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BGR ENERGY STUDY

Data and Developments Concerning German and Global Energy Supplies

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Data and Developments Concerning German and Global Energy Supplies

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Prof. Dr. Ralph Watzel
President of the Federal Institute for Geosciences and Natural Resources

One of the major challenges of future decades is the conversion of the energy systems. Germany has already implemented important measures in charting its course to achieve low-emission energy supplies. Measures include the already resolved strategy to completely end the use of nuclear power, and the phased decrease in the use of coal for power and energy production. A clear sign of the energy transition is the growing share of renewable energy sources in providing energy. Their share of power generation in 2018 was 35 per cent. In addition to the further expansion of biomass, windpower and photovoltaics, it is foreseeable that natural gas will have to cover the remaining demand until primary energy can be supplied in a climate-neutral way by the middle of the century.

Renewable energy sources came in first place in the expansion of power generation capacities world-wide in 2018 with a share of 64 per cent. As in previous years, the largest growth here came about in China. Overall, renewable energy sources now cover 18 per cent of global consumption.

Despite a rise in energy efficiency, the growing global population, and the rise in overall living standards in many countries, means that the demand for energy will continue to rise in the long term as well. Despite the continuing shift in the global energy mix, only a small number of energy resources continue to dominate global energy supplies. Fossil fuels and nuclear power will therefore continue to play a significant role in the decades to come to enable the global rise in energy consumption to be adequately satisfied in future as well.

The Energy Study 2019 clearly reveals that countries are converting their energy systems along very different lines. For instance, nuclear power accounted for 39 per cent of primary energy consumption in France in 2018, corresponding to 75 per cent of total power consumption. However, the French government plans to reduce the share from 75 per cent to 50 per cent by 2035. By way of contrast, 55 nuclear power plants are currently under construction world-wide, of which 32 are in Asia alone. There is a rapid demand for primary energy in the emerging economies: India had a primary energy consumption of 539 million tons coal equivalent in 2010, but by 2018, this had risen to 809 million tons, a growth of around 50 per cent. Most of the increase in demand is covered by coal − with a corresponding rise in greenhouse gas emissions. These figures clearly highlight the challenges associated with harmonising climate protection in emerging economies with the economic growth which is needed to underpin the growing prosperity in these countries.

We, the Federal Institute for Geosciences and Natural Resources (BGR), present in this energy study data and facts of the usual high quality covering the global availability, production, and imports and exports of energy resources. The data on fossil energy resources are supplemented by data on renewable energy resources. The latest energy study has a new layout. In addition to a significant reduction in the amount of text, graphics have now been added to supplement the comprehensive tables, and to enable you, the reader, to quickly assimilate the most important information.

Yours

Ralph Watzel

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1 Summary

Even though global energy consumption is declining during the ongoing COVID-19 pandemic, the long-term trend is for a rise in global energy demand. As in previous years, global energy demand grew further in 2018, this year's reporting year. The rise in the number of people living on the planet, and the increase in general living standards, will probably also lead to a growing demand for energy in the long term, even in the face of higher energy efficiency. The growth in energy consumption is now covered in almost equal proportions by renewables and fossil energy resources, although crude oil, natural gas and coal continue to play a dominant role in global energy supplies. This is why a part of global energy supplies will continue to be covered by fossil energy resources into the foreseeable future. Germany is no exception, and despite the high rates of growth in renewables, there will still be an increase in its high dependency on imports of fossil energy resources in the foreseeable future. As in the past, crude oil, natural gas, hard coal and lignite accounted for the largest proportion of German primary energy consumption in 2018, accounting for around 79 per cent. A major challenge in the decades to come is therefore the conversion of the energy systems with the aim of achieving the climate targets agreed in Paris. This energy study comes to the conclusion that the use of natural gas will increase in importance in the short to medium term as a flexible bridge technology, alongside the renewables.

Methodology – The latest Energy Study issued by the Federal Institute for Geosciences and Natural Resources (BGR) contains statements and analyses as at the end of 2018 on the situation of the energy resources crude oil, natural gas, coal, nuclear fuels, and renewable energy, including deep geothermal energy. The main focus of the report is estimating the geological inventory of energy resources by making reliable assessments of reserves and resources. The commodity markets are also analysed with respect to the development of production, exports, imports, and the consumption of energy and fossil energy resources, and topical and socially-relevant

energy issues are considered as well. The study is the basis for the natural resource industry advice given to the Federal Ministry for Economic Affairs and Energy (BMWI), German industry, and the general public.

The datasets published in the BGR Energy Study are a classified and evaluated extract of BGR's energy resources database, and were compiled from information in technical journals, scientific publications, reports issued by industry, specialist organisations and political bodies, and internet sources, and the results of our own surveys. If not explicitly mentioned otherwise, all of the data presented here are derived from BGR's energy resources database.

Results – All of the renewables together cover around 18 % of global energy consumption. This is dominated by the "classic" renewables such as hydropower and biomass. The "modern" renewables such as photovoltaics and windpower have the greatest future growth potential. However, fossil energy resources were also used worldwide in larger amounts in 2018 as well. More than 43 % of global primary energy consumption was accounted for by Austral-Asia – a region in which demand is primarily satisfied by hard coal. North America (around 21 %), and Europe (around 14 %), follow in second and third place, whereby crude oil and natural gas are the main energy resources used here to cover primary energy consumption (Fig. 1-1) (BP 2019).

The global comparison of the energy resources produced to date and therefore consumed, with the still available reserves and resources, reveals that there is still considerable potential for fossil energy resources (including uranium) in all regions around the world (Fig. 1-2). These are primarily large coal deposits which are found on all continents, and which are not limited to just

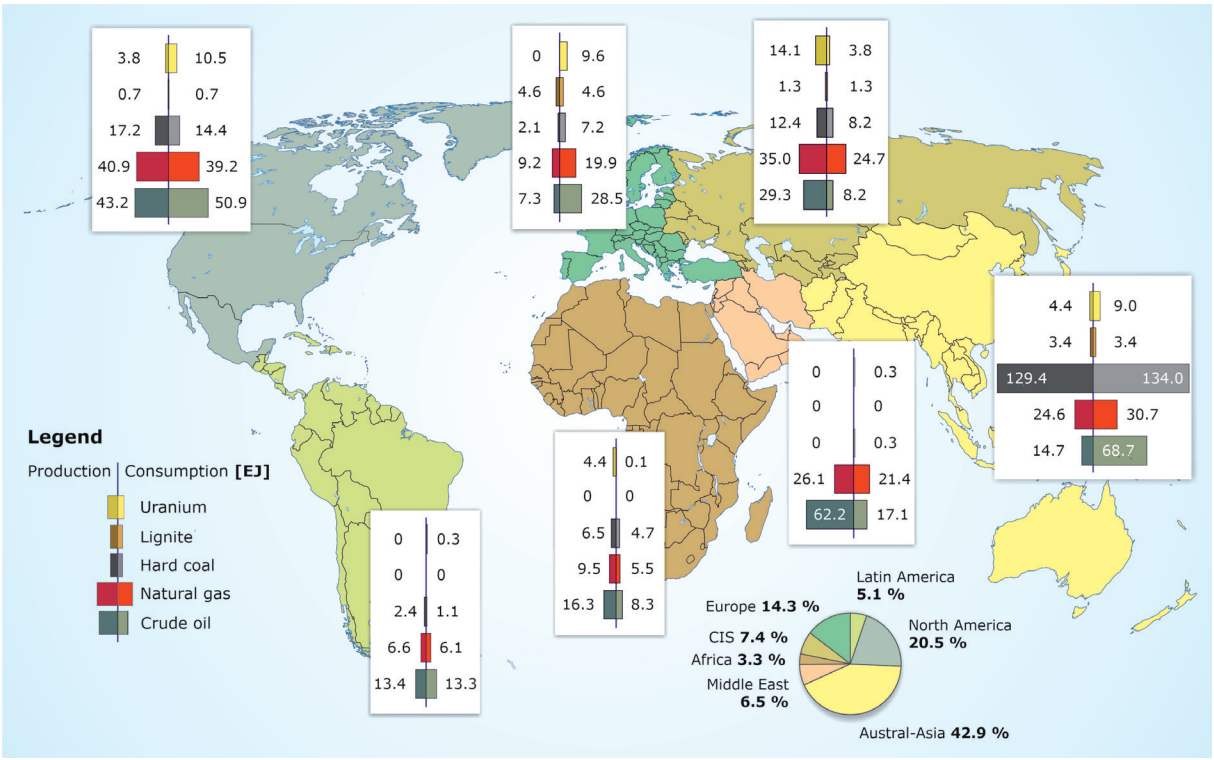


Figure 1-1: Regional distribution of the production and consumption of fossil energy resources divided up into crude oil, natural gas, hard coal, lignite and uranium in 2018 (BGR energy resources database), as well as regional shares of global primary energy consumption (BP 2019).

a few regions, as is the case for conventional crude oil and natural gas. In addition, there are also enormous potential reserves of renewables whose quantities cannot be adequately quantified.

At 504,805 exajoules (EJ; 1018 Joule), the largest proportion of global non-renewable energy potential is defined as resources, and exceeds reserves many times over. Compared to the previous year, there are significant changes overall in resources (minus 8.3 %), primarily attributable to a re-evaluation of Russian coal resources. In contrast, the energy content of all reserves last year rose to 40,769 EJ (plus 1.3 %), primarily due to re-evaluations and the success of exploration for shale oil. In terms of energy content, coal is the dominant energy resource with respect to resources and reserves. Crude oil, however, continues to dominate consumption and production. Because of the larger unconventional portions in comparison to natural gas, crude oil is also in second place in terms of reserves after coal. Fossil fuels continue to dominate the overall global energy mix, i.e. the actual energy consumed, including renewables. In terms of geological availability, the known reserves of energy resources are capable of covering the growth in demand for natural gas, coal and nuclear fuels in the long term as well, and can thus safeguard the change to a low-carbon energy system. Conventional crude oil is the only energy resource whose availability appears to be limited.

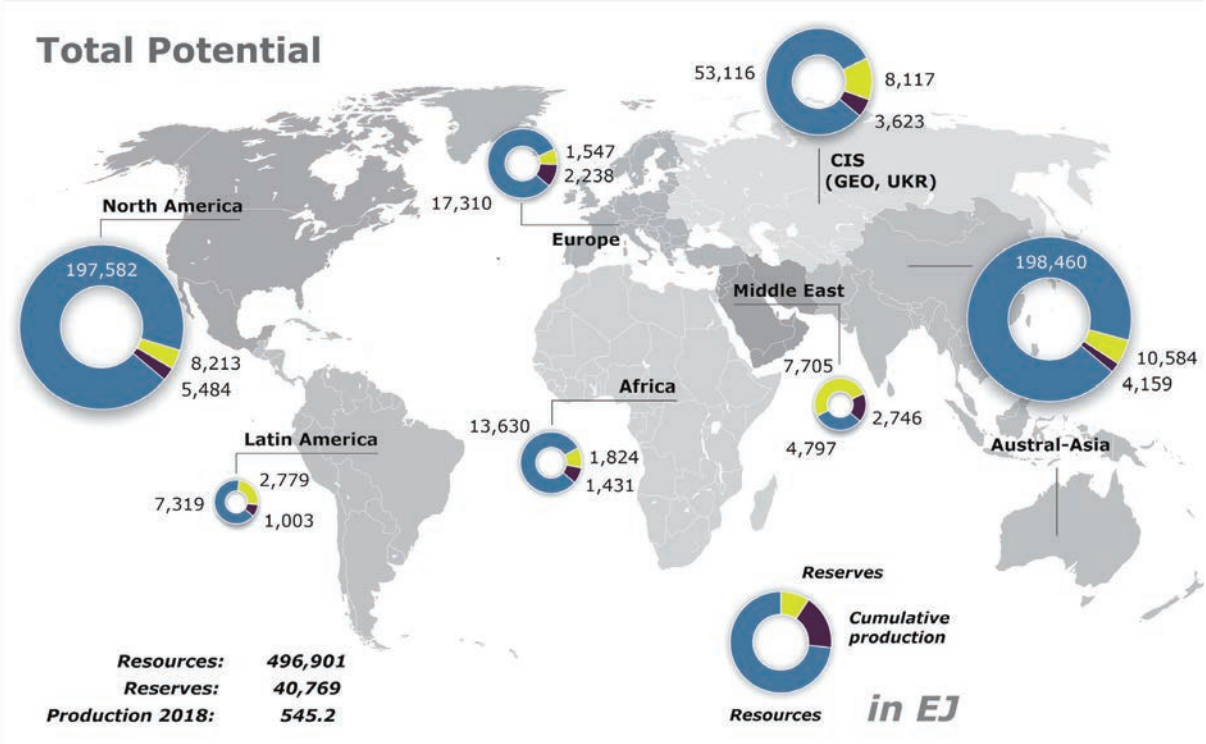


Figure 1-2: Total potential of fossil energy resources including uranium for 2018. (Does not take into consideration resources in the Antarctic, or aquifer gas, natural gas from gas hydrates and thorium, because these cannot be assigned regionally. The cumulative production of coal is estimated from 1950).

Key remarks on crude oil, natural gas, coal, nuclear fuels, deep geothermal energy and other renewables:

Crude oil

- **Crude oil is the world's most important energy resource. Global crude oil production rose by 1.8 %.** The expansion of US-American shale oil production accounted for the largest proportion of this growth.

- **Global oil prices recovered further after the collapse in prices,** but still remain at levels too low for many crude oil exporting countries to balance their budgets.

- **Conventional crude oil reserves are particularly relevant for supplying the world with liquid hydrocarbons.** Around two thirds of these reserves are found in Middle Eastern countries.

- **From a geological point of view, supplies of crude oil can be maintained in the coming years, even in the light of a moderate rise in consumption.** Geopolitical risks and the consequences of relatively low investments in the E&P sector arising from the low crude oil prices could, however, limit the availability of liquid hydrocarbons in the short to medium term.

Natural gas

- **Natural gas consumption world-wide rose in 2018 by more than 4 %,** and the annual production of natural gas rose by 5 %. The Russian Federation has the largest natural gas reserves and resources.

