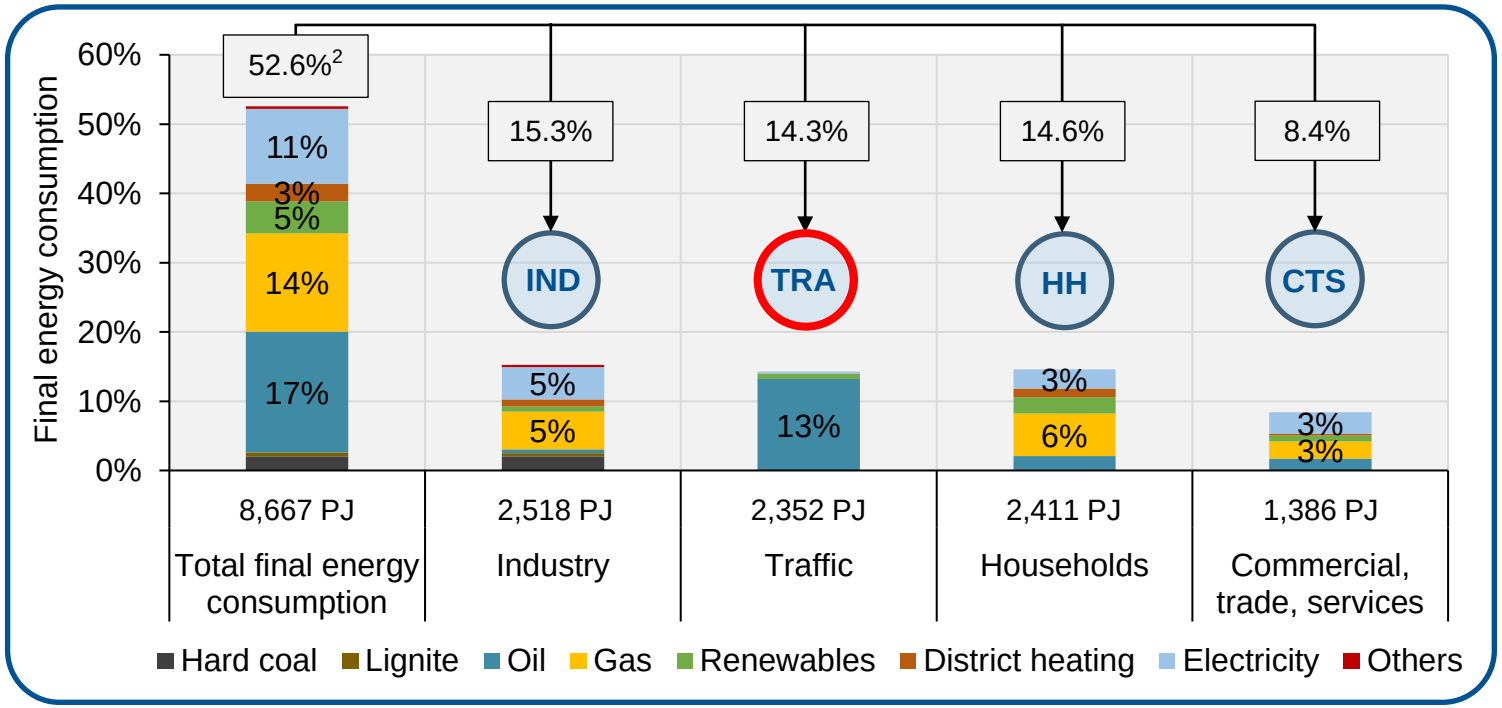

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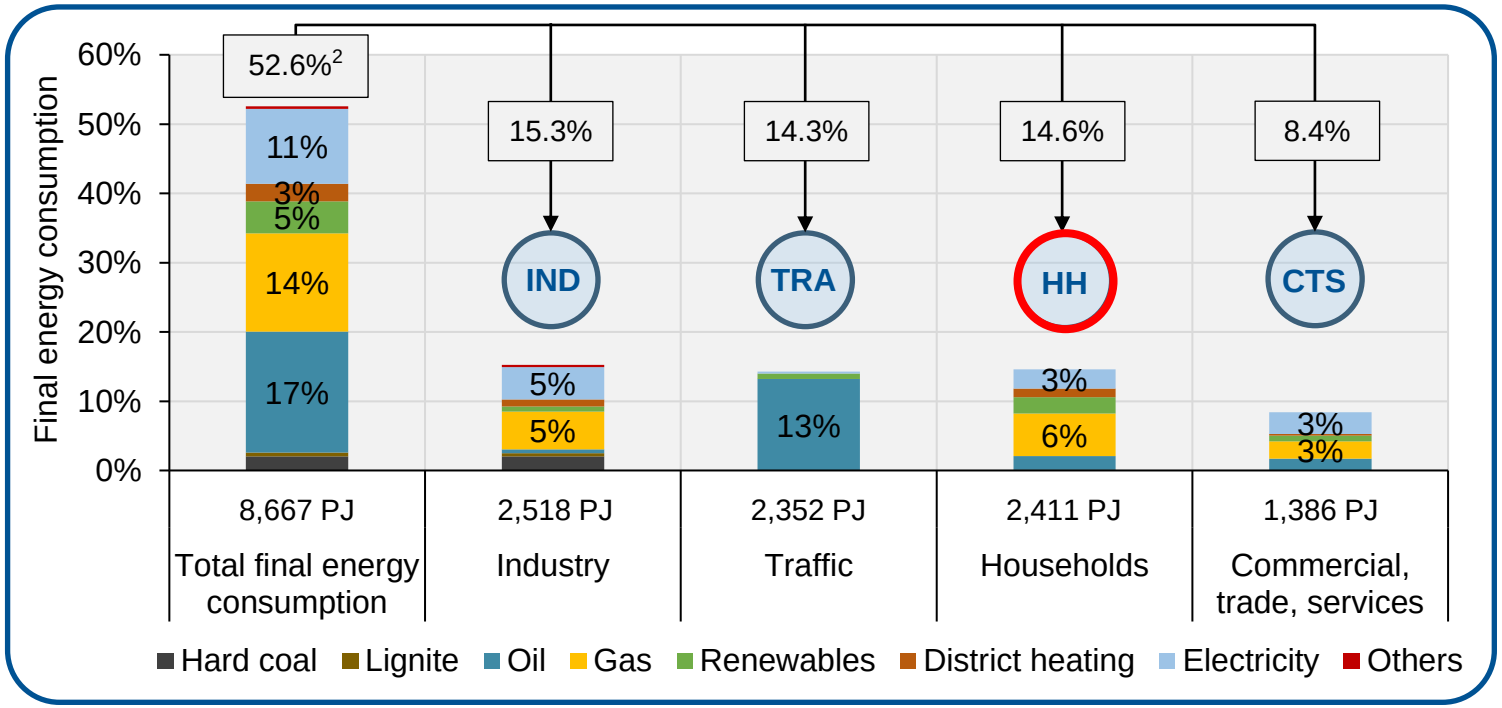

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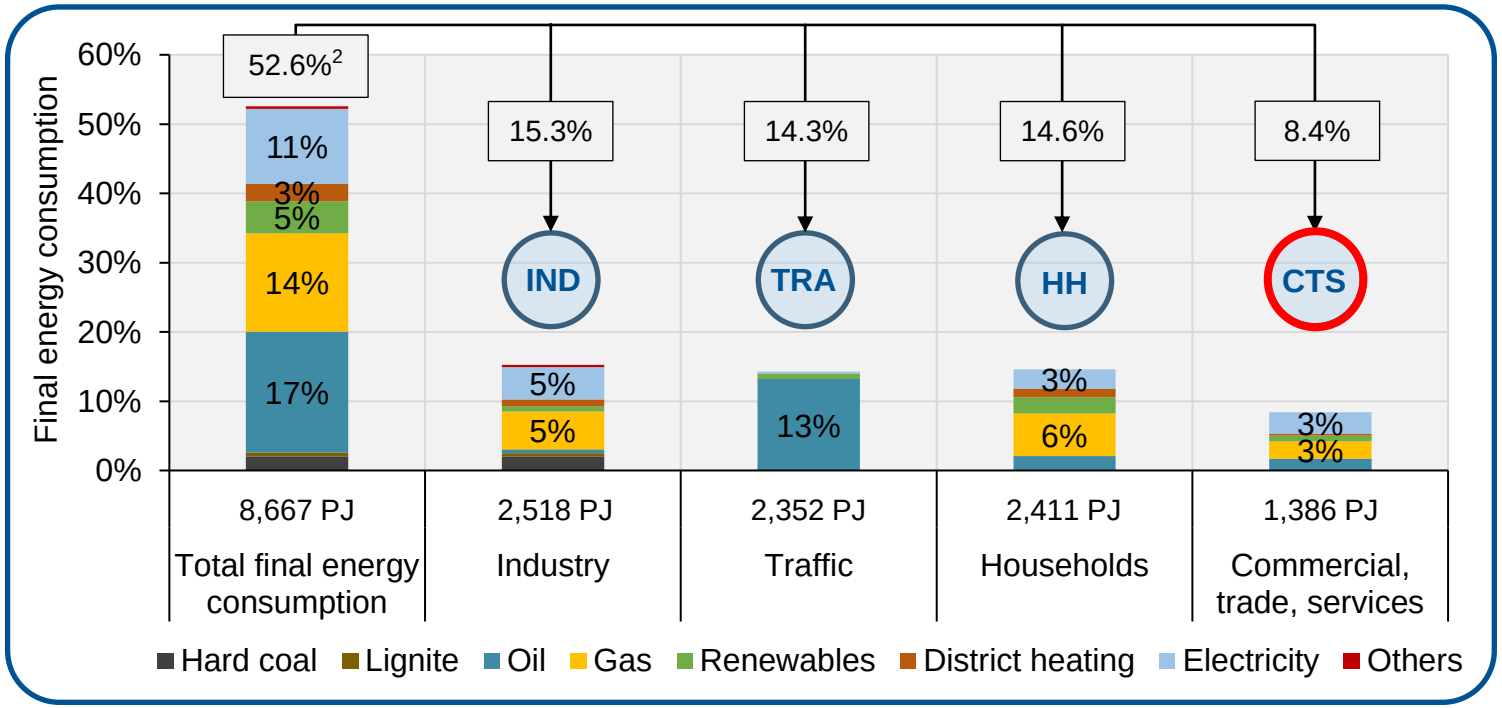