- **The shale gas boom in the USA continues –** the shale gas proportion of total production here in 2018 was around 69 %, and natural gas production overall rose by 12 %. The USA became a net exporter even though it is the world's largest gas consumer.

- **China was the world's biggest natural gas importer in 2018.** The global trade in liquefied natural gas (LNG) rose by 8 %. The largest proportion of LNG was supplied to Asia, which accounted for 76 %.

Coal

- **As in the previous year, the global production of coal has increased further – hand-in-hand with the rise in demand.** Global coal production increased by around 4 % in 2018, and rose by another 2 % in 2019 according to the latest estimates.

- **Germany imported almost 10 % less hard coal in 2018 with around 44 Mt.** Because of the closure of the last two German hard coal mines at the end of 2018, Germany now has to import all of its hard coal requirements, although the amounts will probably decrease further in the years to come.

- **The reserves and resources of hard coal and lignite can cover the foreseeable demand for several decades to come from a geological point of view.** With a share of around 55 % of reserves and around 88 % of resources, coal has by far the largest reserves potential of all non-renewable energy resources.

Nuclear fuels

- **The uranium market continues to be affected by relatively low spot market prices, which threaten the profitability of various mines and exploration projects.** As a consequence of the reactor accidents in Fukushima in 2011, there was a global collapse in the uranium market and a decline in uranium prices. This price trend rose slightly again for the first time in seven years.

- **Global uranium production continues to decline.** Numerous mines cut their production or temporarily shut down their production completely because of the stagnating demand, and this also affected the market-dominating mines in Canada, Kazakhstan and Australia. The production declines in some mines is intended to reduce the large amounts of uranium currently available on the global market.

- **There continues to be growing interest world-wide in the use of nuclear fuels as a source of energy. 55 nuclear reactors were under construction in 18 countries at the end of 2018.** 11 of these were in China alone. The demand for uranium will rise further in the long term in Asia, as well as in the Middle East. Numerous countries plan to add nuclear power to their energy mixes or expand their production.

- **The complete withdrawal from nuclear power for commercial electricity generation was laid down in law in Germany.** Eleven of Germany‘s 17 nuclear power plants have been switched off since the change to the Atomic Energy Act in 2011. Withdrawal is scheduled to be completed at the end of 2022. The Philippsburg 2 nuclear power plant was disconnected from the grid as planned at the end of 2019.

Deep geothermal energy

- **The global geothermal energy potential is very high, but so far, it has only been exploited to a very minor extent.** In 2018, the share of geothermal energy in global power production reached about 0.3 %. The global potential for geothermal energy down to a depth of 3 km is estimated to reach about 300 EJ/a for heat generation, and around 100 EJ/a for power generation.

- **With the exception of geothermally favourable regions (high enthalpy regions), the practical implementation and profitability of geothermal projects is currently still considered to be difficult.** There are considerable variations in investment costs, which are quite difficult to estimate in advance. Typical amortisation periods extend to more than 25 years. Geothermal energy could become particularly important for developing countries. In regions with structurally disadvantaged infrastructures, it can make a significant contribution to the generation of power as well as heat.

- **The expansion of geothermal energy production has stagnated in Germany.** After several years of strong growth, there has hardly been any change in installed capacity between 2016 and 2018. Since 2016, no further expansion of power generation in geothermal power plants occurred in Germany. In 2018, the installed electrical capacity of the ten German geothermal power plants amounted to 43 MW_e, giving rise to a total production of 166 GWh_e in electrical power.

Renewable energy resources

- **The share of renewables in global energy supplies continues to expand.** Around 18 % of global primary energy consumption was accounted for by renewables in 2018 and primarily by „classic“ renewable energy sources such as solid biomass and hydroelectric power. The proportion of „modern“ energy resources such as windpower and photovoltaics is still low despite the strong global expansion.

- **The expansion of power generation capacities is globally dominated by renewables.** 64 % of the global expansion of electricity power generation capacities is currently accounted for by the expansion of renewables. International activities to promote renewables remain high. Around 187 countries have currently formulated specific objectives to expand renewables further.

- **The globally installed power generation capacity has reached new record levels.** 2,351 GW of renewables are installed world-wide for power generation. This corresponds to around 30 % of estimated global power generation capacities. Photovoltaics again boast the highest growth rates. The new installed capacity totals 100 GW, of which around 50 % was accounted for by China alone.

- **Renewables in Germany account for the largest proportion of electrical energy generation.** The share of renewables in the German power mix reached 35 % in 2018 and accounted for around 14 % of primary energy consumption. Biomass, windpower and photovoltaics accounted for the main share. A further expansion in renewables in the electricity, transport and heat sector is expected in the future. Renewables are therefore the most important domestic energy resource.

2 Energy situation in Germany

2.1 Energy supplies and primary energy consumption

In 2018, primary energy consumption (PEC) in Germany declined by around 3.5 % compared to 2017 to a total of 12,964 PJ. The decline is attributable to a rise in energy prices, mild weather, and an increase in energy efficiency. When adjusted for the effect of the weather, there was still a decline of 2.4 % (AGEB, 2019).

Petroleum continues to be the most important energy resource (34.3 %), followed by natural gas (23.7 %), renewables (14.0 %), coal (10.0 % hard coal and 11.3 % lignite), and nuclear power (6.4 %) (Fig. 2-1). Renewables in particular were able to increase their share in the energy mix. Hard coal on the other hand, underwent a significant decline, whilst petroleum experienced a slight decline (AGEB, 2019), although the share of natural gas rose slightly. The decline in energy consumption was reflected in particular by a slump in the consumption of hard coal (minus 11.2 %), petroleum (minus 5.0 %) and lignite (minus 2.9 %). The only increase was reported by renewables which rose by around 1.1 %. Despite the decline in fossil fuels, their share of primary energy consumption was still around 79 %. The share of renewables in total energy consumption in Germany rose in 2018 to 14 % (AGEB, 2019).

>> Fossil fuels still account for 79 % of primary energy consumption

As a highly developed industrial country, Germany is one of the largest energy consuming countries worldwide, and 70 % of its energy demand is covered by imported energy resources (AGEB, 2019). Domestic production in 2018 only accounted for around 2 % of the crude oil consumption, and 6 % of the natural gas consumption (Fig. 2-2), and the trend here continues to point downwards (LBEG, 2019). The decline in production is largely attributable to the

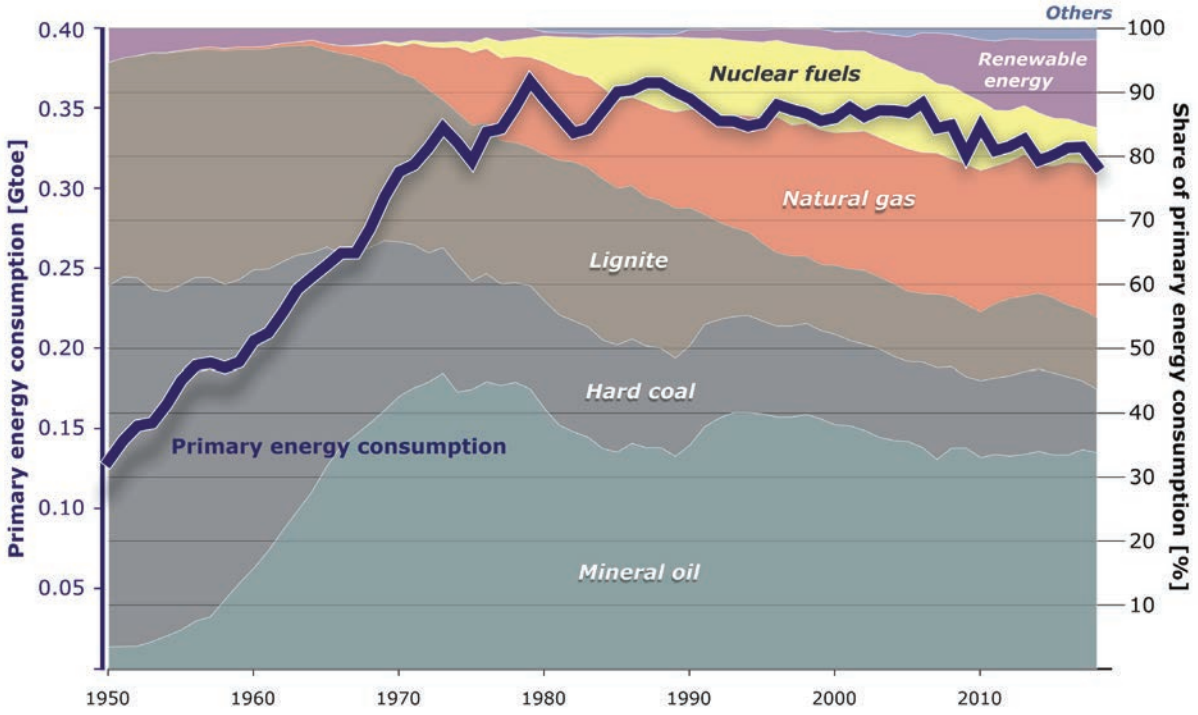


Figure 2-1: Development of German primary energy consumption from 1950 to 2018 (Data: AGEB 2019).

increasing depletion of the oil and gas fields, and the absence of any major new discoveries. In 2018, only around 6 % of German hard coal consumption was accounted for by domestic production. And with the complete halt in domestic hard coal production at the end of 2018, all of Germany‘s future demand for hard coal will have to be covered by imports. Of all the fossil fuels, lignite is the only one which is found in large, economically extractable amounts in Germany. Germany supplies all of its demand for lignite from domestic production, and is the largest producer and consumer worldwide. Lignite production declined by around 2.9 % in 2018. Renewables have established themselves as the most important domestic energy resource (around 46 %), followed by lignite accounting for around 38 %. Both were well ahead of natural gas, hard coal and crude oil (AGEB, 2019).

>> Renewables are the most important domestic energy resource

A comparison covering the last 10 years reveals a decline in the contribution to primary energy of petroleum, hard coal, lignite and nuclear power. In contrast, there was a slight rise in natural gas consumption, and a significant rise in renewables. The amount of primary energy generated by geothermal energy has risen fourfold in the last ten years, but still remains at a very low level (Fig. 2-2). The contribution made by domestic fossil fuels has declined further because of the drop in production from domestic conventional oil and gas fields, and the end of subsidised hard coal production.

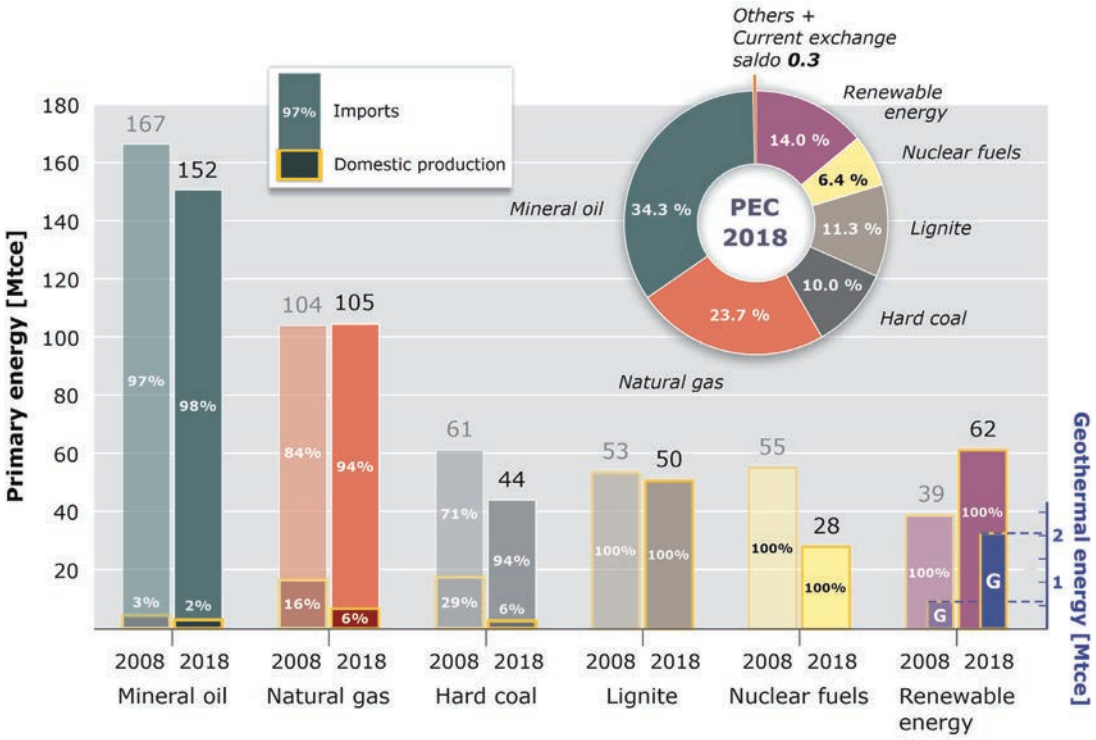


Figure 2-2: Import dependency and self-sufficiency level in Germany of some primary energy resources in 2008 and 2018. Pie diagrams: share of individual energy resources of German primary energy consumption in 2018 (Data: AGEB 2019).

2.2 Energy resources and energy in detail

Crude oil

With a share of around 34 % of primary energy consumption, petroleum is still the most important source of energy in Germany (AGEB, 2019). There was a significant decline in the production and consumption of crude oil, as well as in the imports of crude oil in 2018. In contrast, crude oil reserves rose slightly because of the higher crude oil prices as well as a revised evaluation of the reserves in existing fields (Tab. 1).

Crude oil products were primarily used as fuel in the transport sector. Around 94 % of end energy consumption in the transport sector in the year

Table 1: Crude oil metrics for Germany 2018, and year-on-year change (LBEG, 2019; MWV, 2019; BAFA, 2019a)

Production	2 Mt	- 7.0 % ↘
Reserves	29 Mt	+ 1.6 % →
Consumption	101 Mt	- 4.2 % →
Imports	85 Mt	- 6.1 % ↘

before last was accounted for by petroleum products (AGEB, 2019). Crude oil is also the most important raw material for the organic-chemistry industry (VCI, 2017).

>> *Crude oil is the most important primary energy source accounting for 34 %*

The largest proportion of Germany's crude oil reserves are located in the North German Basin, and primarily in the states of Schleswig-Holstein and Lower Saxony. 51 oilfields were under production at the end of 2018. Around 88 % of total oil production came from the ten most productive oilfields, of which the largest German oilfield at Mittelplate/Dieksand alone accounts for 54 % of total production (LBEG, 2019). Tertiary production measures such as steam and hot water flooding accounted for a 13 % share of total production (LBEG, 2019).

The company with easily the largest domestic oil production was DEA Deutsche Erdoel AG with a share of around 58 % of total production (LBEG, 2019).

Thanks to the higher oil and gas prices compared to the previous year, the royalties paid to the German states by the oil and gas producers rose to around € 261 million (plus 2 %). Oil production accounted for € 98 million of the royalties. 24 wells were drilled in 2018, meaning that domestic drilling activity stayed the same year-on-year. 8,291 employees were working in the German oil and gas industry at the end of 2018, 94 fewer than the previous year. The workforce in the German oil and gas industry has declined by around 18 % since 2013 (BVEG, 2019).

As one of the largest petroleum consumers worldwide, Germany is almost completely dependent on imports of crude oil and crude oil products. Crude oil imports declined year-on-year by around 5 Mt to around 85.2 Mt (Fig. 2-3). Although these imports were supplied by over 29 countries, German crude oil supplies are particularly dependent on the Russian Federation and Norway, which together account for 48 % of all German crude oil imports.

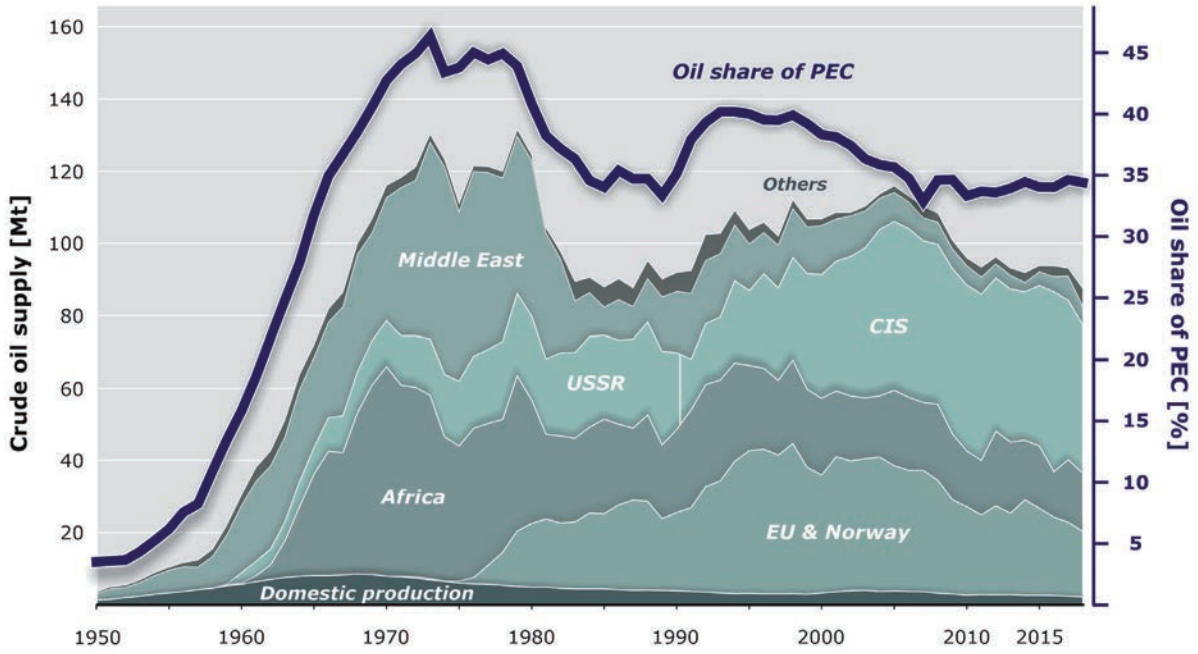


Figure 2-3: German petroleum supplies from 1950 to 2018.

The Federal Republic of Germany is almost completely dependent on imports of petroleum. Because of this dependence, the creation of an obligatory federal reserve was decided in 1966, and was put into legal force in 1978 by the Crude Oil Strategic Reserve Act (ErdölBevG) (EBV, 2008). The 30 member states of the intergovernmental IEA, which was established in 1974 as a response to the first oil crisis, and whose aims include having a stabilising effect on the oil market during periods of shortages in crude oil supplies, also have strategic crude oil reserves.

The statutorily prescribed minimum size of the strategic reserves in Germany corresponds to the daily average net imports for 90 days with respect to the three calendar years preceding the respective period. The strategic reserves contain crude oil as well as petroleum products. These are stored in various facilities including caverns, tank farms and the strategic storage facilities of refineries (BMJV, 2012). As at 31.03.2018, the strategic reserves contained 14.18 Mt crude oil and 9.37 Mt petroleum products (EBV, 2018). Although strategic reserves are stored in all German federal states, the reserves are concentrated in northwest Germany where the conditions allow storage in caverns. Major cavern storages are located in Willhelmshaven-Rüstlingen, Heide, Lesum and Sottorf.

Natural gas

With a share of 24 % of primary energy consumption, natural gas remains the second most important source of energy in Germany (AGEB, 2019). The large-scale production of natural gas in Germany only began in the 1960s as a result of the development of natural gas deposits, primarily in Lower Saxony. Production − which has been declining for over 15 years now – as well as reserves, sank considerably because of the increasing depletion of the fields, and the cutback in exploration activities. In the past, domestic natural gas production covered around 20 % of the natural gas consumed in Germany, today it only accounts for around 8 %. Consumption was slightly down on the previous year. However, there was a considerable increase in natural gas imports as well as re-exports (Tab. 2).

>> Domestic natural gas production has more than halved since 2000

With a share of 98.6 % of crude gas reserves, Lower Saxony is the state in Germany with the largest natural gas reserves. Lower Saxony also accounts for the lion‘s share of production, accounting for around 94 %. 77 fields were in operation in the reporting year (LBEG, 2019). The largest natural gas producer by far in terms of

Table 2: Natural gas metrics for Germany 2018, and year-on-year change (LBEG, 2019, BAFA, 2019b)

Production	7 bcm	- 13.0 % ↓
Reserves	30 bcm	- 18.0 % ↓
Consumption*	85 bcm	- 3.6 % →
Imports	117 bcm	+ 9.7 % ↗
Exports	40 bcm	+35.0 % ↑

* 1.000 Nm^3 = 38 x 10^9 J

domestic gas production was ExxonMobil Production Deutschland GmbH, which accounts for over half of domestic gas production (LBEG, 2019). Natural gas production by German companies abroad (CIS/Russian Federation, America, Europe, Africa) is primarily generated by Wintershall Holding GmbH and DEA Deutsche Erdoel AG. These two companies produced around 19.8 bcm of gas overseas in 2018, and thus slightly more than the previous year. The companies merged in early 2019 to form Wintershall Dea.

The technically producible natural gas resources in Germany are estimated to be around 1.4 tcm (BGR, 2019). The natural gas potential in shale gas reservoirs is around 0.3 tcm to 2 tcm with respect to depths between 1,000 m to 5,000 m (BGR, 2016). In addition, potential of around 1 tcm is estimated in tight gas reservoirs, and another approximately 0.5 cm in coal bed methane. The remaining potential of natural gas resources and conventional reservoirs is 0.02 tcm (BGR, 2019).

Gross natural gas imports rose by around 10 % in 2018 compared to the previous year according to calculations by BAFA (2019b). A large proportion of this was re-exported to neighbouring countries, so that natural gas exports rose by around 35 % to around 40 bcm. Total turnover (imports and domestic production) in 2018 were 4,664,443 TJ (Fig. 2-4). 99.720 TJ natural gas in total was injected into natural gas storages.

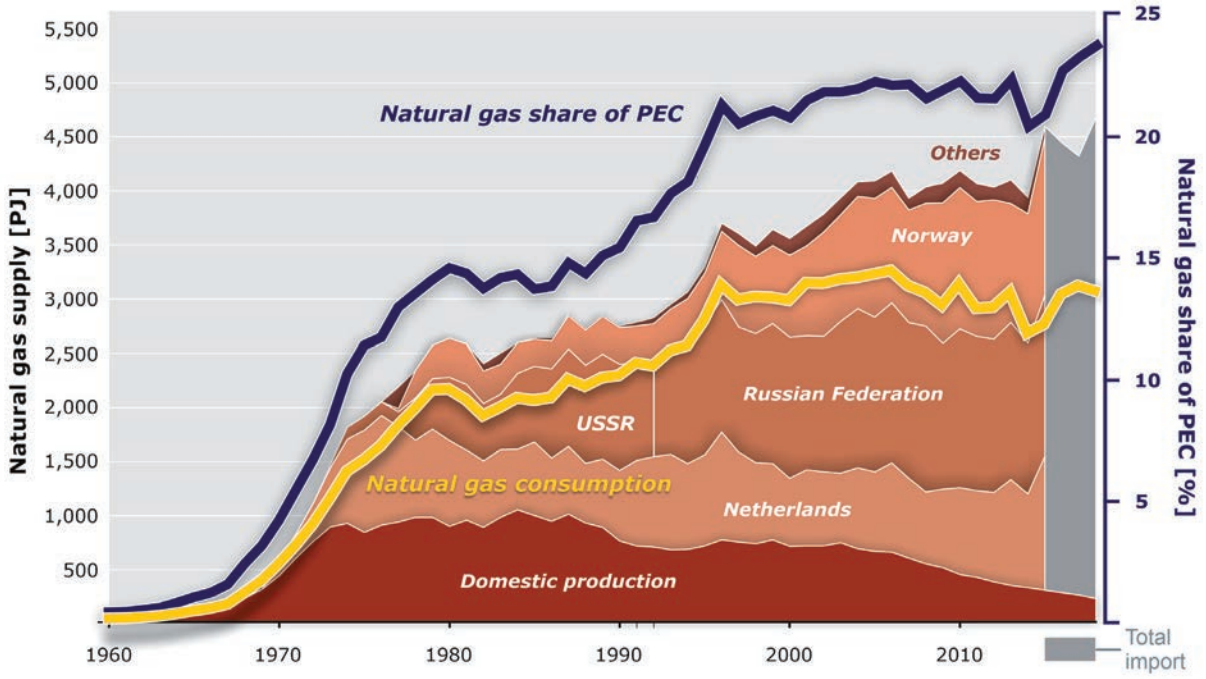


Figure 2-4: German natural gas supplies from 1960 to 2018, and natural gas proportion of PEC. Yellow curve shows German natural gas consumption in terms of total volume (BAFA, 2019b; AGEB, 2019). For data protection reasons, the Federal Office of Economics and Export Control has not published any information on the delivery quantities of the individual exporting countries since 2016.

Coal

With a share of 21.3 %, coal (hard coal and lignite) was Germany's third most important energy resource in 2018 after crude oil and natural gas (AGEB, 2019). Pursuant to the coal compromise reached at the beginning of 2019 („The growth, structural change and employment" Commission − BMWi, 2019a), coal is planned to continue to make a contribution to German energy supplies until 2038. Whilst domestic hard coal production came to an end at the end of 2018, lignite is easily the most important domestic fossil fuel in terms of reserves and production. Both the production and the consumption of lignite and hard coal declined in the reporting year (Tab. 3, Fig. 2-5, 2-6).

>> *Reduction in production and consumption*

In addition to the main use of coal for the production of power, coal is also used for other purposes, including the heating market, coal gasification and liquefaction, and coking. The use of coke in particular, made from coking coal, currently has no large-scale substitute in the production of pig iron, and thus for the steel industry as a whole. For climate protection reasons, the step-wise reduction in the use of coal for power generation is one of the stipulated objectives of the German government (BMU, 2016).

Figure 2-5: Active, significant and shut-down lignite fields and coalfields in 2018.

Table 3: Metrics for the German lignite and hard coal sector in 2018, and year-on-year change (AGEB, 2019, DEBRIV, 2019, SdK, 2019, VDKI, 2019a)

	Lignite		Hard coal	
Production	166.3 Mt	- 2.9 % ↘	2.6 Mt v. F.	- 29.6 % ↓
Imports (incl. products*)	0.04 Mt	+ 11.7 % ↑	46.6 Mt	- 9.1 % ↘
Exports (incl. products*)	1.5 Mt	- 0.6 % →	1.1 Mt	- 1.9 % →
Consumption	50 Mtce	- 2.9 % ↘	44.4 Mtce	- 11.2 % ↓
Reserves (End of 2018)	35,900 Mt	- 0.6 % →		

* Products like dust, briquettes und coke

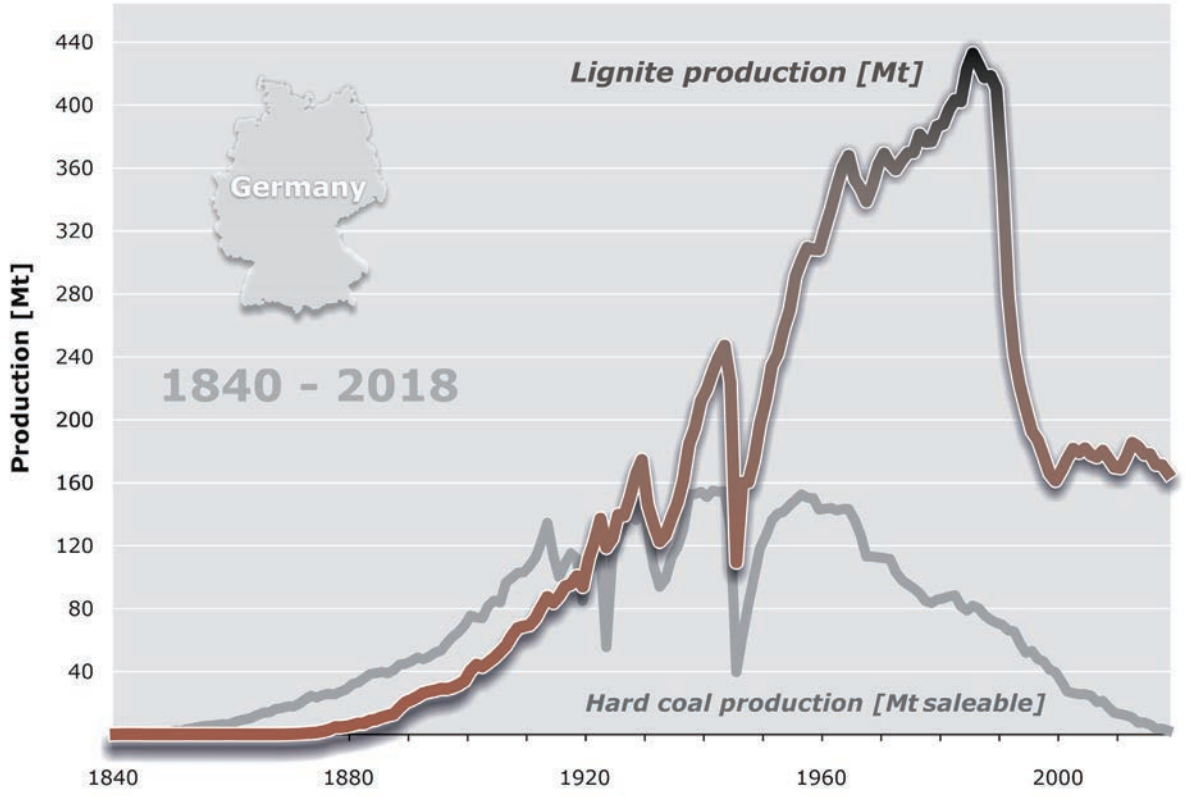


Figure 2-6: Development of German coal production from 1840 to 2018 (after SdK 2019).