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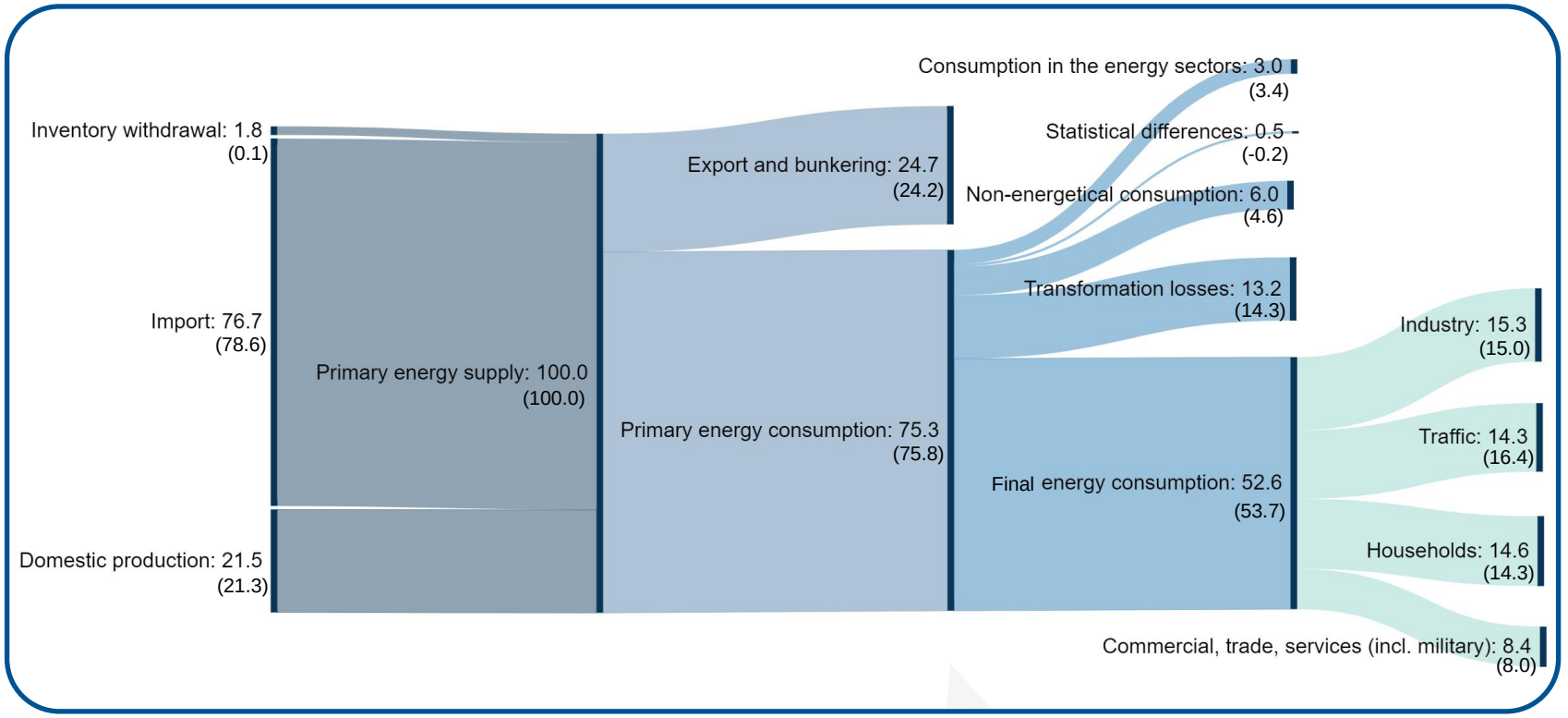

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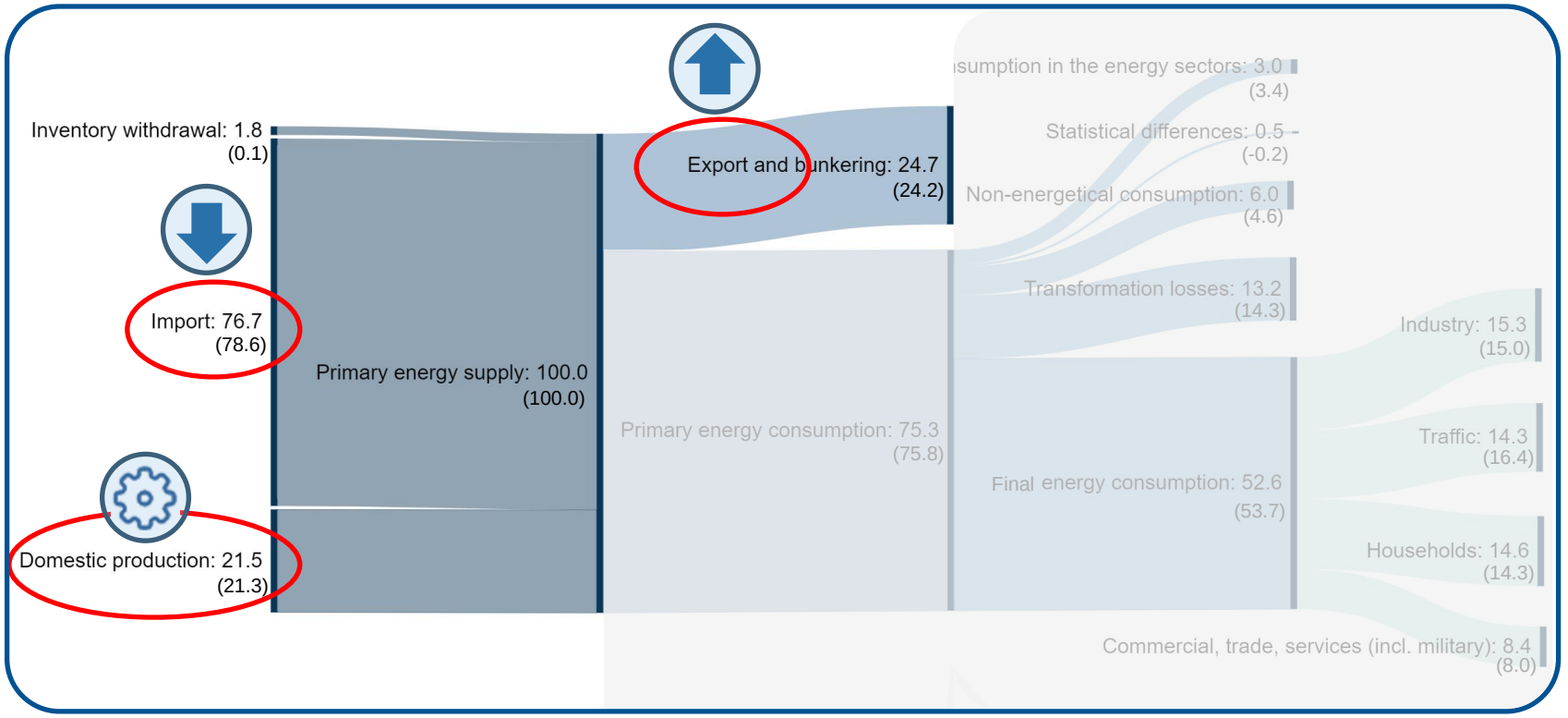

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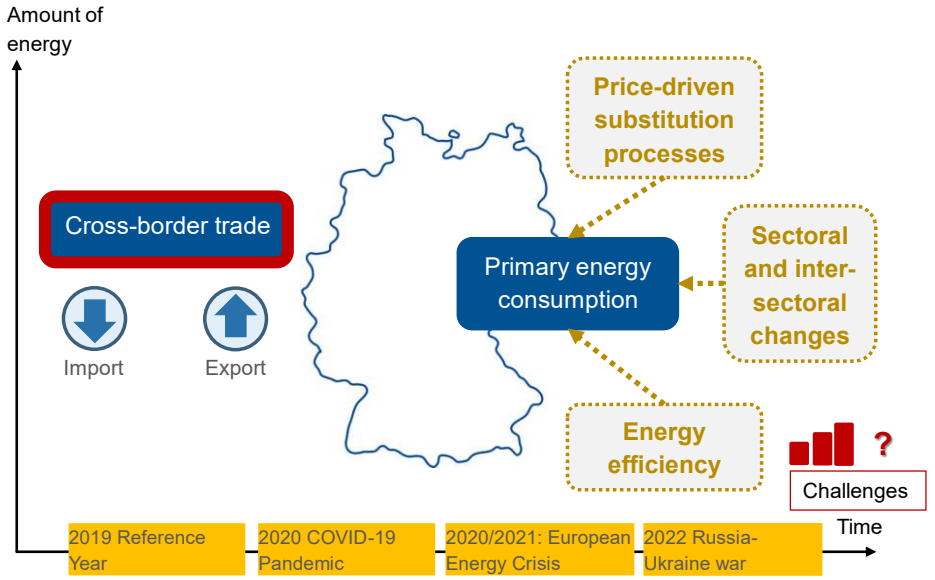
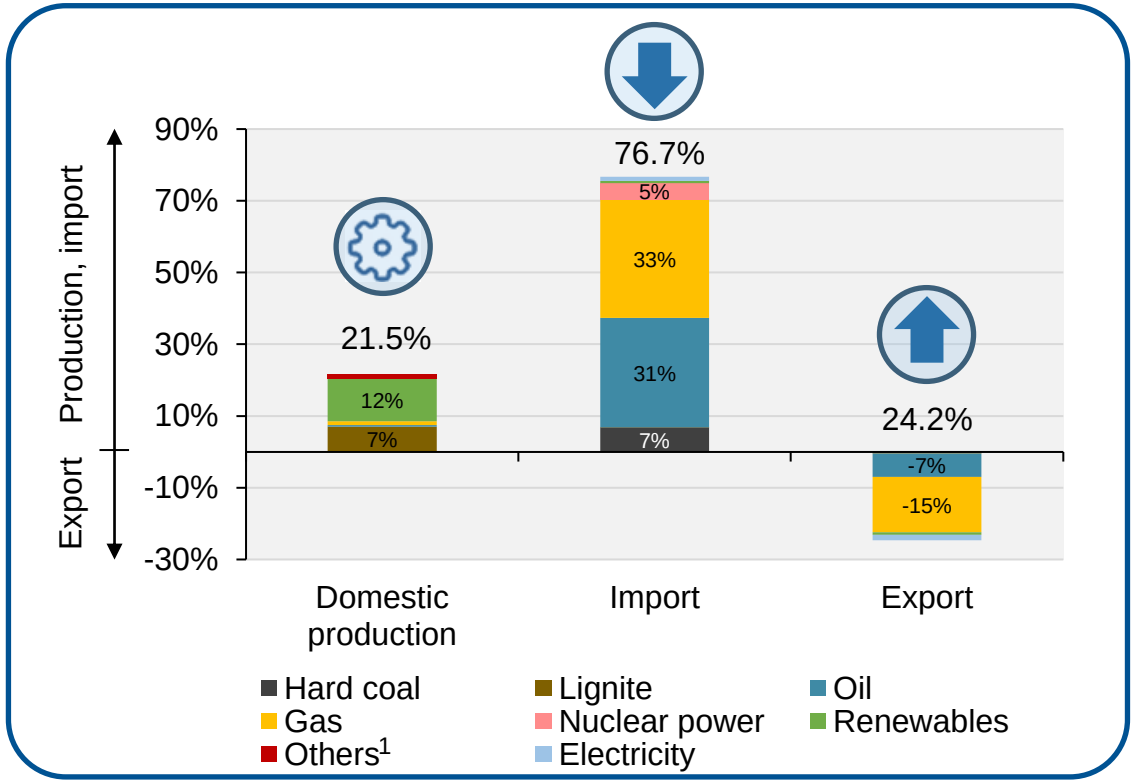


Primary energy production, cross-border trade

Overview

Domestic production and cross-border trade, 2021;
In %



Own representation based on AGEB (2022a), based on unit PJ
Primary energy supply: 16,492 PJ; 1 Mio. T SKE ≙ 29,308 PJ; Deviations in the totals are due to rounding
[1] Non-renewable waste, waste heat