Hard coal

German hard coal production in 2018 totalled 2.58 Mt saleable production. In the Ruhr coalfield (Fig. 2-5), the Prosper-Haniel mine produced around two thirds (1.8 Mt saleable production) of total German hard coal production in 2018. The Ibbenbüren mine in the Ibbenbüren coalfield accounted for around a third (0.8 Mt saleable production) of German hard coal production. These two mines were the last two hard coal mines operating in Germany, and production here also finally came to an end in 2018.

>> December 2018: The end of German hard coal production

The consumption of hard coal in Germany was lower in the reporting period than in 2017. As in the previous year, it declined by more than 11 % to around 44.4 Mtce. The share of hard coal in primary energy consumption therefore dropped to 10 %, after accounting for 10.9 % the previous year. Only around 6 % of German hard coal consumption in 2018 was derived from domestic production. The total turnover of German hard coal declined slightly in the reporting year by 4.9 % to 4.46 Mt. The workforce in the German hard coal mining industry has been declining ever since 1958. The number of employees in the mining industry in 2018 declined by 27.8 % year-on-year to 4,125 (AGEB, 2019; SdK, 2019).

Imports of hard coal and hard coal products sank by around 9.1 % to 46.6 Mt compared to 2017 (Fig. 2-7). The Russian Federation, with around 19 Mt (40.8 %), was again the largest supplier in 2018, followed by the USA (20.9 %) and Colombia (8.1 %). Imports from Poland, the only significant coal exporting country in the EU-28, shrank to around 1.7 Mt, and around 1.5 Mt of this was accounted for by coke (VDKI, 2019a). As in the previous year, imports accounted for around 94 % of total coal turnover in Germany. Following the closure of the last two German hard coal mines at the end of 2018, Germany now has to import all of its requirements for hard coal.

>> *Hard coal consumption and imports declining over a period of several years*

The price of imported steam coal ranged between 88 and around 101 €/tce in 2018, and therefore at a relatively high level. The annual average price was 95.49 €/tce (plus 4 % compared to 2017). The price of coke also rose slightly year-on-year by 6 % to an annual average price of 271.61 €/t. The only reported decline was in the annual average price for coking coal which sank slightly by around 6.3 % year-on-year to 163.87 €/t (BAFA, 2019c; VDKI, 2019b).

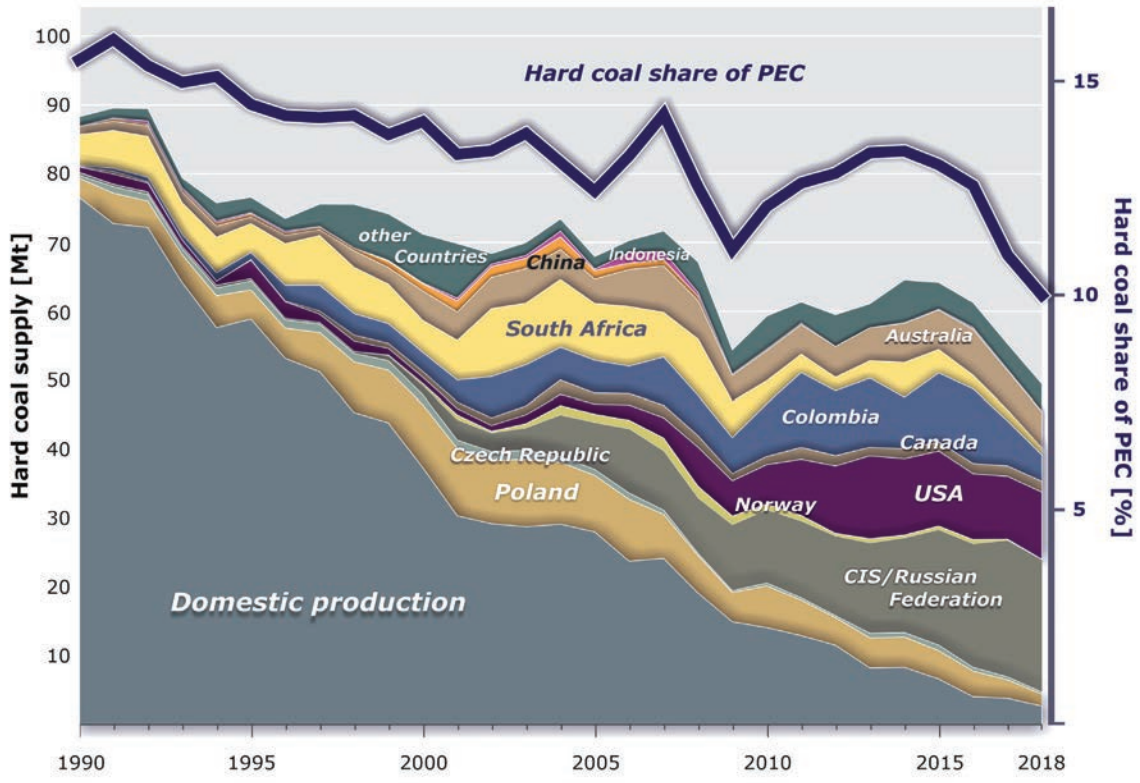


Figure 2-7: German hard coal supplies from 1990 to 2018 (Data: AGEB, 2019, SdK, 2019, VDKI, 2019a).

The end of German hard coal mining

Domestic hard coal built the foundations of the industrial revolution in Germany. Peak hard coal production in Germany was reached in 1941, during the Second World War, when it reached around 155 Mt saleable production (Fig. 2-6). After the end of the Second World War, as an important domestic energy resource, hard coal was a major platform for the reconstruction of the country, and the subsequent economic upswing in Germany. The highest post-war production peak of German hard coal production was reached in 1956 with 152.5 Mt saleable production. The workforce in the German coal mining industry at this time totalled around 600,000, and there were over 170 hard coal mines (GVSt, 2019b). German hard coal production has declined almost continually since 1956 because of decreasing demand, as well as relatively high production costs. The use of domestic hard coal has been superseded in past decades by crude oil, natural gas, uranium and imported coal. The growth in renewables has also had a negative effect on the use of coal for a number of years as well.

German hard coal mining has not been internationally competitive for many years, mainly due to the unfavourable geological conditions. However, to still make a contribution to supplying power plants and steel works with coal, as well as for job market policy reasons, domestic hard coal mining has been supported by public subsidies. In 2018, € 1,091 million of public funding was assigned to hard coal mining (BMWi, 2019). In February 2007, the German government, the states of Nordrhein-Westfalen and Saarland, as well as RAG AG, and IG BCE (trade union), reached an agreement to end the subsidised production of hard coal in Germany in a socially acceptable way by the end of 2018. Financing the long-term and eternal liabilities of the hard coal mining industry by RAG AG (such as, mine water management and mining damage) was put on a secure footing with the establishment of the RAG Foundation on 10 July 2007. The closure of the last two German hard coal mines at the end of 2018, marked the end of an industrial era, particularly in the Ruhr area, and brought over 200 years of industrial hard coal production in Germany to an end.

Lignite

Unlike hard coal, German lignite continues to remain competitive without subsidies with respect to imported energy resources. The favourable geological conditions in the fields make it possible to use efficient surface mining techniques so that large volumes can be sold to nearby power plants for power generation. Germany has been the largest lignite producer worldwide since the beginning of industrial lignite production.

>> Germany is the world's largest lignite producer

Lignite is produced in three fields in Germany (Fig. 2-5). The Rhenish lignite field in the west produced 5.4 % less in total with a production of 86.3 Mt. Production in the fields in the east of the country (Central German and the Lusatian lignite fields), was maintained at the previous year's level of around 80 Mt. Total German lignite production in 2018 was around 166 Mt (SdK, 2019). 3.65 Gt of lignite reserves are accessible in Germany via surface mines. Other reserves total 32.25 Gt. The lignite resources total 36.5 Gt. RWE Power AG operates three surface mines in the Rhenish field: Garzweiler, Hambach and Inden. Lignite from the Garzweiler surface

mine is supplied to the Frimmersdorf, Neurath and Niederaußem lignite-fired power plants. The Frimmersdorf power plant and blocks E and F of the Niederaußem power plant were transferred to stand-by mode for security of supply reasons on 1 October 2017 and 1 October 2018 respectively. These lignite-fired power plants are no longer used in the regular market and can only be started up again upon request by the transmission grid operator responsible for the system stability of the transmission/power grids. The Hambach surface mine supplies lignite to the Niederaußem, and Goldenberg power plants, and the Cologne Gas and Electricity Company (Gas- und Elektrizitätswerke Köln). The Weisweiler lignite-fired power plant is supplied with lignite from the Inden surface mine.

Production in the Lusatian lignite field is managed by Lausitz Energie Bergbau AG which operates the four surface mines in Jänschwalde, Welzow-Süd, Nochten and Reichwalde. Lausitz Energie Kraftwerke AG operates the lignite-fired power plants in Jänschwalde (Block F in stand-by mode for security of supply reasons since 1 October 2018) Boxberg, Lippendorf/Block R and Schwarze Pumpe. Both of the aforementioned companies – formerly Vattenfall Europe Mining AG and Vattenfall Generation AG & Co. KG respectively – have been operating under the shared LEAG brand name since autumn 2016, and are owned by the Czech energy company Energetický a Průmyslový Holding (EPH) and its finance partner PPF Investments.

Three surface mines are active in the Central German lignite field: the Profen and the Vereinigtes Schleenhain surface mines operated by Mitteldeutsche Braunkohlengesellschaft mbH (MIBRAG) − which was completely taken over by the Czech holding EP Energy in 2012 − as well as the Amsdorf surface mine operated by Romonta GmbH. Most of the lignite from the former two surface mines is used for power generation in the Schkopau and Lippendorf lignite-fired power plants. However, the lignite produced in the Amsdorf surface mine is solely used for the production of raw montane wax.

>> Most of the production from the German lignite fields is used for power generation

Total lignite turnover in the reporting year declined by around 2.9 % to approximately 166.3 Mt. Lignite's share of primary energy consumption closely matched the previous year's level and accounted for 11.3 % (50 Mtce). Around 90 % of German lignite production is used for power generation in lignite-fired power plants and fed into the national grid. The lignite-fired power plants accounted for 22.5 % of gross power generation in 2018, and were therefore the second most important source of energy in the German power mix after renewables. The workforce in the lignite mining industry declined slightly during the reporting period to 15,872 nationally, and thus 0.2 % lower than the previous year (AGEB, 2019, Kaltenbach & Maassen, 2019).

Nuclear power

The key factor in the energy transition is the withdrawal from nuclear power production. With the 13th amendment to the Atomic Energy Act adopted on 6 August 2011, the German government sealed the end of the use of nuclear power for commercial power generation. The act stipulates that the last nuclear power plant in Germany will be switched off in 2022 at the latest. The withdrawal takes place in phases, with specific shutdown dates. A total of 37 nuclear power plants were built in Germany, starting in 1962, for the commercial generation of electricity. Only seven were still in operation in 2018. They will be switched off according to the following time schedule at the end of the year mentioned:

- 2019: Philippsburg 2,
- 2021: Grohnde, Gundremmingen C and Brokdorf,
- 2022: Isar 2, Emsland and Neckarwestheim 2.

>> 6.4 % of primary energy from seven nuclear power plants

The share of nuclear power of primary energy consumption (Fig. 2-2) sank further to 829 PJ (2017: 833 PJ). This corresponds to a share of primary energy consumption of 6.4 % (2017: 6.2 %). In terms of public power supplies, nuclear power had a share of 11.8 %, and therefore came in fifth place behind renewables (34.9 %), lignite (22.5 %), hard coal (12.9 %) and natural gas (12.9 %).

646.1 TWh power were produced in Germany in 2018. Power generation was therefore slightly down year-on-year (minus 1.2 %; 2017: 653.7 TWh). The share of nuclear power of gross power generation was close to last year's level with 76.0 TWh (2017: 76.3 TWh). Before eight nuclear power plants were closed in 2011, there were 17 nuclear power plants operating with a gross capacity of 21,517 MW_e. There are currently only seven nuclear power plants, with 10,013 MW_e (gross) capacity, connected to the grid.

>> Uranium in German nuclear power plants is 100 % imported

The demand for natural uranium in nuclear fuel was 1,644 t. This demand was covered by imports and from inventories. The amounts of natural uranium required for fuel production were almost exclusively derived on the basis of long-term contracts with producers in France, Canada, and the Netherlands.

After the closure of the Soviet-German company Sowjetisch-Deutsche Aktiengesellschaft (SDAG) WISMUT in 1990, there has been no more mining in Germany for the production of natural uranium. As part of the flood water treatment of the Königstein remediation site operations, natural uranium has been and will continue to be separated out on occasions (2018: 0 t).

However, the treatment works at the Königstein site is currently being modified to adapt it to future requirements, and will no longer incorporate the technical processing steps required for selective uranium separation. In future, uranium will be treated alongside other heavy metals. The main remediation tasks at Wismut GmbH's remediation sites continues to be water management and the treatment of contaminated water from flooded mines, and the remediation of industrial settling plants. In 2018, the six water treatment facilities handled around 12.3 million m^3 of contaminated water in total, and discharged the clean treated water into the river system.

The decommissioning and remediation of former production sites and facilities operated by SDAG WISMUT entered the 28th year of clean-up operations in 2018. The work is undertaken on behalf of the Federal Ministry for Economic Affairs and Energy by Wismut GmbH, and the work is technically supported and evaluated by the Federal Institute for Geosciences and Natural Resources (BGR). The main remediation objectives (decommissioning of the mines, flooding of the underground workings, water treatment, dismantling and demolition of contaminated facilities and buildings, remediation of heaps and slurry ponds, environmental monitoring) are now more than 90 % complete. Of the Euro 7.1 billion set aside for this major project, around 92 % (Euro 6.5 billion) had already been spent by the end of 2018.

Geothermal energy in Germany

There are three main regions in Germany with favourable conditions for deep geothermal energy: the North German Basin, the Upper Rhine Graben in the west, and the Molasse Basin in the south. In the three German states of Baden-Württemberg, Bavaria and Rheinland-Pfalz, ten power-generating sites in total were active in 2018. Specifically, these are as follows: Bruchsal (2010), Dürrnhaar (2012), Grünwald/Laufzorn (2014), Holzkirchen (2018), Insheim (2012), Kirchstockach (2013), Landau (2007), Sauerlach (2013), Taufkirchen (2018) and Traunreut (2016); here, the year of commissioning is provided in parantheses. With a total installed electrical capacity of 43 MW_e, around 166 GWh_e were produced in 2018 (Weber et al., 2020). Another facility with 4.5 MW_e is currently under construction at Garching a. d. Alz (Weber et al., 2020).

>> Installed capacity 43 MW_e, and 166 GWh_e total production in 2018

Heat remains the largest use of geothermal energy in Germany, accounting for 57 % of the total geothermal energy consumption. Of this number, around two thirds are accounted for by private households (BDEW, 2019). In 2018, renewables achieved the highest share of the heating of new private homes for the first time, of which geothermal energy plants supplied around 16 % (DESTATIS, 2019). The growth trend for the use of heat pumps continued further in 2018: 84,000 heating heat pumps were sold in Germany in this year, corresponding to a year-on-year growth of 8 % (BWP, 2019), and a total produced thermal volume of 4400 MWth (Weber et al., 2020).

After the strong growth rates in the previous ten years, the installed capacity for the direct thermal use of geothermal energy has also stagnated since 2016 at almost 375 MW_{th}, and an annual production of approximately 1377 GWh_{th}/a. (LIAG, 2019). The installed capacity is divided between the following three sectors: building heating (84 %), thermal baths (15 %), and district heating (1 %). Whereas for heat production, a slight shift in terms of heat production can be observed: building heating (65 %), thermal baths (34 %) and district heating (1 %), data according to LIAG (2019).

Geothermal energy production in Germany contributed again 0.082 % of primary energy consumption, which totals 13,106 PJ in the reporting period 2018 (BMWi, 2019c). If geothermal energy were used at a wide range of scales and at various depths (Weber et al., 2020), its major potential could be used for a much large number of applications in the future.

>> Major geothermal energy potential in Germany remains unused

SEIGER — Monitoring of deep geothermal power plants and possible seismic impacts

The SEIGER research project is funded by the German government and part of the Seventh Energy Research Programme. It is intended to support the achievement of the overriding objectives of the energy transition. The joint project, co-ordinated by the Federal Institute for Geosciences and Natural Resources (BGR), investigates various aspects of induced seismicity in the Munich area and in the Upper Rhine Graben. BGR is joined in this project by the Friedrich Schiller University Jena (FSU Jena), the Johann Wolfgang Goethe University Frankfurt am Main (JWGU Frankfurt), the Ludwig Maximilians University Munich (LMU Munich), BESTEC GmbH Landau in der Pfalz (BESTEC), DMT GmbH & Co. KG Essen (DMT), and the Institute for Innovation, Transfer and Consultation gGmbH Bingen (ITB). The project is scheduled to run for three years, and concluding at the end of April 2022. The joint project comprises the following sub-projects:

- Data gathering and evaluation of the impact of induced seismicity and co-ordination of the joint project (BGR, DMT).
- The Südpfalz research network − real time monitoring, network optimisation and public relations (BGR).
- Development of a cost-effective array system for the regional and synchronous seismic monitoring of geothermal power plants and reservoirs (JWGU Frankfurt).
- Deep geothermal energy in intra-urban regions (LMU Munich, DMT).
- Mapping of seismically active faults during the production operations and the possibility of forecasting them prior to drilling (BESTEC, ITB).
- Automatic determination of moment magnitude for induced seismicity associated with deep geothermal energy projects (FSU Jena).

The aim of this project is the prediction of induced seismic activity related to the use of deep geothermal energy and therefore providing the possibility to incorporate the results already in the planning phase to evaluate risk assessment.

The SEIGER joint project is funded by the Federal Ministry for Economic Affairs and Energy (BMWi) and supervised by the Projektträger Jülich (PTJ) under project number: 03EE4003A.

Renewable energy resources

The proportion of renewable energy in Germany's energy supply mix is growing. This is due to the Renewable Energy Act (EEG) adopted on 1 April 2000, and amended in 2014 and 2017. The German government has the aim, on the one hand, of raising the share of renewables of gross end energy consumption to at least 18 % by 2020, and generating 40 % to 45 % of the electricity used in Germany from renewable energy by 2025 (BMWI 2017; BMWI 2018). The target for 2030 is to raise the share of power consumption to 65 %, and to boost this further to 80 % by 2050 (Fig. 2-8). The second pillar of the energy transition alongside the expansion of renewables is energy efficiency. The demand for primary energy in Germany is to be slashed to 50 % of the 2008 figure by 2050 (BMWI 2019d).

The implementation of renewable energy has primarily focused to date on the power sector. Around 35 % of the power in Germany is currently generated by renewables. Windpower and biomass are the most important renewable energy resources for power generation in Germany. Additional contributions are made by solar power, hydropower and geothermal energy, which all play their part in satisfying the energy consumption.

>> 35 % of power and 14 % of primary energy consumption from renewables

IPower production from windpower (onshore and offshore) totalled 111.6 billion kWh, and accounts for a share of 18.6 % of the German power mix, putting it in second place in the power generation ranking in Germany behind lignite (AGEB, 2019). Despite this potential, the expansion of windpower on land experienced a strong decline in 2018 (minus 55 % compared to the previous year). Although there are many reasons for this, the main problems are associated with approval and tendering procedures. Windpower plants with a total capacity of 2,273 MW were commissioned onshore in Germany in 2018 (UBA, 2019), which is the lowest level since 2013. Despite the relatively low expansion in the number of windpower plants onshore, the favourable wind conditions meant that 5 % more power was generated year-on-year with a total of 92.2 billion kWh.

The offshore wind farms also generated 9 % more electricity than the previous year. The main reason, in addition to the good wind conditions in 2018, is the continuous expansion of offshore wind farms in recent years. Whilst the offshore windpower generation in 2014 only stood at 1.4 billion kWh, this had already risen to 19.3 billion kWh in 2018. Germany has a total installed windpower capacity (onshore and offshore) of over 58,980 MW (Tab. A-44 in the Appendix).

>> Windpower and biomass the most important renewables for power generation

The second most important renewable energy resource for power generation in Germany is biomass. 51.3 billion kWh of electricity were generated from biogenic fuels (solid, liquid and gaseous biomass) in 2018, with almost 9,000 MW of installed capacity. In addition to biogas, this also includes landfill and sewage works gas, as well as sewage sludge, not to mention biogenic waste for the generation of power in waste power plants (AGEB 2019). The share of biomass in the German power mix was 8 % as in the previous year. Although there was hardly any change in the installed capacity of solid and liquid biomass, investments are being made particularly in boosting the capacity of existing biogas plants, as well as in building new plants (UBA 2019).

Power generation from solar energy (photovoltaics) continues to be intensely expanded in Germany and has the highest installed capacities of all of the renewables with the exception of windpower. After a decline in the volume of expanded capacity in recent years, there has now been a major increase in expansion. Around 2.9 GW of new photovoltaic power generation capacity was added in 2018, which meant that the expansion framework of 2.5 GW per year defined in the Renewable Energy Act was exceeded for the first time (UBA, 2019). Almost 45,300 MW of installed electrical generation capacity from photovoltaic plants is available in Germany (Tab. A-44 in the Appendix). Power generation from this source rose by 17 % to 46.2 billion kWh in 2018, primarily due to the record high levels of sunshine in 2018.

>> Power generation from photovoltaics rose 17 % compared to 2017

The share of renewables for heat generation in 2018 was almost the same as the previous year at 13.9 %. Because of the mild weather in 2018, total end energy consumption in Germany declined slightly, so that there was also a slight decline in the use of solid biomass (in particular wood) in households. The exception here is the consumption of wood pellets, which rose again (plus 5 %) to 2.2 Mt. With a share of around 86 %, solid biomass (including biogenic waste) is the most important renewable for heat generation.

>> 5.6 % of German fuel demand provided by renewables

Biofuels such as bioethanol, biodiesel and biogas account for the biggest share (88 %) of the renewables used in the transport sector (UBA, 2019). Sales rose further in 2018 by another 5 %. In addition to the use of biofuels, there is also a rising trend in the amount of electrical energy (12 %) used in the transport sector.

Although there has been a significant rise in the number of electric vehicles on the road from 53,861 in 2017 to 83,175 in 2018, their overall share in Germany continues to be very low compared to the total number of vehicles registered in Germany totalling 57.3 million in 2018 (KFB, 2019). There is also a big difference between rail transport and road transport when it comes to power consumption from renewables and conventional power generation sources: the power consumption by electric vehicles totalled around 0.2 billion kWh/a, and thus remains well below the consumption of power by the railways which totalled 11.1 billion kWh/a (UBA, 2019).

Analysis of the share of renewables in primary energy consumption (PEC) according to areas of application reveals that the dominant form is power generation with a share of 57 %. The second biggest application of renewables is thermal generation, whereby thermal generation from primarily privately-used systems (stoves, solar thermal systems, heat pumps, etc.) with a share of 24 %, easily dominates the applications, whilst the use of heat generation in industrial power plants only accounts for 6 %. Another 6 % is used in the transport sector as ad-mixtures to petrol and diesel fuels, and another 6 % is used by industry (AGEB 2019). With a share of the renewables in PEC of almost 54 %, biomass is the dominant energy form (Fig. 2-10), followed by windpower (22 %), solar power (11 %), waste (7 %), hydropower (3 %), and geothermal energy (3 %).

>> *Primary energy consumption in Germany down around 3.5 %*

PEC in Germany declined to 12,963 PJ in 2018, and was therefore down almost 3.5 % year-on-year. Over the long-term as well, statistical analysis reveals a reduction in energy consumption in Germany, as well as a step-wise reduction in the use of fossil energy resources for the generation of energy. Compared to 2001, primary energy consumption in Germany has declined by 12 % from 14,679 PJ (2001) to 12,963 PJ (2018), whilst the proportion of renewables in PEC has quadrupled at the same time from 427 PJ (2001) to 1,809 PJ (2018). Each of the renewable energy resources made different contributions to this growth (Fig. 2-8). With the exception of hydropower, the proportion of all renewables in PEC has grown considerably in the last 17 years. The planned further expansion of renewables in Germany will lead to another increase in their share, and a lower demand for fossil fuels as a consequence. At the same time, there will be an increase in weather-related fluctuations in energy generation because of the variable character of most renewable energy resources in Germany.

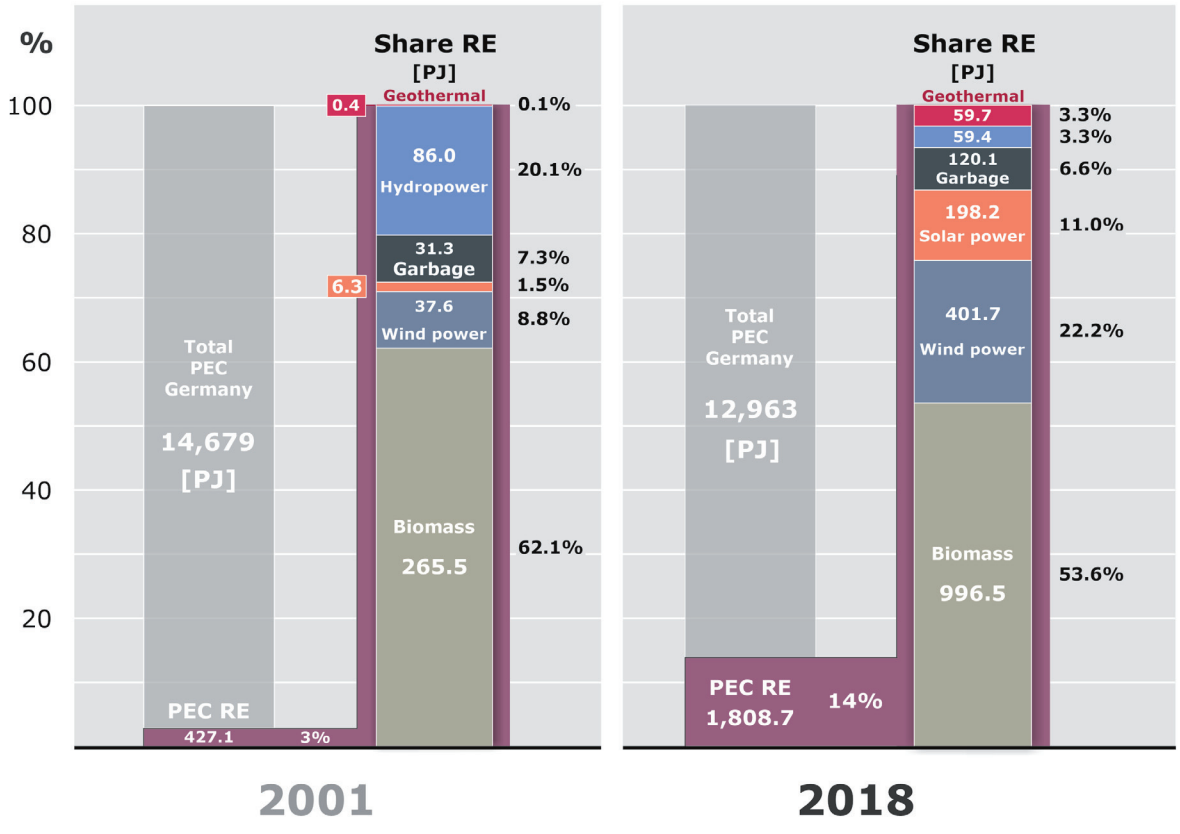


Figure 2-8: Primary energy consumption in Germany in 2001 and 2018, as well as a comparison of the share of individual renewables (Data: AGEB, BMWi).