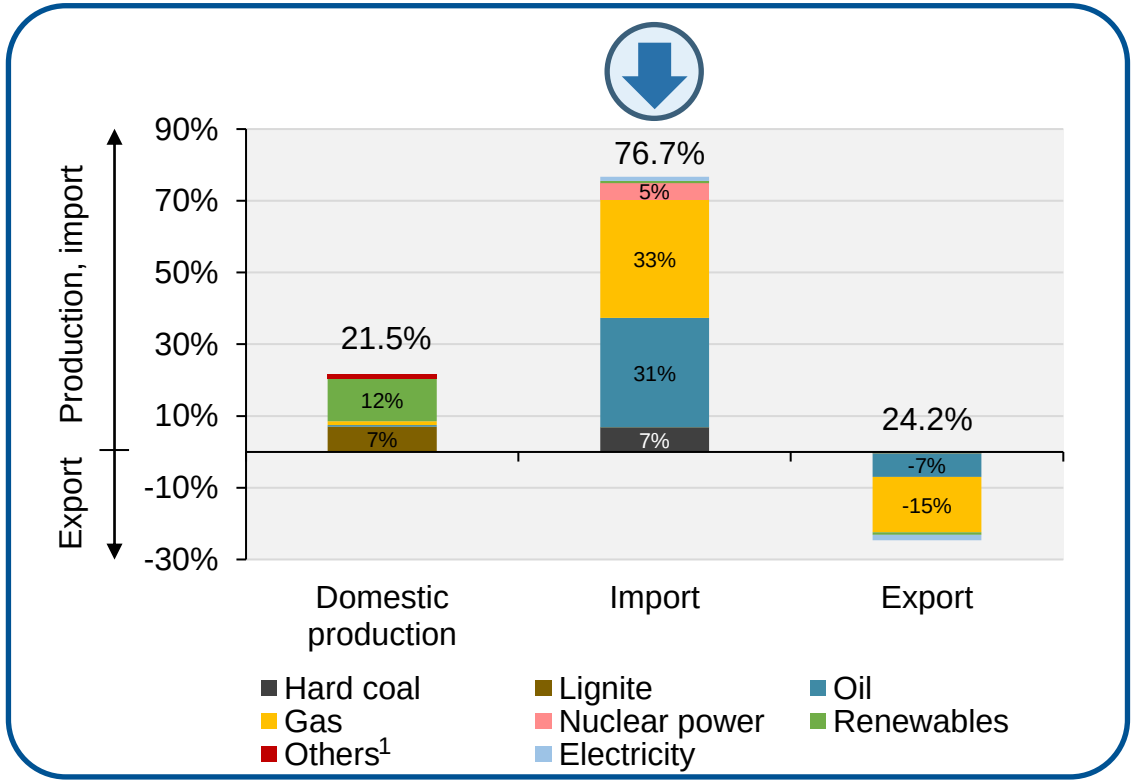
Germany, 2021:

- Domestic production:
  - Lignite and renewable energies are fully produced domestically (AGEB, 2022a)
- Import:
  - 33% of the domestic energy supply was imported as natural gas. (AGEB, 2022a)
  - 31% of the domestic energy supply was imported in form of mineral oil. (AGEB, 2022a)
  - Hard coal and uranium consumed domestically were fully imported. (AGEB, 2022a)

Primary energy production, cross-border trade

Overview

Domestic production and cross-border trade, 2021;
In %



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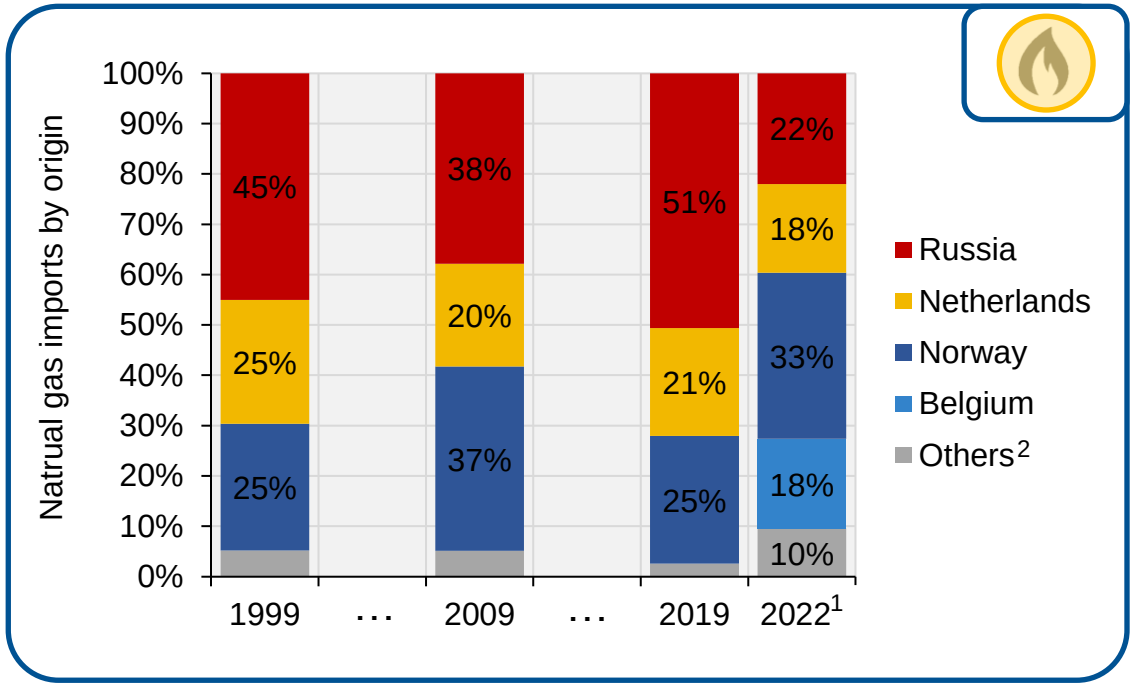
Primary energy production, cross-border trade

Where does our primary energy come from?

DE-Natural gas imports by origin, 2022[1] (2019);
In %



Own representation based on BAFA (2022), BNetzA (2023)
Deviations in the totals are due to rounding
[1] Preliminary
[2] incl. Denmark, France, Czech Republic and other countries

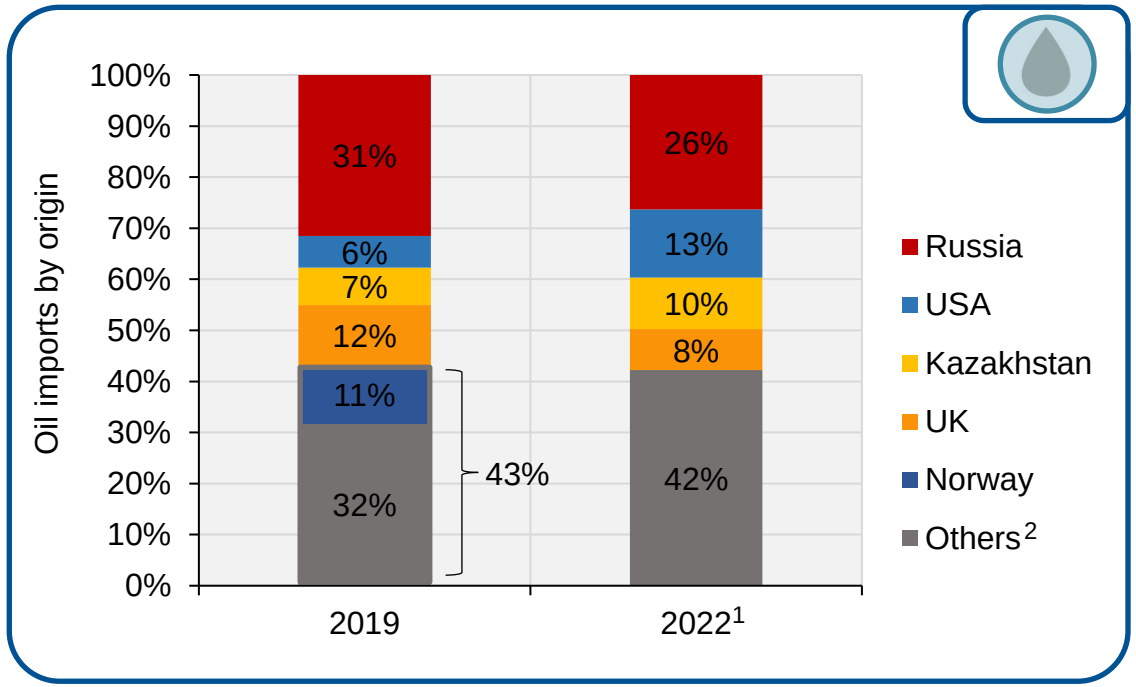
- Since 1999, 38%-51% of natural gas imported into Germany has come from Russia. (BAFA, 2022; BNetzA, 2023)
- While more than a half (51%) of the imported natural gas came from Russia in 2019, Russian natural gas deliveries decreased significantly in 2022 and were completely stopped in September 2022 (due to the Nord Stream pipeline blast). (BAFA, 2022; BNetzA, 2023)
- The lack of gas deliveries from Russia was partly compensated by additional imports from Norway as well as from other countries. (BAFA, 2022; BNetzA, 2023)

→ BMWK, 2022: the aim is to achieve extensive independence from Russian natural gas by mid-2024.

Primary energy production, cross-border trade

Where does our primary energy come from?

DE-Oil imports by origin, 2022[1] (2019);
In %



Own representation based on BAFA (2020) and BAFA (2023)
Deviations in the totals are due to rounding
[1] Preliminary
[2] In 2022 Norway was listed among the “Others”

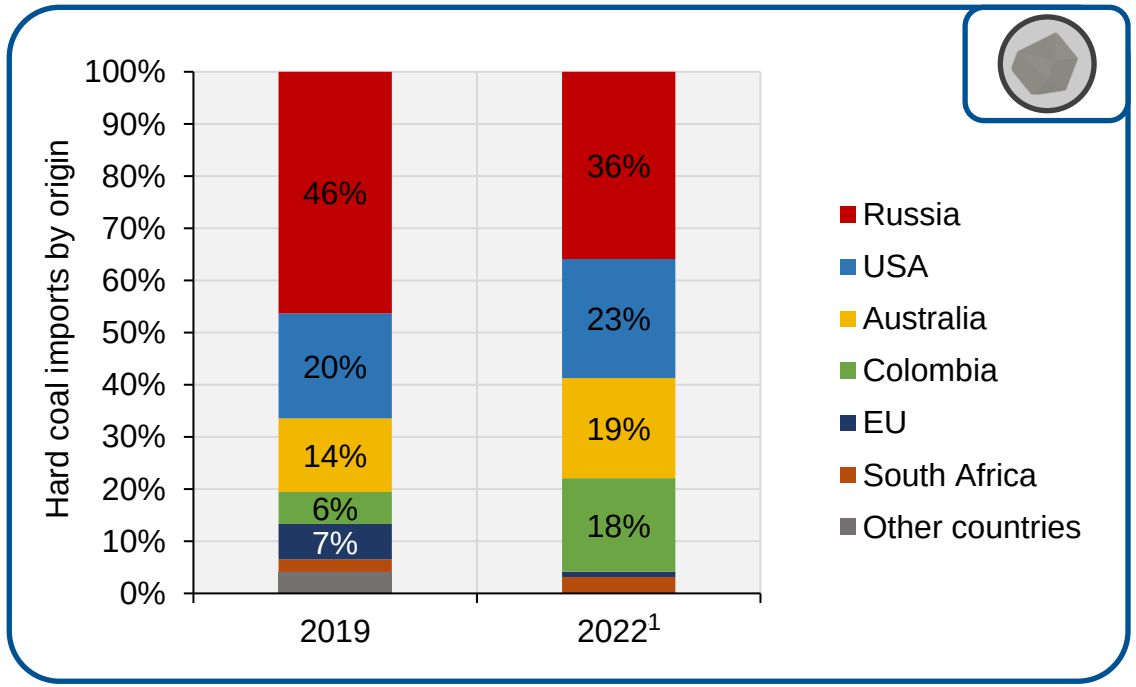
- The 5 most important of a total of 29 supplier countries in 2019 were: (BAFA, 2020)
  - the Russian Federation (27.1 million t)
  - Great Britain (10.2 million t),
  - Norway (9.7 million t),
  - Libya (8.3 million t) and
  - Kazakhstan (6.3 million t).
- The 4 most important of a total of 30 supplier countries were in 2022: (BAFA, 2023)
  - the Russian Federation (21.2 million t),
  - United States (10.8 million tons),
  - Kazakhstan (8.2 million t) and
  - Great Britain (6.5 million t).