3 Energy resources worldwide

The global demand for energy has risen almost continuously for many decades, whilst the changes in the energy mix appear only marginal (Fig. 3-1). However, the dramatic change from biomass to coal, and the subsequent step-wise change to today's energy system based largely on fossil energy resources, is only revealed within a historical time frame. The latest development is the increasing establishment of "modern" renewables such as solar power and windpower since the start of the new millennium. However, every new energy source added to the mix, has so far only served to cover the additional demand rather than displace already established energy resources. As a consequence, the volumes of all energy resources consumed has grown in recent years, and reached new record levels in the case of crude oil and natural gas in 2018 to satisfy the world's demand for energy.

The increase in human population numbers worldwide, combined with a rise in general living standards, will result in a growth in energy demand in the long term as well, despite the gains being made in improving energy efficiency. Notwithstanding the increasing shift in the global energy mix, a limited number of energy resources will continue to make the biggest contributions to satisfying energy supplies. Without a considerable boost to the modification of the global energy system, fossil fuels will continue to remain indispensable in the long term as well. To continue to adequately satisfy the growing global demand for energy, fossil fuels as well as nuclear power will continue to play a major role in the coming decades as well (Fig. 3-1).

Following the global review of the reserves situation, a more detailed look is undertaken at individual fossil fuels and energy resources in terms of reserves and potential, production, consumption and important developments. Deep geothermal energy is the only energy resource in the geological sector which counts as a renewable energy. It is therefore documented in a separate chapter.

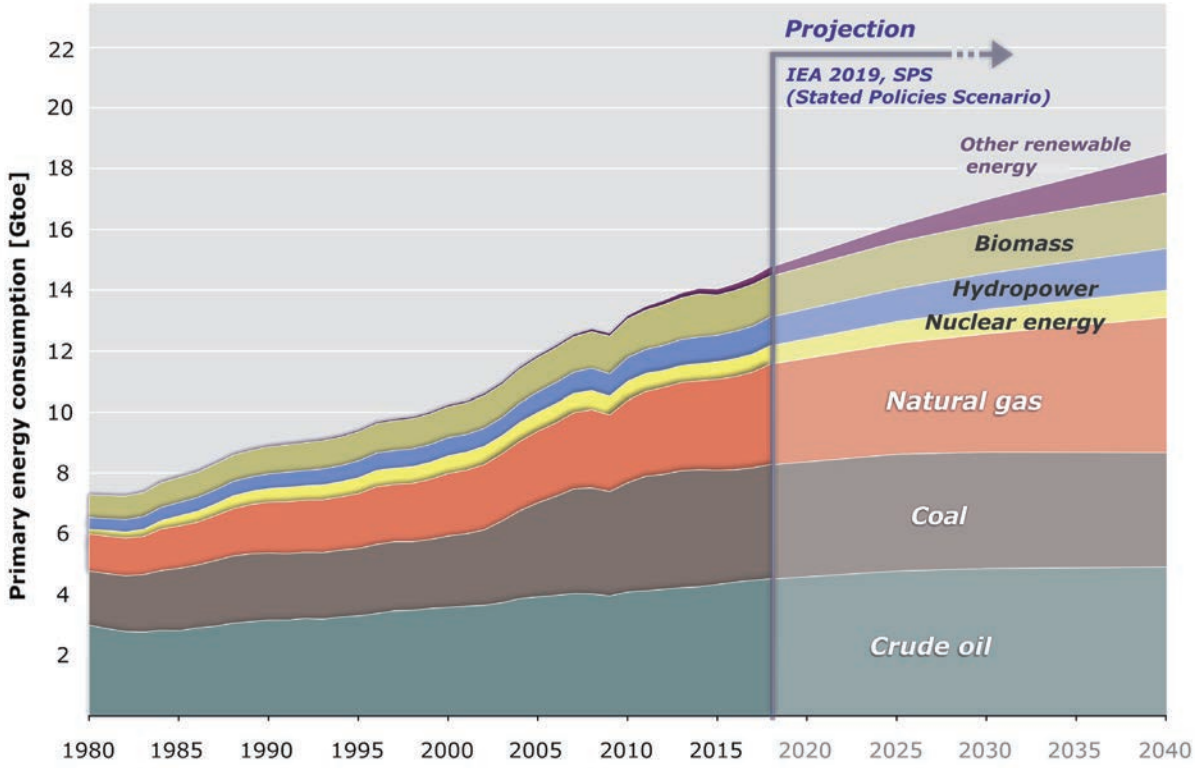


Figure 3-1: Development of global primary energy consumption according to energy resources (IEA 2019a: Stated Policies Scenario), and a possible scenario for future development (after BP 2019, IEA 2019a).

3.1 Global reserves situation

Table 4 shows all known global potential for fossil energy resources including nuclear fuels. This is supplemented by a visualisation of the theoretical CO_2 emissions released by their use (calculated after IPCC, 2006). Values come from the totals derived from the country data as listed individually in Tables A-8 to A-44 in the Appendix. It also includes figures on the global resources of aquifer gas, natural gas from gas hydrates, and thorium, because their quantities cannot be broken down to individual countries. Despite gaps in the data, unconventional potential is presented as far as possible. These include the resources and reserves from shale oil, bitumen (oil sand), ultra-heavy oil and oil shale, as well as tight gas, shale gas and coal bed methane. The study pursues a conservative approach overall, so one of the main criteria is the potentially economic production of energy resources. For this reason, the enormous in-place quantities, which are not considered to be producible, even in the long term according to today's understanding and technology, are not generally listed, or only after providing additional explanations. For this reason, the resources of aquifer gas and natural gas in gas hydrates in particular appear relatively low in this table.

With a share of 504,805 EJ, the largest proportion of non-renewable global energy potential is defined as resources, and exceeds the reserves figure several times over. The resources sank significantly overall by around 8.3 % compared to the previous year (BGR, 2019). Growth in the resources was primarily attributable to

Table 4: Reserves and resources of non-renewable energy resources, as well as theoretical CO_2 emissions (calculated after IPCC, 2006)

Fuel	Unit	Reserves			Resources		
		(cf. 2nd column)	EJ	Gt CO_2	(cf. 2nd column)	EJ	Gt CO_2
Conventional crude oil	Gt	173	7,230	530	214	8,942	655
Shale oil	Gt	3.2	133	9,8	67	2,813	206
Oil sand	Gt	26	1,079	115	67	2,785	298
Extra heavy oil	Gt	42	1,752	187	42	1,767	189
Oil shale	Tcm	< 0.5	7.2	0.77	112	4,681	501
Cude oil (total)	Tcm	244	10,201	843	502	20,988	1,850
Conventional natural gas	Tcm	191	7,243	406	324	12,314	691
Shale gas	Tcm	9.9	376	21	203	7,713	433
Tight gas	Tcm	–[1]	–[1]	–[1]	57	2,184	123
Coalbed methane	Tcm	1.8	67	3.7	44	1,690	95
Aquifer gas	Tcm	–	–	–	24	912	51
Gas hydrates	Tcm	–	–	–	184	6,992	392
Natural gas (total)	Tcm	202	7,685	431	837	31,805	1,341
Hard coal	Gtce	636	18,634	1,763	13,702	401,583	37,990
Lignite	Gtce	123	3,608	364	1,399	41,014	4,142
Fossil fuels (total)	–	–	40,129	3,402	–	495,390	45,323
Uranium[2]	Mt	1.3[4]	640[4]	–	12[5]	6,238[5]	–
Thorium[3]	Mt	–	–	–	6.4	3,178	–
Non-renewable fuels (total)	–	–	40,769	3,402	–	504,805	45,323

– no reserves or resources

[1] included in conventional natural gas reserves

[2] 1 t U = 14,000 to 23,000 tce, lower value used or 1 t U = 0.5 x 10^{15} J

[3] 1 t Th assumed to have the same tce-value as for 1 t U

[4] RAR recoverable up to 80 USD / kg U

[5] Total from RAR exploitable from 80 to 260 USD/kg U and IR and undiscovered < 260 USD / kg U

conventional crude oil (plus 27 %), and shale oil (plus 13 %), because of exploration and re-evaluations. Lower resources are primarily associated with lignite (minus 21 %), hard coal (minus 8.4 %), and coal bed methane (minus 13 %), due to re-evaluations. A comparison of all of the energy resources reveals that coal (hard coal and lignite) continues to dominate with a share of 87.7 % (Fig. 3-2). Way behind in second place are natural gas resources, accounting for 6.3 %, and which is dominated by unconventional deposits. The other energy resources, including crude oil (4.2 %) play a very subordinate role in terms of the energy content of their resources.

>> Slight rise in global reserves of energy resources

The energy content of the reserves in 2018 totalled 40,769 EJ, and was therefore up around 1.3 % compared to the previous year. The biggest changes were associated with shale oil (plus 46 %) and shale gas (plus 12 %) as a result of exploration activity and the re-evaluation of reserves, particularly in the USA. In terms of energy content, coal continues to dominate the reserves with a share of 54.6 %. Crude oil (conventional and unconventional) accounts for 25 % of the total reserves, natural gas 18.9 %, and uranium 1.6 %. This means that there has only been a relatively small change in the shares of all energy resources compared to the previous year. The amount of crude oil produced during the year was completely compensated for and even exceeded by the re-evaluation of reserves.

Non-renewable energy resources with an energy content of around 545 EJ were produced in 2018. This corresponds to a rise in production of 3 % year-on-year (2017: 529 EJ).

With respect to energy content, the shares of natural gas and hard coal rose in the production mix due to the rise in production volumes on the one hand, and a decline in the production of uranium on the other hand (Fig. 3-2). Crude oil continues to be the most important energy resource (34.2 %), followed by hard coal (31.2 %), natural gas (27.9 %), uranium (4.9 %) and lignite (1.8 %).

Global energy consumption in 2018 was 624 EJ, and this encompasses the total amount of primary energy used worldwide. The global energy mix continues to be dominated by fossil fuels, led by crude oil accounting for 30.2 %, coal (25.6 %), and natural gas (22 %). Nuclear power accounted for a 4.8 % share of PEC worldwide. Of the renewable energy resources, the most important was biomass with 9.1 %, ahead of hydroelectric power (6.4 %). The other renewables including solar power and windpower accounted for a global share of 2 % (BP, 2019, IEA, 2019b).

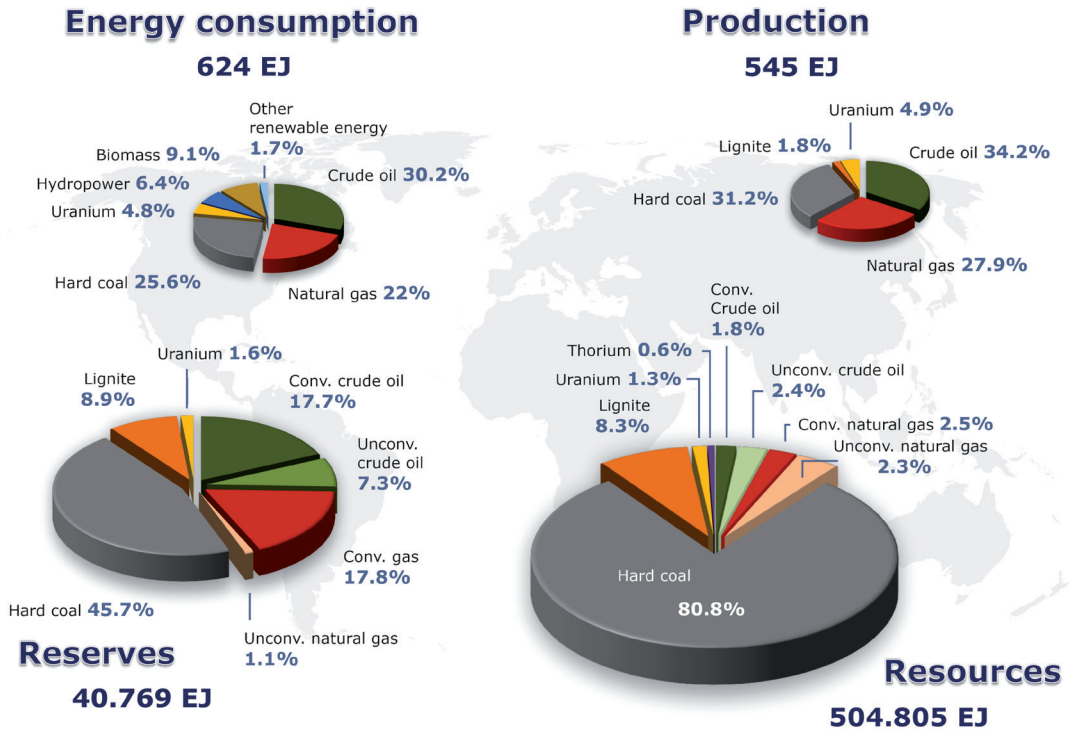


Figure 3-2: Global shares in consumption of all energy types and energy resources (IEA, 2019a), as well as production, reserves and resources of non-renewable energy resources at end 2018. Power efficiency of hydroelectric power calculated after BP 2019.