→ BMWK, 2022: the import of Russian oil is to be stopped by the end of 2022 at the latest.

Primary energy production, cross-border trade

Where does our primary energy come from?

DE-Hard coal imports by origin, 2022[1] (2019);
In %



- The 5 most important supplier countries of hard coal for Germany in 2019 were:
  - Russia (15.8 million t),
  - USA (6.9 million t),
  - Australia (4.8 million t),
  - EU (2.3 million t) and
  - Colombia (2.1 million t).
- The 4 most important supplier countries of hard coal for Germany in 2022 were: (Destatis, 2023a)
  - Russia (11.5 million t),
  - USA (7.4 million t),
  - Australia (6.2 million t) and
  - Colombia (5.8 million t).

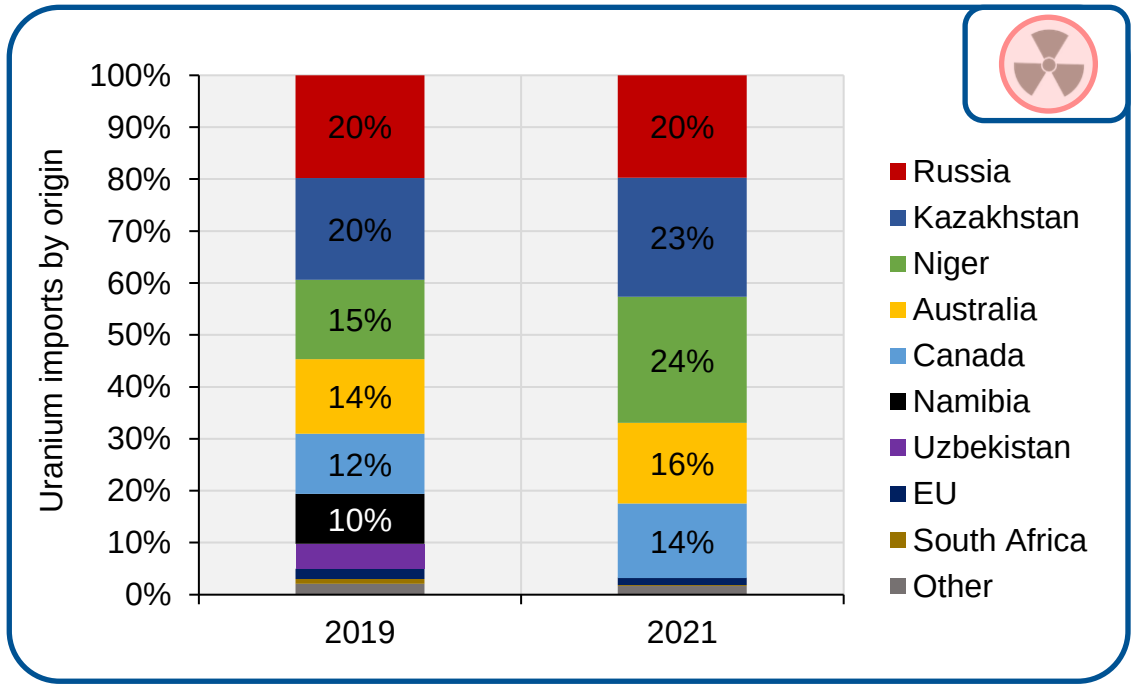
→ BMWK, 2022: the import of Russian hard coal was banned throughout the EU from August 2022.

Own representation based on Destatis (2023a) and VDKi (2022)
Deviations in the totals are due to rounding
[1] Preliminary: Data unknown or kept secret (UK, Canada, Other third countries); own calculations (South Africa)

Primary energy production, cross-border trade

Where does our primary energy come from?

EU-Uranium imports by origin, 2021 (2019);
In %



Own representation based on Euroatom (2020a) and Euroatom (2021a),
No published reports for Germany
Deviations in the totals are due to rounding

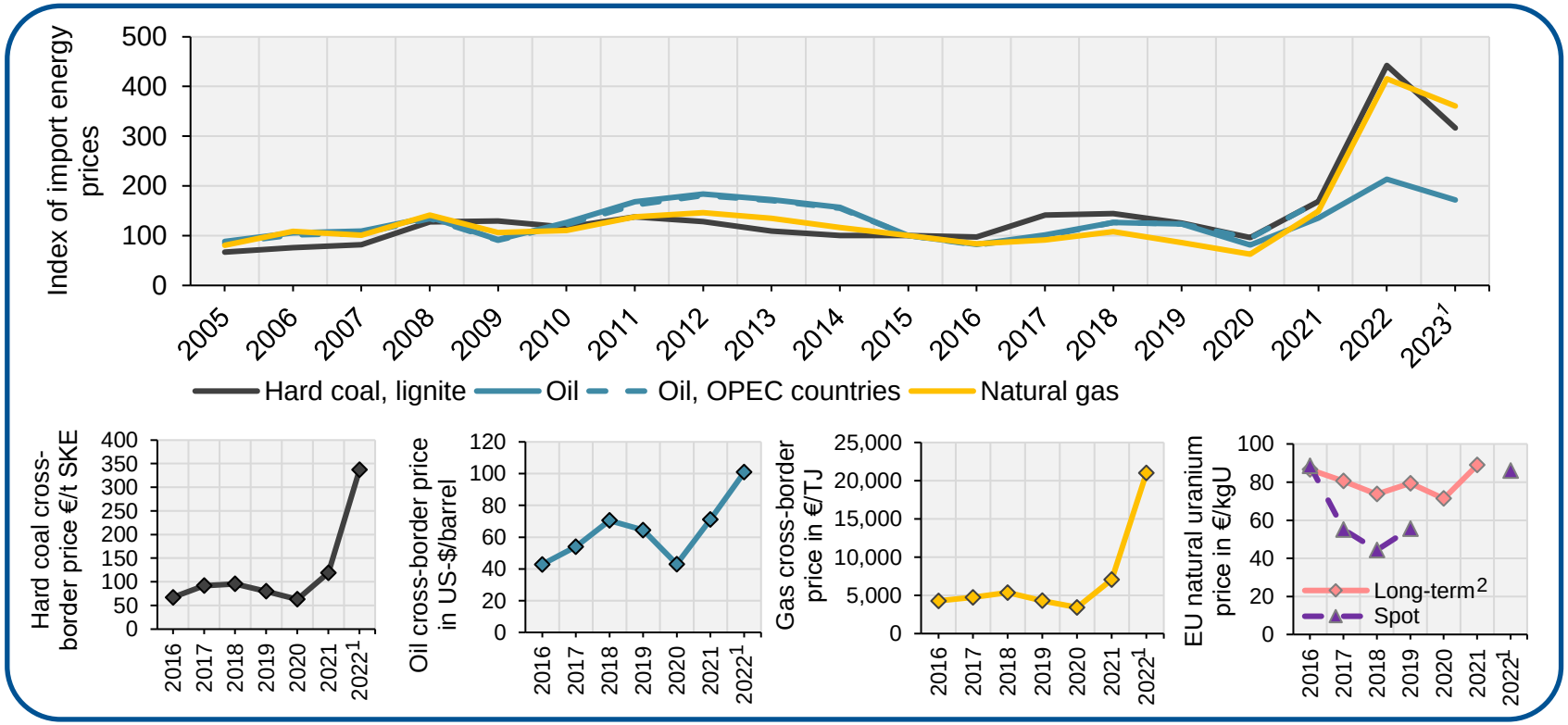
- The 6 most important supplier countries of uranium for EU in 2019 were: (Euroatom, 2020a)
  - Russia (2,543 tU),
  - Kazakhstan (2,518 tU),
  - Niger (1,962 tU),
  - Australia (1,851 tU)
  - Canada (1,485 tU) and
  - Namibia (1,234 tU).
- The 5 most important supplier countries of uranium for EU in 2021 were: (Euroatom, 2021a)
  - Niger (2,905 tU),
  - Kazakhstan (2,753 tU),
  - Russia (2,358 tU),
  - Australia (1,860 tU) and
  - Canada (1,714 tU).
- PreussenElektra[1]: German nuclear power plants mainly operated with uranium from Russia and Kazakhstan. (URANA Atlas, 2022)

[1]PreussenElektra GmbH, based in Hanover, is a 100 percent subsidiary of E.ON SE and operates all of E.ON SE's activities in the field of nuclear power

Primary energy production, cross-border trade

Cross-border prices

Yearly cross-border price development by commodity classification



- Price developments 2020-2022:
  - 2020: Slump in the global economy
  - 2020/2021: Recovery of the global economy and unexpectedly high energy requirements
  - 2022: Uncertainty and reduction in energy supply (especially gas market), forced filling of gas storage facilities, recourse to LNG at high prices

Own representation based on BAFA (2018), BAFA (2022), OECD (2021), VDKi (2023), Destatis (2022), Euroatom (2020b) and Euroatom (2021b), Euroatom (2022)