>> Crude oil, coal and natural gas accounted for almost 78 % of global energy consumption in 2018

According to the information available today, there are still enormous quantities of fossil energy available which, in geological terms, can still cover rising energy demand for several decades. Impossible to answer here is the question of whether all energy resources can individually always be available in future in adequate quantities when required. This challenge affects crude oil in particular because of the low amount of investment in the crude oil sector in recent years, and the advanced degree of depletion of many fields around the world. Whether and when, which energy resource can be used depends amongst others on the geological understanding, the technical and economic extractability, and therefore needs-based availability. The availability of fossil energy resources is secured for many years. However, the focus today is much more on questions relating to sustainability and environmental compatibility. In addition to the expansion of renewable energy, the further growth in global energy demand will have to be covered by the rising production of fossil energy resources in the foreseeable future. Given the current significant decline and further reduction in investments in this sector, one can again expect there to be temporary production shortages and price rises for some natural resources in the medium term.

3.2 Crude oil

Crude oil continues to be the most important energy resource worldwide. Its share of primary energy consumption was around 30 %. Both global crude oil production as well as reserves rose again as in previous years (Tab. 5). The significant rise in crude oil resources is primarily attributable to an improvement in the data available from the Russian Federation and Australia.

Global crude oil reserves are very unequally distributed. The three countries with the highest crude oil reserves − Venezuela, Saudi Arabia and Canada − account for over 45 % of global reserves. Around two thirds of conventional crude oil reserves, which are particularly important for global supplies of liquid hydrocarbons because of their relatively high production efficiency, are located in countries in the Middle East (Fig. 3-3).

>> Three countries account for over 45 % of crude oil reserves

Although global conventional crude oil production has stagnated since 2005, with a share of around 75 % of total production, it will be the backbone of liquid hydrocarbon supplies in future as well (Fig. 3-4). The increase in the overall production of liquid hydrocarbons was primarily achieved by increases in the production of NGL, shale oil, crude oil from oil sands, as well as biofuels.

Table 5: Global development in production and reserves

Production	4.5 Gt	+ 1.9 % →
Conventional Reserves	173 Gt	0.0 %
Unconventional Reserves	71 Gt	+ 1.3 % →
Resources	502 Gt	+ 12.0 % ↑

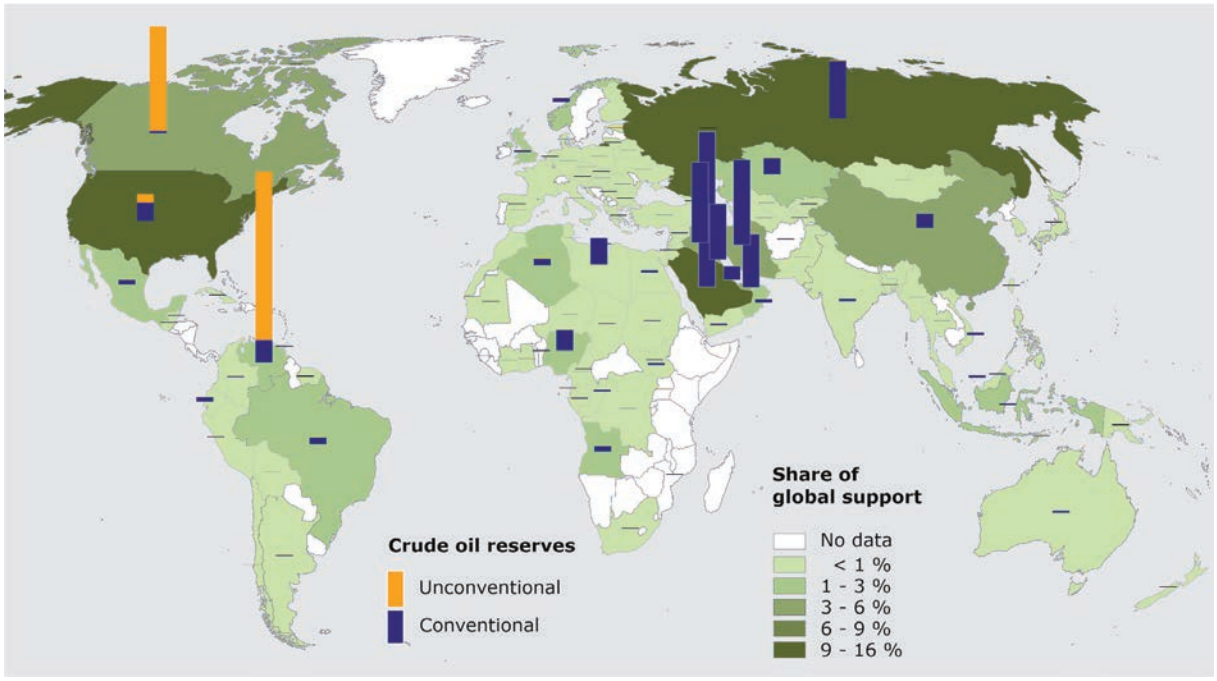


Figure 3-3: Distribution of global conventional and unconventional crude oil reserves.

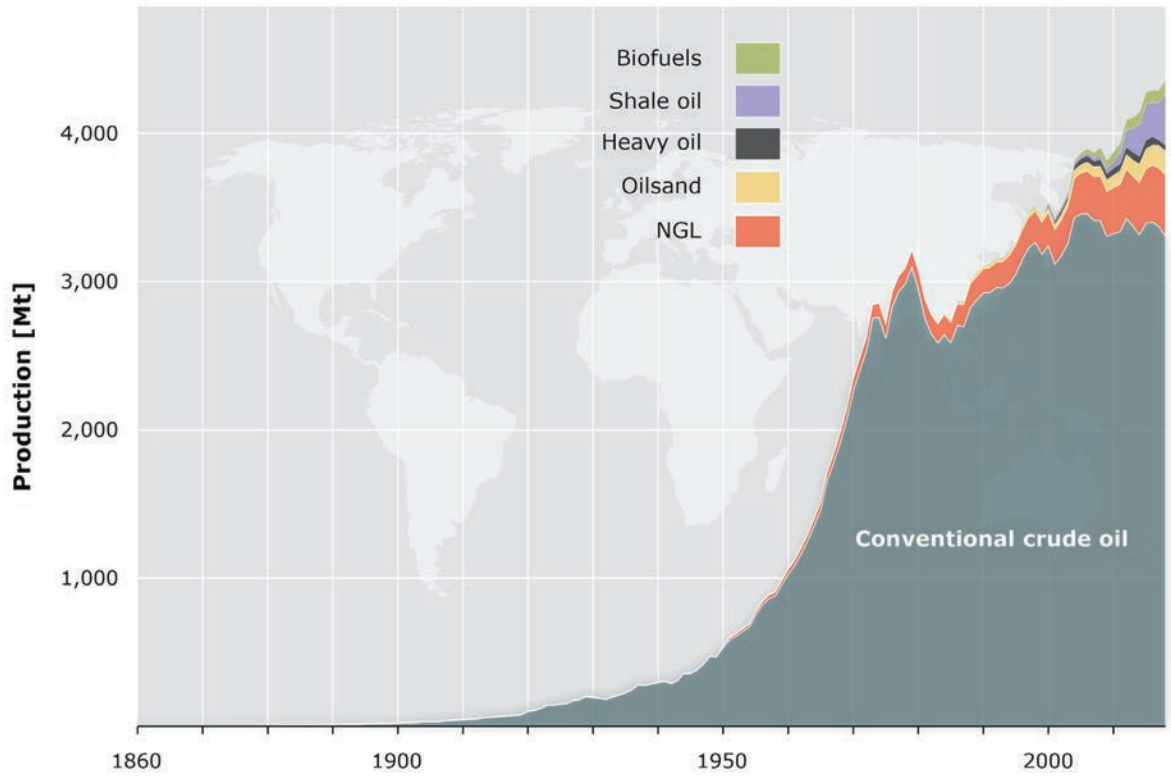


Figure 3-4: Development of global production of liquid hydrocarbons.

NGL is largely a by-product of the processing of natural gas, but is included in crude oil production figures. The increase in the production of natural gas which has continued for decades therefore means there is also a continuing increase in the amount of NGL produced. Unconventional crude oil production has so far been restricted to North and South America. Shale oil is primarily produced in the USA – where it already accounts for a share of 59 % of total crude oil production (EIA, 2019a) – as well as to a lesser extent in Canada and Argentina. Crude oil from oil sands has so far only been extracted in Canada. Production here began in 1967, and has been continually extended ever since. The production of ultra-heavy oil only takes place in the Orinoco ultra-heavy oil belt in Venezuela. This country has, however, been confronted by considerable problems in its oil sector because of the decline in crude oil prices since 2014, and this has led to a major cut-back in the production of ultra-heavy oil.

Although the production of biofuels (bioethanol and biodiesel) has enjoyed annual growth rates of around 9 % in the last decade (BP, 2019), its share of overall liquid hydrocarbon production is very low. The USA and Brazil together account for over 60 % of worldwide biofuel production.

Although every country in the world uses crude oil in the form of fuel (petrol, diesel or kerosene) or petrochemical products, only 102 countries actually produce crude oil. Moreover, crude oil production in volume terms is spread very unequally amongst countries and regions. The top 20 crude oil producing countries alone account for 88 % of total crude oil production. The most important producing region continues to be the Middle East, which accounts for a share of 33 %.

The countries with by far the highest production levels remain the USA, Saudi Arabia and the Russian Federation. Thanks to another significant increase in shale oil production, the USA boosted its crude oil production by another 17 %, to significantly increase its leading position amongst the oil producing countries. The rise in production was attributable to higher productivity (EIA, 2019b), as well as a rise in oil drilling activity compared to the previous year (Baker Hughes, 2019).

>> *Shale oil underpins the USA's position as the leading oil producer worldwide*

There was another significant reduction in production in Venezuela (minus 35 %). The decline in the level of production which began in 2014 worsened again significantly in the reporting year. This decline is primarily a result of many years of inadequate investment in the upstream and downstream sectors (Pein, 2018). There was also a significant decline in production from Iran (minus 6 %). This was attributable to the sanctions put in place by the US government, which came into force in November 2018 (The New York Times, 2018). Oil production in Mexico has also declined further by 7 %. This is due to the increasing depletion of large oilfields in the country, which are difficult to produce, such as Cantarell and the Ku-Maloop-Zaap complex (PEMEX, 2019).

Because oil production has been in decline in Mexico since 2004 (minus 47 %), the Mexican government implemented measures via the state-owned Petroleos Mexicanos (Pemex) to counteract the decline in production by intensifying exploration, developing new fields and expanding the production from already producing fields. A change in the law at the end in 2013 also allows foreign countries to participate directly in hydrocarbon production and exploration

>> *Petroleum consumption rises again*

Global petroleum consumption has risen again compared to the previous year by around 1.6 % to 4,667 Mt. As the world's most important traded commodity, most significant energy resource, and raw material for the chemical industry, the development of crude oil consumption is a major indicator for the state of the global economy. Despite higher prices for the crude reference types compared to the previous year, crude oil continues to be cheaper than the average over the last ten years. This and the positive development of the global economy gave rise to higher consumption.

Over three quarters of the petroleum was used by the 20 leading consuming countries. Of these, only five countries (Saudi Arabia, Russian Federation, Canada, Mexico and Iran) are able, arithmetically at least, to cover their demand from domestic production, and to become (net) crude oil exporters. The countries of the European Union (EU-28) only manage to cover 12 % of their needs from domestic production.

>> *Three quarters of petroleum is consumed in only 20 countries*

Of the crude oil produced in 2018, over half was traded internationally directly as crude oil. Most of the transport takes place via oil tankers and pipelines, and to a very minor extent also by rail or road tankers. Around 2,309 Mt of crude oil were exported worldwide, corresponding to a year-on-year rise of 2.4 %. The two leading exporting countries are Saudi Arabia and the Russian Federation. The five largest exporting countries accounted for almost half of all exports.

The most significant importing regions continued to be Austral-Asia, with a share of around 52 %. Africa imported the least amount of crude oil, with a share of 0.5 % of the total. The largest crude oil importing country in the world was China with 460 Mt (plus 9.5 Mt), followed by the USA with 385 Mt annual imports, and India with 225 Mt. These three countries alone accounted for around 46 % of all imports.

>> *China the largest crude oil importing country*

The average price in 2018 for the US-American reference oil type "West Texas Intermediate" (WTI) was around 65 USD/bbl (EIA, 2019c). This represents a price rise of around 28 % compared with the previous year (around 51 USD/bbl), and continued the trend in rising oil prices which began in January 2016. The oil price rose from the beginning of 2018 with minor fluctuations from almost 64 USD/bbl to 75 USD/bbl at the beginning of October. However, during the last quarter 2018, oil prices slumped significantly to below 50 USD/bbl by the end of the year (Fig. 3-5). The reasons for this were a combination of the increasing oversupply of crude oil in the market, continually rising storage inventories, as well as concerns about a slow-down in global economic activity.

As in previous years, the crude oil market is affected by two counteracting trends: on the one hand, the latent overproduction, largely attributable to the continuous expansion in US-American shale oil production, and the associated pressure on prices, and on the other hand, an attempt by OPEC countries and other leading production countries including the Russian Federation, to offset this overproduction by implementing regulatory measures on production, with the aim of stabilising the oil price.

Revenues from the sale of crude oil and crude oil products account for a large share of government income in many crude oil exporting countries. Oil prices in 2018 lay below the level necessary for some of these countries to balance their budgets (fiscal break-even crude oil price). This particularly affected the oil exporting countries on the Arabian Gulf, which have suffered from the lengthy period of low oil prices (Fig. 3-6).