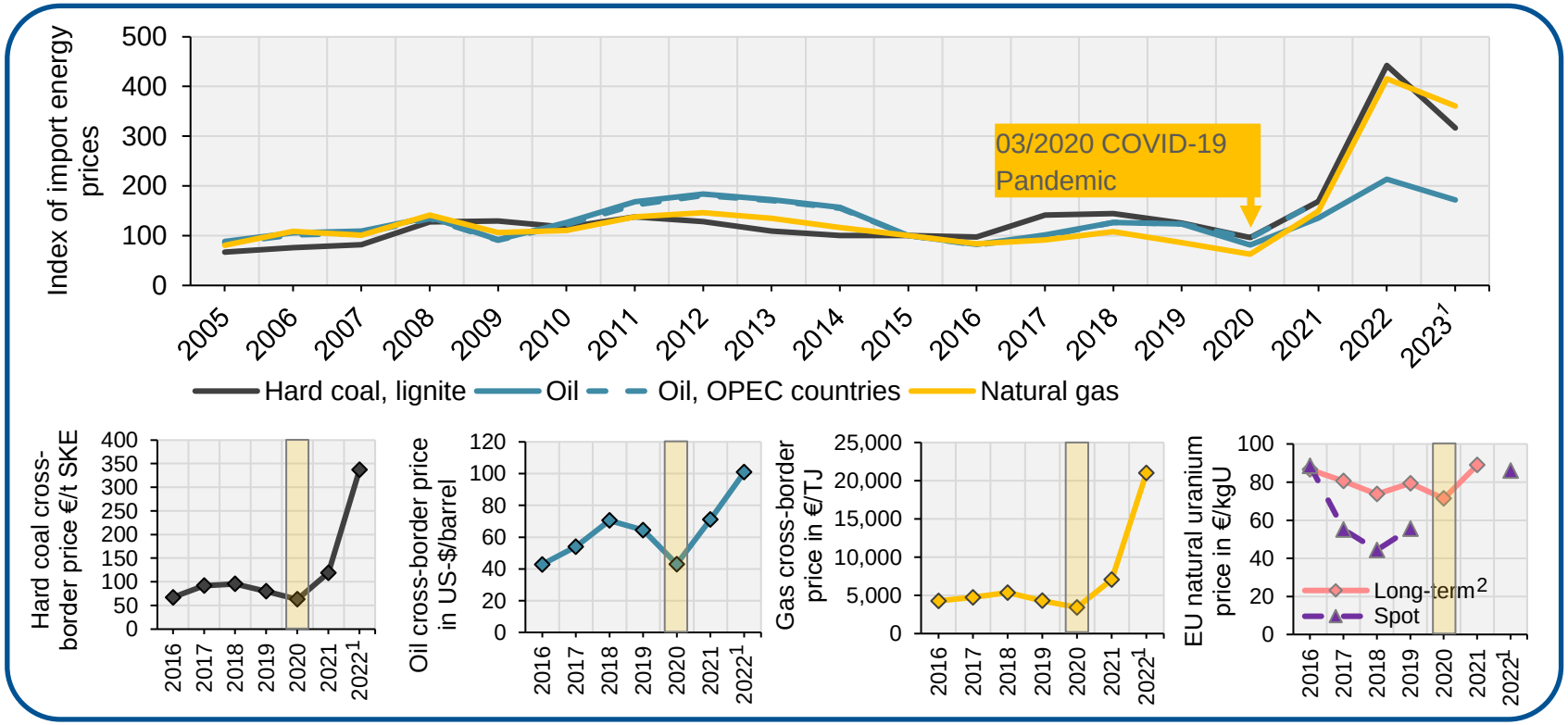
[1] Preliminary

[2] Multiannual contracts reflects the average long-term price paid by European utilities

Primary energy production, cross-border trade

Cross-border prices

Yearly cross-border price development by commodity classification



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Primary energy production, cross-border trade

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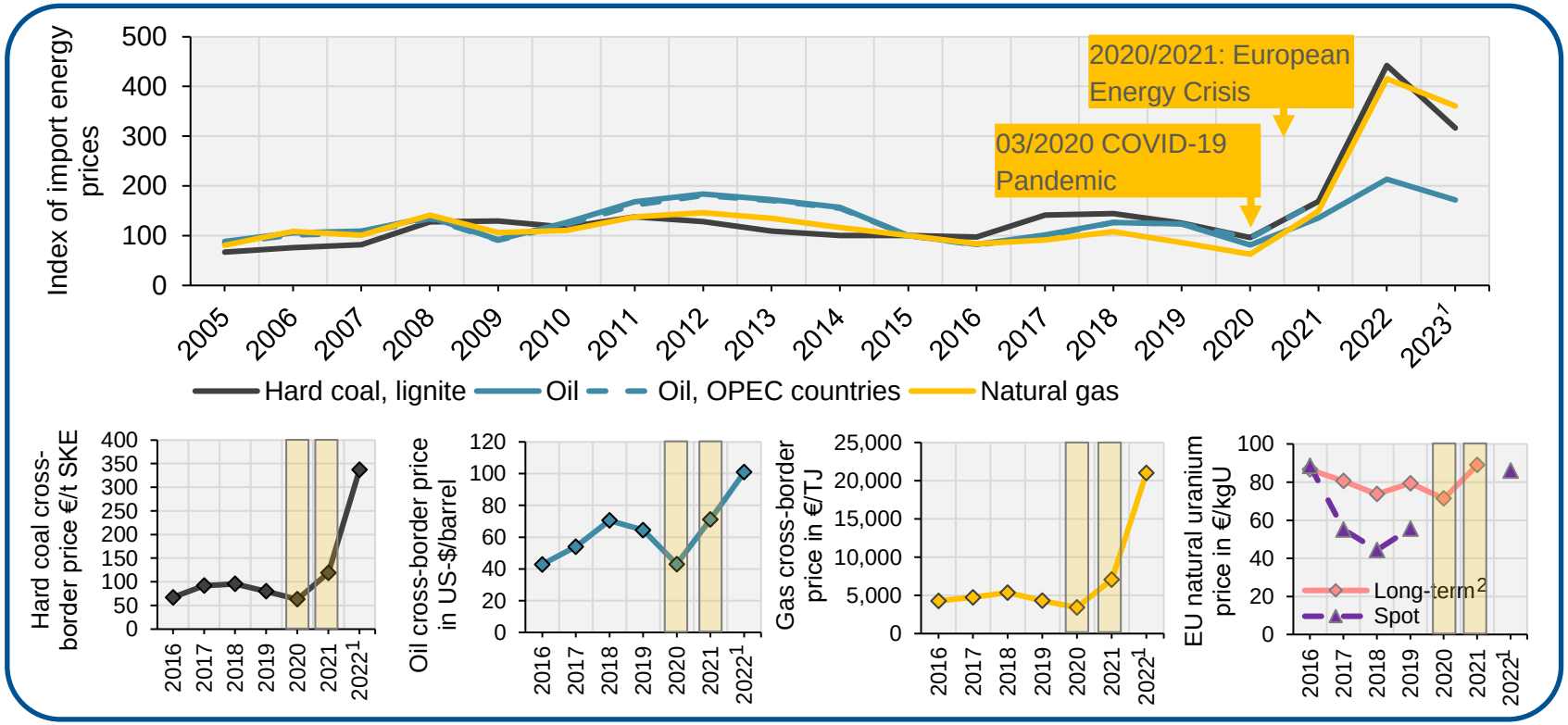

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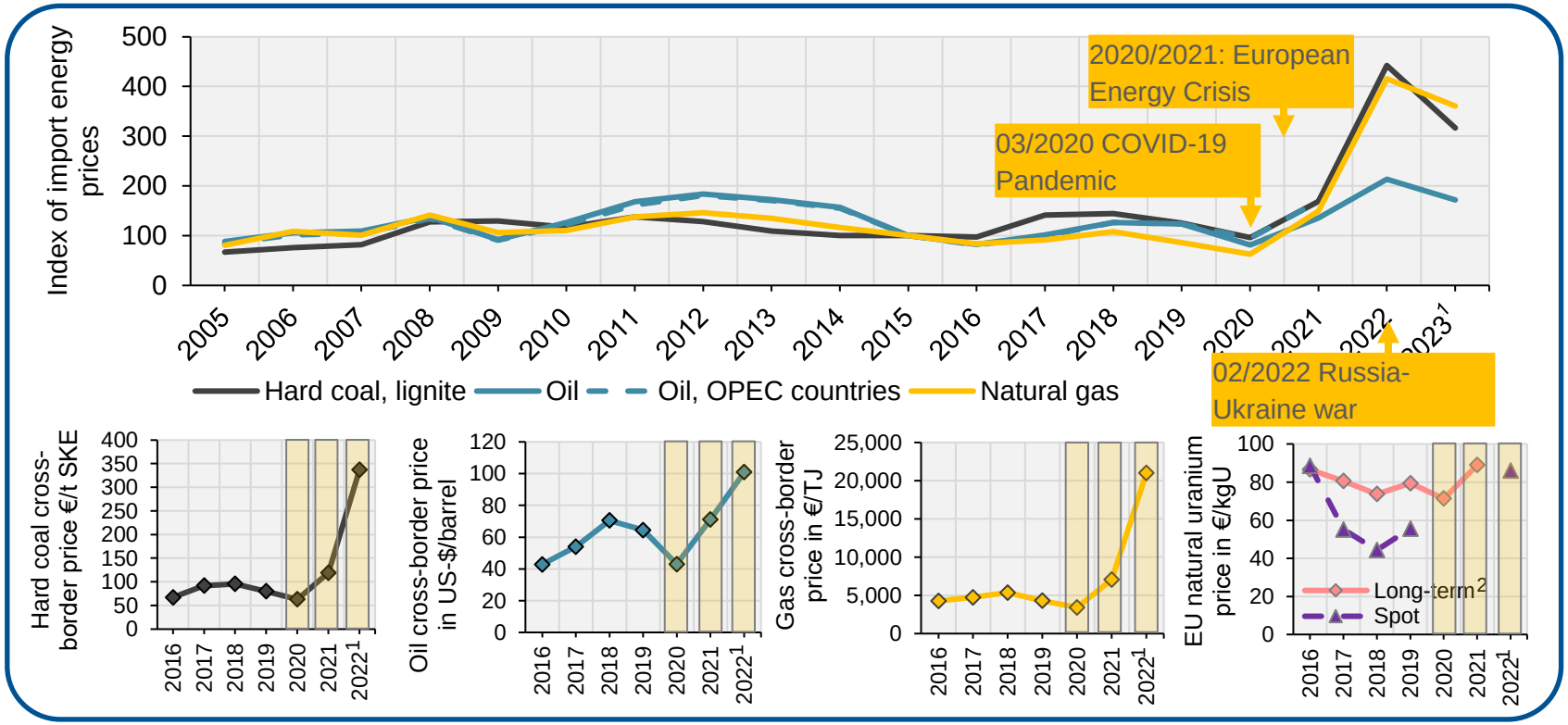

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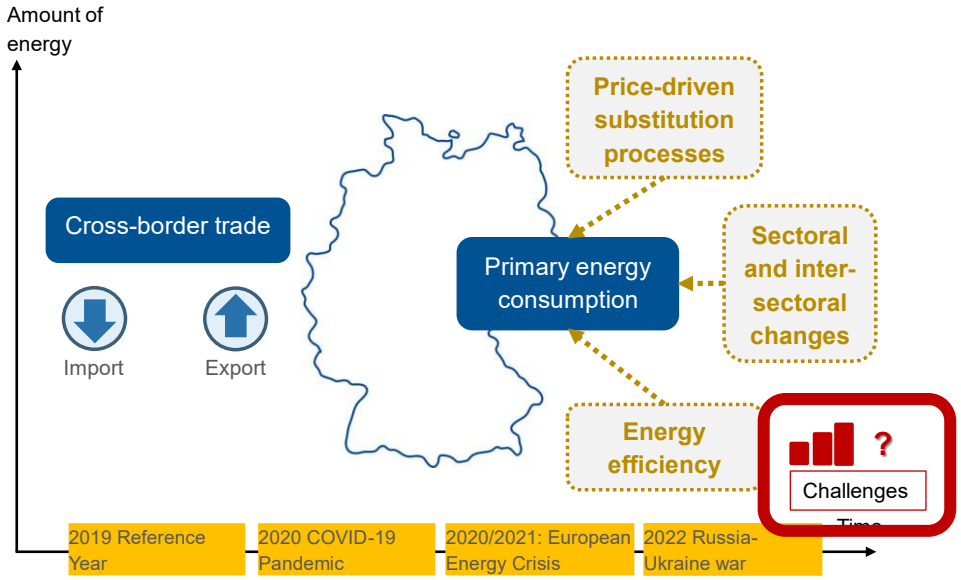
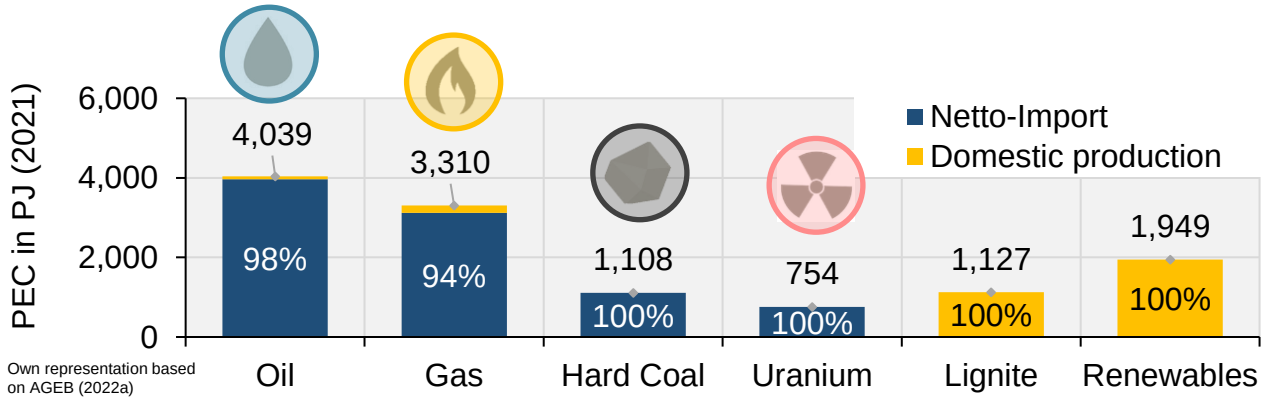
Content



Challenges in the field of German energy supply

Reduction of energy import dependence in order to avoid rising energy prices and thus economic upheavals

Cross-border trade



Own representation based on AGEB (2022a)

Total import dependency, 2021

Domestic

Content based on (BMWK, 2022)

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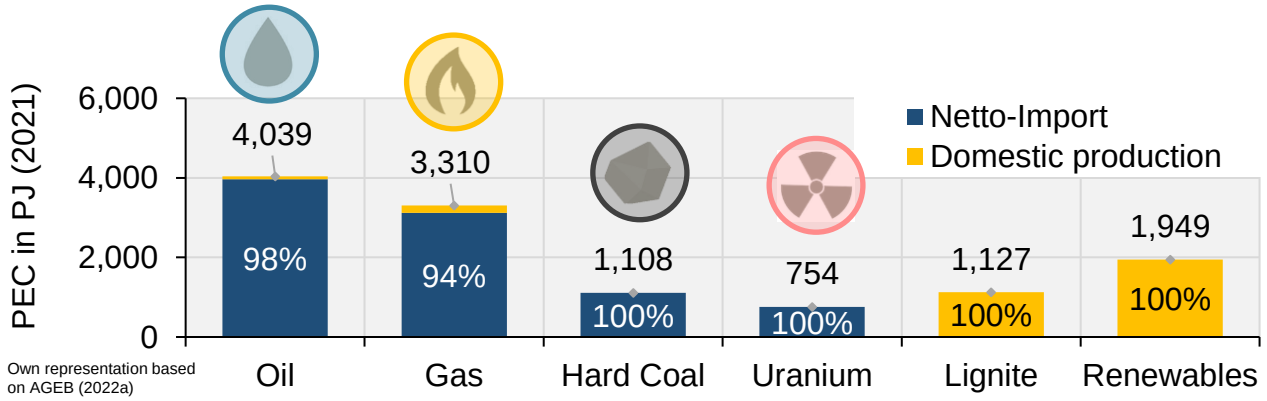

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Total import dependency, 2021

Diversification of supplier countries and transport structures

Domestic

Content based on (BMWK, 2022)

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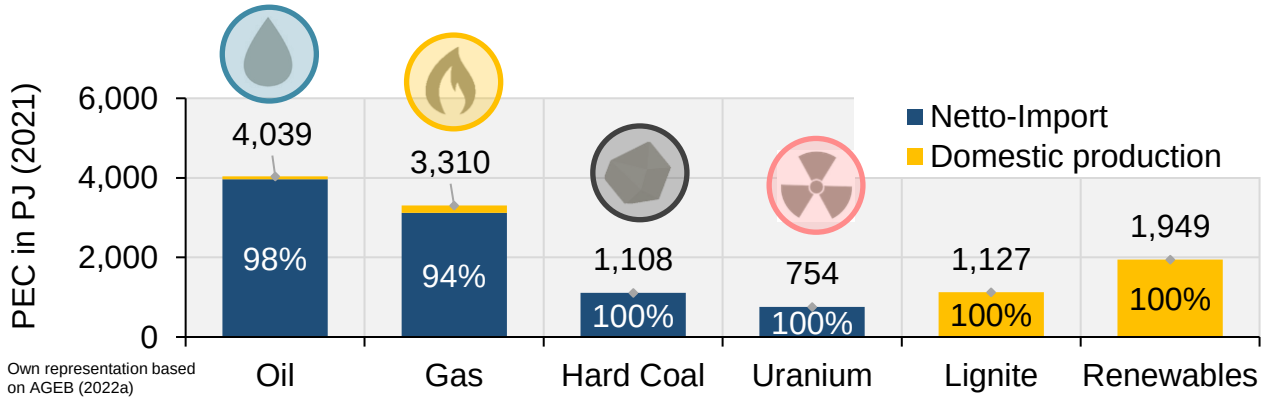

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Total import dependency, 2021

Diversification of supplier countries and transport structures

Domestic

Expansion of renewable energies

Energy savings on all levels

IND TRA HH CTS

New technologies?

Content based on (BMWK, 2022)

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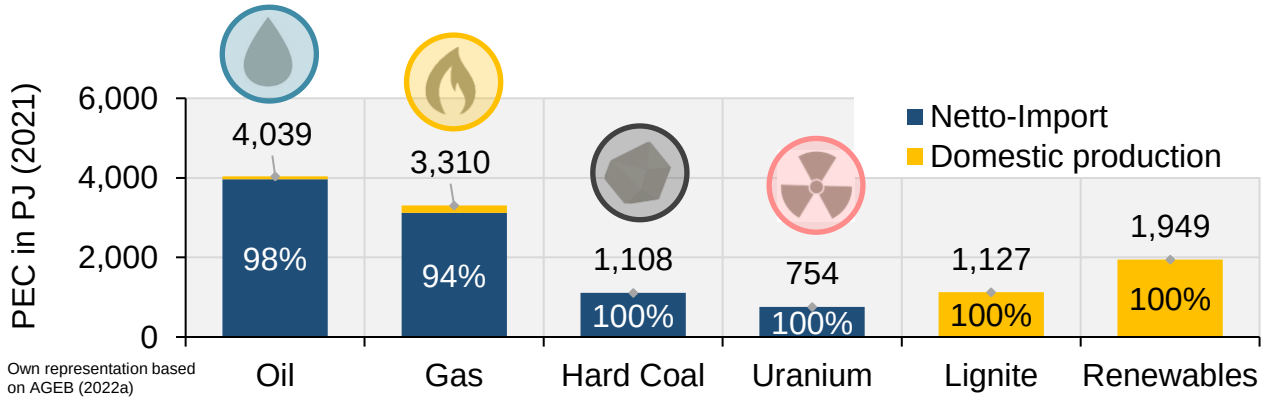
Cross-border trade



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Total import dependency, 2021

Diversification of supplier countries and transport structures

Domestic

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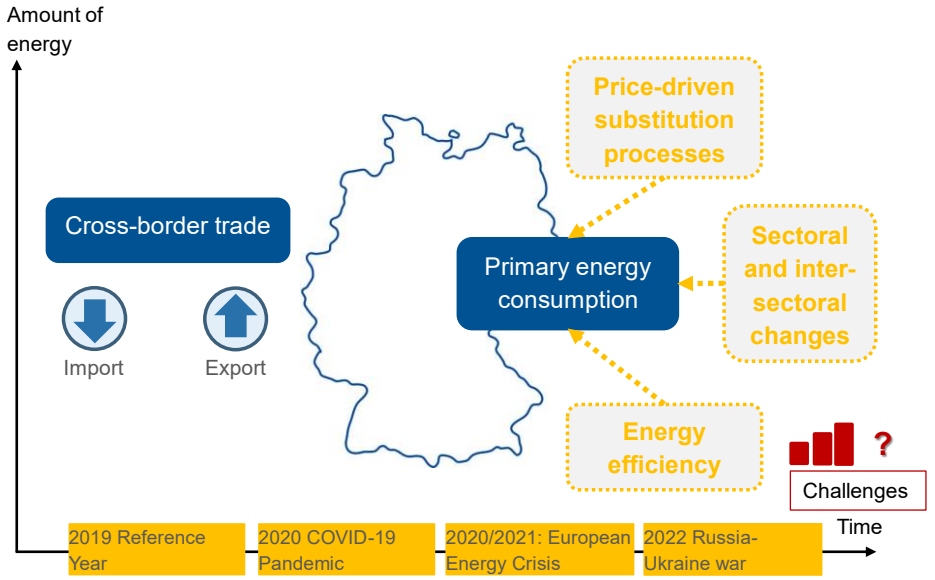
IND TRA HH CTS

New technologies?

Moderate price for energy

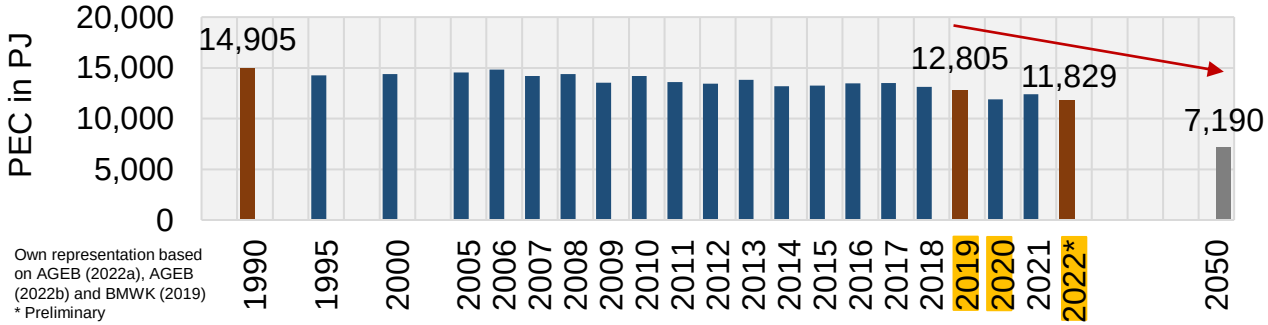
Content based on (BMWK, 2022)

Content



Summary

How the PEC in Germany develops?



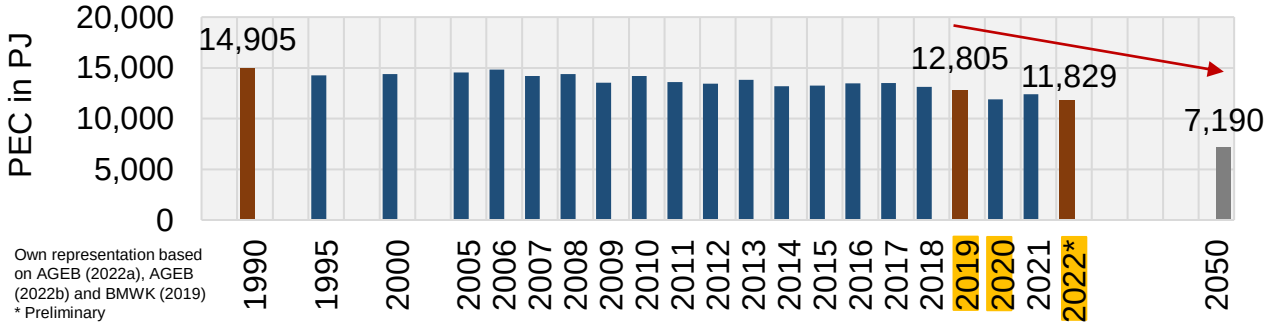
Own representation based on AGEB (2022a), AGEB (2022b) and BMWK (2019)
* Preliminary

- Corona pandemic caused a special effect in PEC development in 2020.
- PEC falls to lowest level since 1990s in 2022.

→ Goal: Reducing PEC by 50% by 2050 compared to 2008.

Summary

How the PEC in Germany develops?



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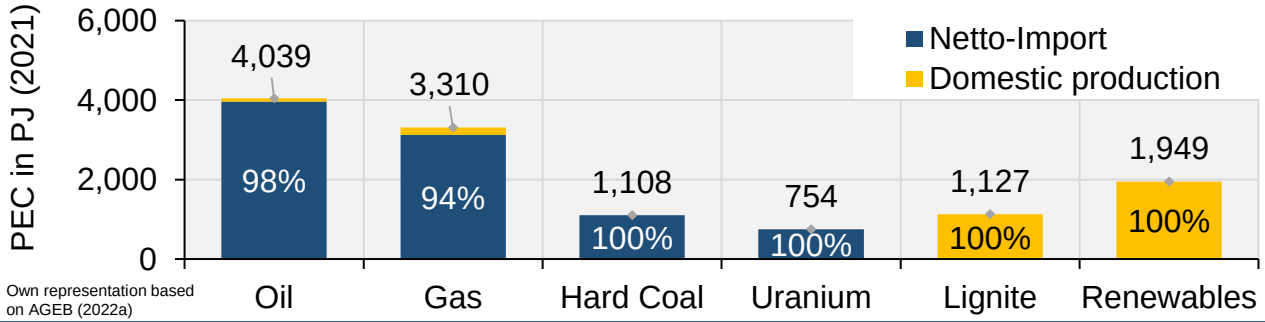
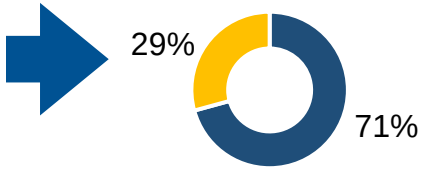
Where does our primary energy come from?



Own representation based on AGEB (2022a)

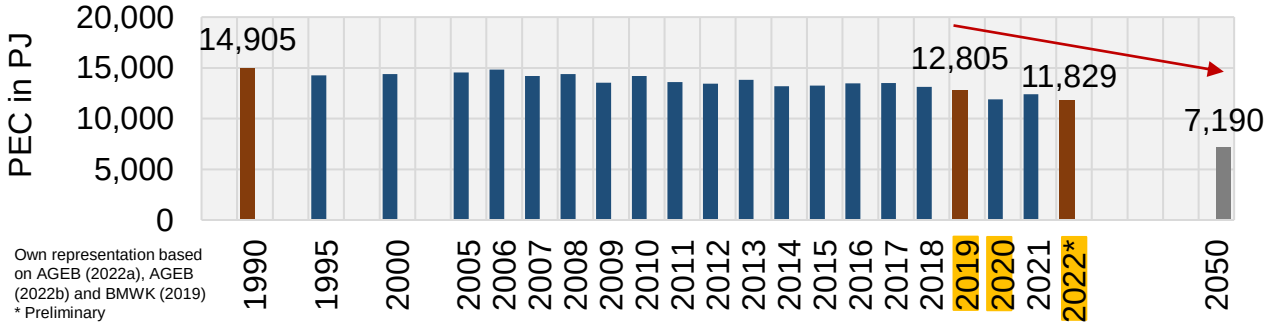


- 71% of the primary energy consumed domestically is imported.
- Until mid-2022 main primary energy imports from Russia.

→ Trend end-2022: Reduction of import dependency (on Russia)

Summary

How the PEC in Germany develops?



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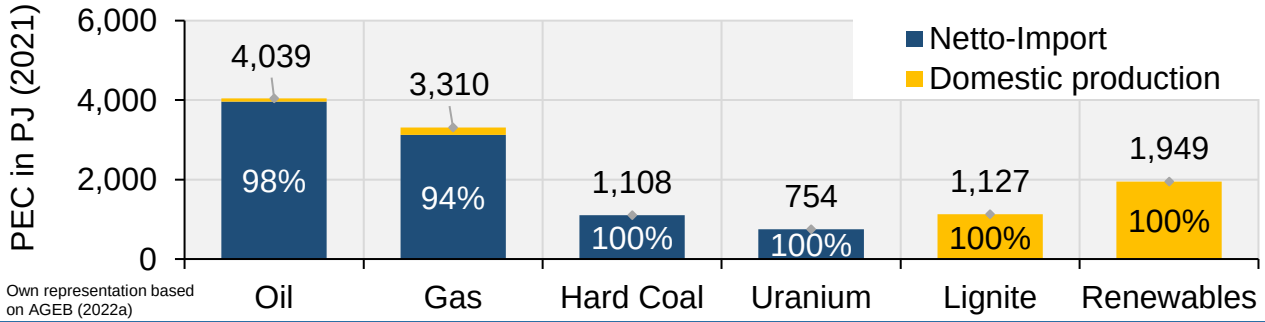
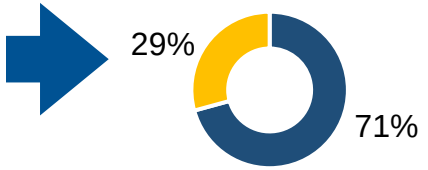


Own representation based on AGEB (2022a)



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Which challenges result in the field of German energy supply?

Reduction of energy import dependence in order to avoid rising energy prices, by:

- Diversification of supplier countries and transport structures
- Expansion of renewable energies
- Energy savings on all levels
- New technologies

Content based on (BMWK, 2022)

Literature

AGEB (2022a): Evaluation tables for the energy balance from 1990 to 2021.

AGEB (2022b): Primary energy consumption year 2022.

AGEB (2022c): Energy consumption falls in 2022.

AGEB (2022d): Additional information in 2022.

AGEB (2022e): Energy flow figures.

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BAFA (2023): RohölINFO November 2022

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Euroatom (2020b): EU natural uranium price: ESA indices since 1980.

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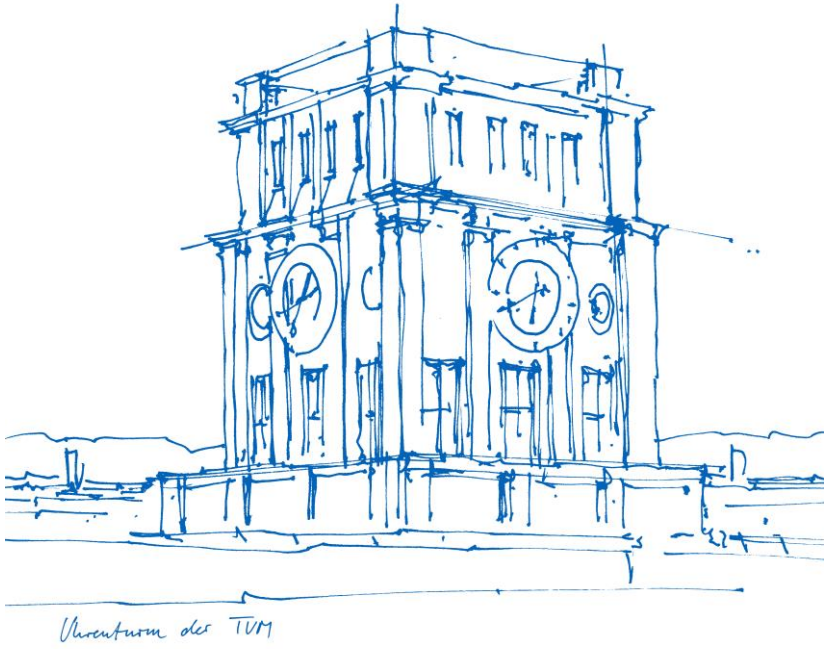
Technical University of Munich (TUM-ENS)

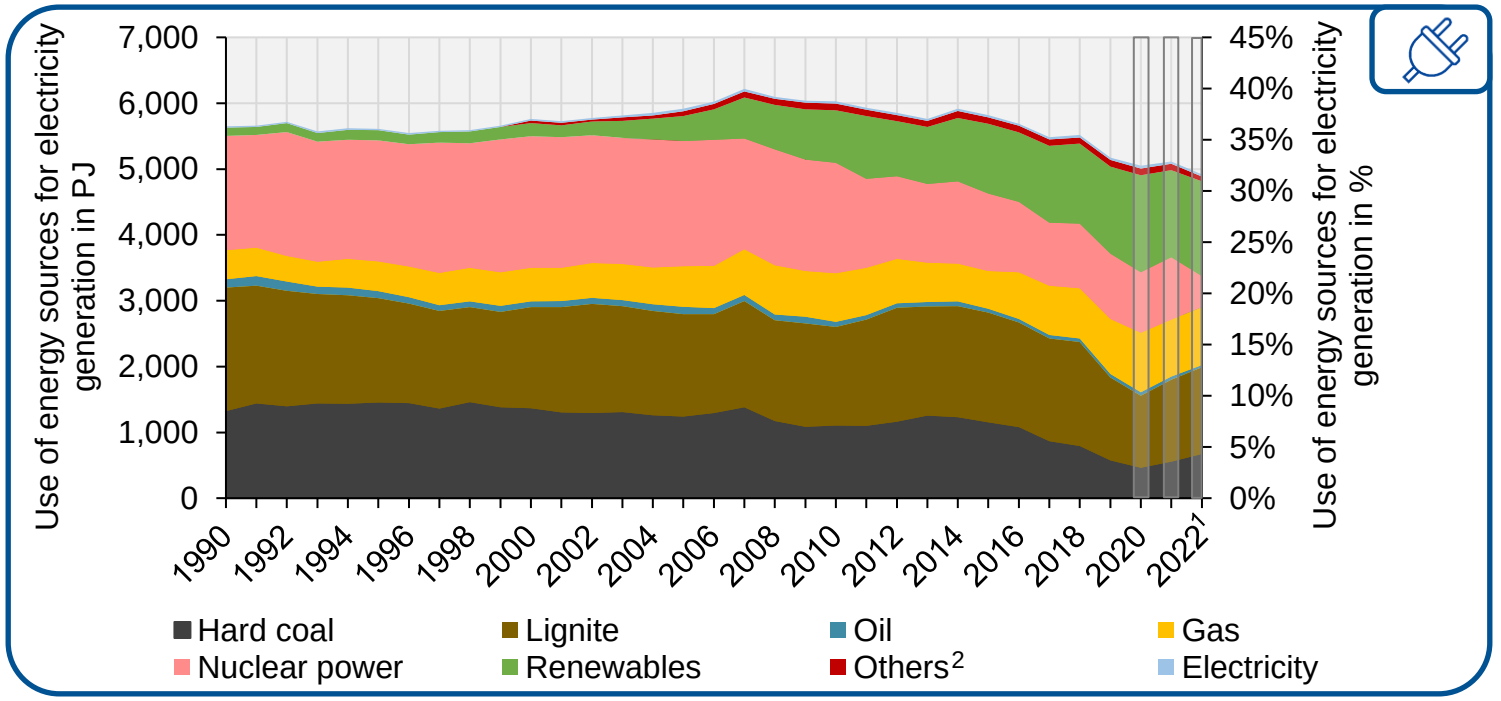


Backup

The primary energy consumption in Germany

Use of primary energy for electricity generation

Use of primary energy for electricity generation;
In %



Own representation based on AGEB (2022a), based on unit PJ
Primary energy consumption (2022): 11,829.4 PJ
[1] Preliminary, own calculations
[2] Non-renewable waste, waste heat

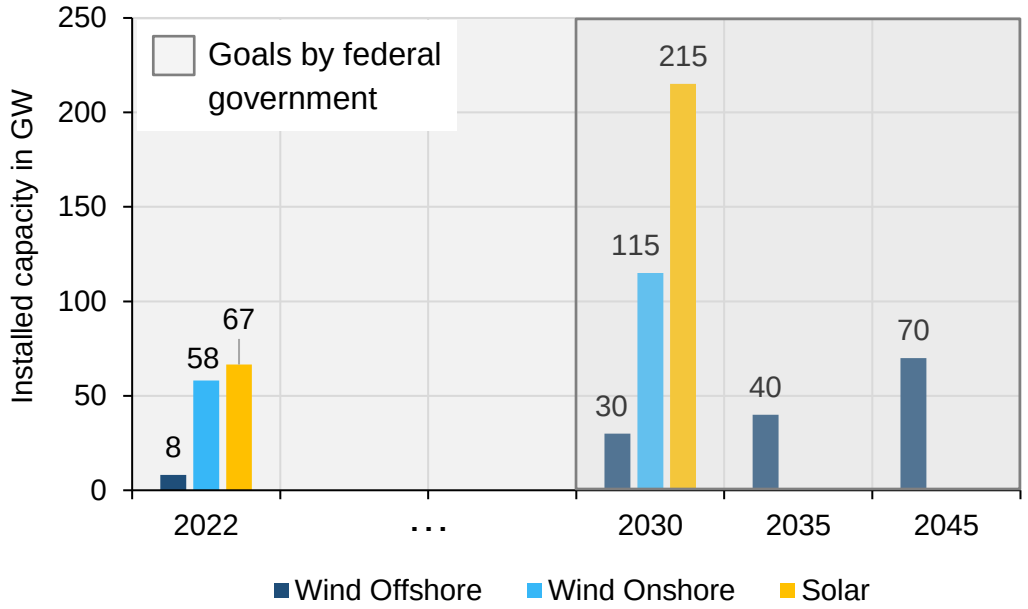
- In 2022, 32% of the consumed primary energy was used to generate electricity. In contrast to 2019, that was 5% less. (AGEB, 2022a, Own calculations)
- While in 2020 the proportion of the primary energy sources hard coal (-20%) and lignite (-13%) fell compared to 2019, the use of stone (17%) and lignite (4%) for power generation increased in 2022. (AGEB, 2022a, Own calculations)
- The use of nuclear energy to generate electricity fell by 53% in 2022 compared to 2019 due to the shutdown of the 3 nuclear power plants. (AGEB, 2022a, Own calculations)
- The gas share in electricity generation increased by 6% in 2022 compared to 2019. This is a decrease of 3% increase compared to 2020. (AGEB, 2022a, Own calculations)
- Renewables increased by 9% in 2022 compared to 2019. (AGEB, 2022a, Own calculations)

Deviations in the totals are due to rounding

Challenges in the field of German energy supply

Expansion targets for renewable energies

Installed capacity of renewables – status and trends;
In GW

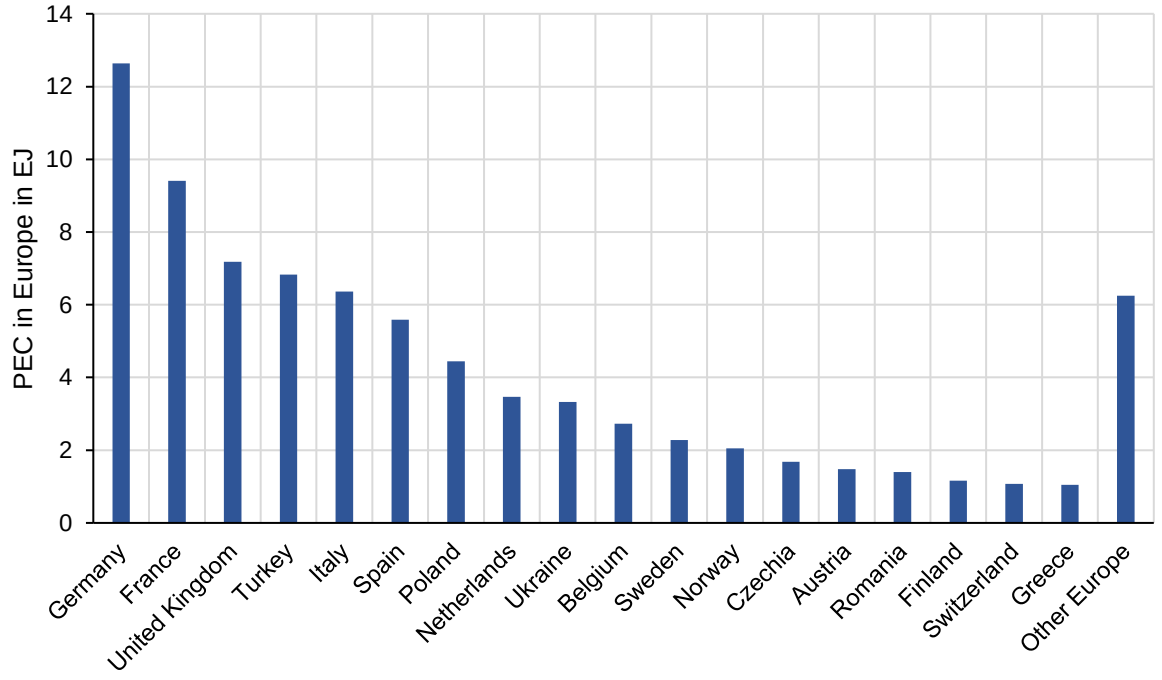


Own representation based on Federal government (2023), BMWK (2023), Destatis (2023c), BWE (2022)

Germany in European comparison

Primary energy consumption

PEC in Europe, 2021;
In EJ

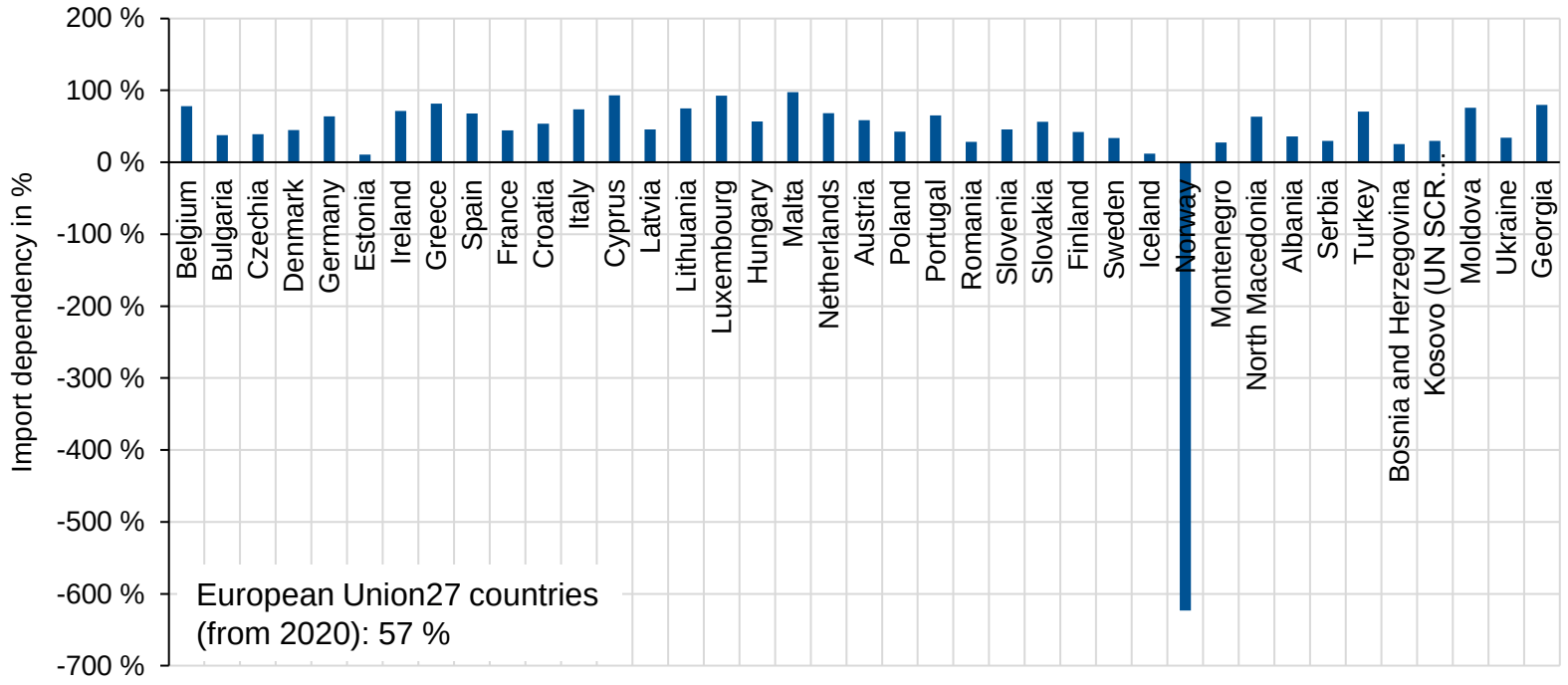


Own representation based on BP (2022)

Germany in European comparison

Import dependency

Import dependency[1] in the EU, 2020;
In %



Own representation based on Eurostat (2023)
[1] Import dependency = (imports - exports) / gross available energy