Against the background of the strong growth in the populations in the MENA region, also predicted in the decades to come (UN, 2019),

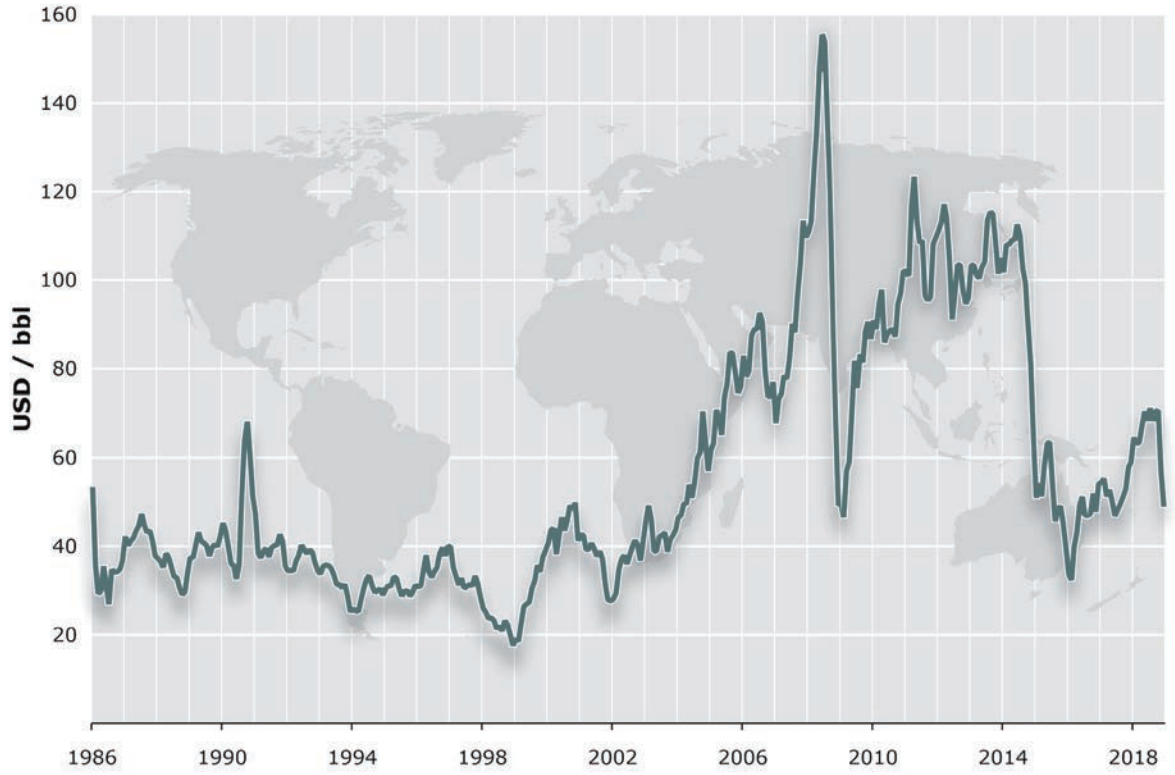


Figure 3-5: Inflation-adjusted development of the WTI crude oil pricebetween 1986 and 2018 (Data: EIA, 2019c, FRED, 2020).

and the low oil prices seen since the end of 2014, the existing dependence on revenues from the oil sector could lead to economic and political instability in the affected countries in future.

Although Saudi Arabia, Qatar and the United Arab Emirates, for instance, have significant foreign currency reserves, and can thus compensate for low oil prices over a long period of time, these national economies have already begun to restructure. The conversion of energy systems which has begun in these countries, as well as many other countries around the world, is aimed at low hydrocarbon energy generation, and raises the possibility of reaching a possible demand peak for crude oil-based products in a few decades time ("peak demand").

Saudi Arabia has so far implemented the most ambitious strategy for restructuring its economy: it presented its VISION 2030 in 2016 (Rashad, 2016) – a plan to diversify the economy and expand public services such as infrastructure, health and education. VISION 2030 is initially to be financed by profits from the crude oil sector. The partial privatisation (1.5 % of the shares) of the state oil company Saudi Aramco should also be seen in this context. The IPO took place in December 2019 with a placing on the Saudi stock exchange in Riyadh (Tadawul).

The storage capacities of OECD countries for crude oil and crude oil products (strategic reserves and industrial reserves) which are stored in caverns or surface tank farms, totalled

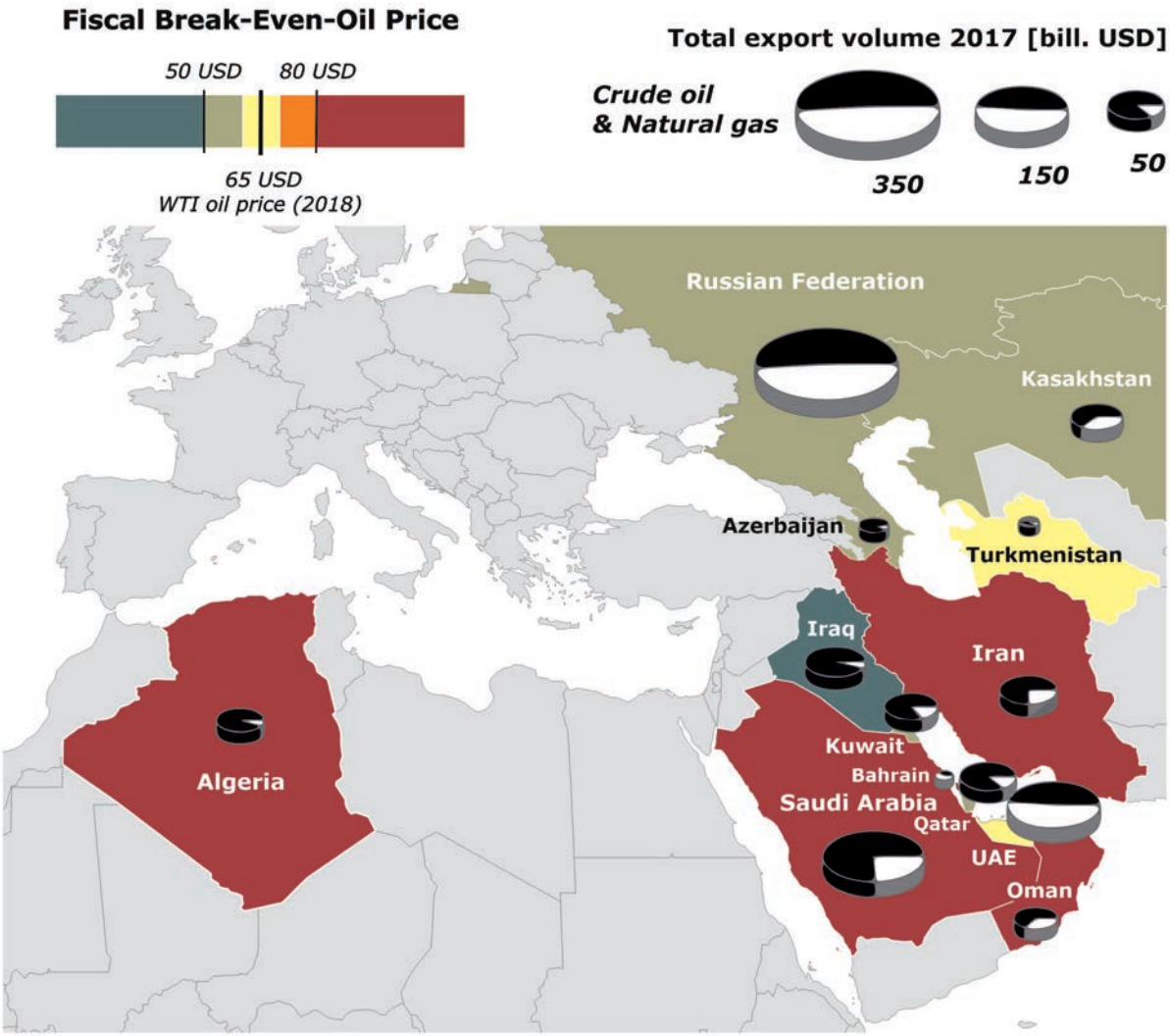


Figure 3-6: Fiscal break-even crude oil price 2018 (Data: IMF, 2019, Forbes, 2018), and total exports 2017 (Data: OEC, 2019).

around 2.858 billion barrels at the end of 2018 (IEA, 2019c). The free production capacity[1] of OPEC countries in the third quarter 2019 was 1.96 million barrels per day (EIA, 2019d).

Tables A-8 to A-14 in the Appendix provide a list of country-specific resources, reserves, production and consumption, as well as crude oil imports and exports (for the 20 most important countries in each case).

1 The additional volume of crude oil available to boost production within 30 days and capable of being maintained for at least 90 days

3.3 Natural gas

With respect to its share of global primary energy consumption, natural gas retained its position as the third most important energy resource behind crude oil and coal in the 2018 reporting year.

>> Global natural gas consumption grows by more than 4 %

Global natural gas resources remain unchanged at around 629 tcm. The global natural gas resources are dominated by conventional fields, followed by shale gas resources accounting for 203 tcm, tight gas with 57 tcm, and CBM with 44 tcm (Tab. A-16 in the Appendix). The largest natural gas resources by far are located in the Russian Federation, followed by the USA, Australia and Canada. Even in terms of conventional gas resources, the largest fields are also found in the Russian Federation, followed by the USA, China and Saudi Arabia (Fig. 3-7).

Considerable natural gas potential also exists in gas hydrate deposits. Estimates of the technically producible resources around the world range from 180 tcm to 300 tcm. However, these figures are not very reliable, and the commercial development and production of natural gas from gas hydrate deposits remains unrealised.

Compared to the previous year, global natural gas reserves remained largely unchanged with a total of 202 tcm (previous year 199 tcm) (Fig. 3-7). Natural gas reserves in the USA rose by around 9 % in 2018, making it the country with the highest assured natural gas reserves for the second year in succession (EIA, 2019e).

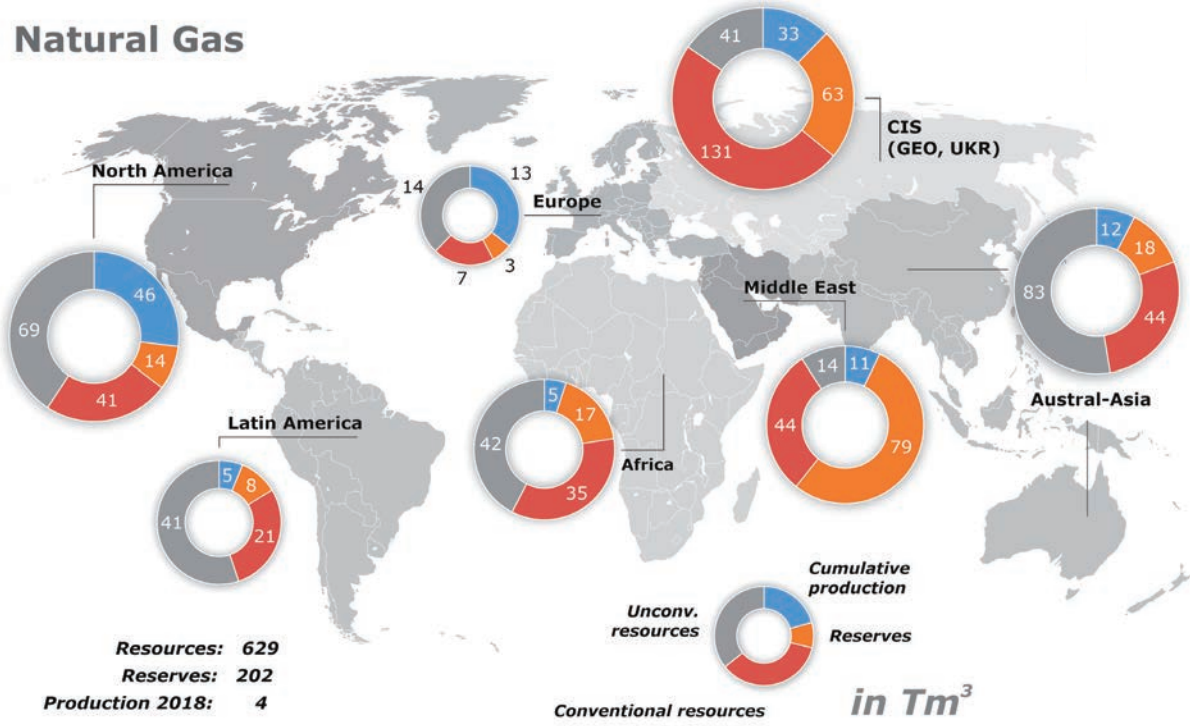


Figure 3-7: Total natural gas potential 2018 (excluding aquifer gas and gas hydrates): regional distribution [tcm].

At a global scale, the share of natural gas reserves in conventional fields lies at around 94 %, whilst unconventional natural gas reserves in shale gas and CBM deposits only account for a small proportion of global reserves (Tab. A-17 in the Appendix). Tight gas reserves are usually not reported separately but included in conventional reserves. Significant shale gas reserves are currently only reported for the USA, where they now account for around 68 % of the total reserves according to the EIA (2019e).

Slightly more than half of global natural gas reserves are in the Russian Federation, Iran and Qatar (Tab. A-17 in the Appendix), and are almost exclusively found in conventional fields. Most onshore reserves are located in the CIS, and in the Russian Federation in particular.

>> The Russian Federation, Iran and Qatar, together account for more than half of global natural gas reserves

The largest offshore reserves are found in the Middle East, of which the dominant share is found in the North Dome/South Pars gas field (Qatar/Iran) in the Arabian Gulf, which is easily the largest gas field in the world. This mega giant natural gas field is estimated to have originally contained almost twice as much producible natural gas as the world's second largest natural gas field, Galkynysh in East Turkmenistan (Tab. 6). The North Dome/South Pars field still contains almost 50 times as much in remaining reserves than the Zohr field discovered offshore Egypt in 2015, which is the largest natural gas field ever found in the Mediterranean (Tab. 6).

The global annual production of natural gas increased by around 5 % in 2018 to 4 tcm (previous year 3.8 tcm). In terms of regions, the largest percentagegrowth in production was found in North America (10 %) and Africa (8 %). Growth in production in Africa is primarily attributable to Egypt, which increased its production by 10 %, thanks to the start of production from the Zohr gas field. There was also a strong increase in production in China (14 %), and Qatar (11 %). Production in the European Union declined year-on-year. In Norway as well, where gas production reached record levels the previous year after three years of continuous growth, natural gas production also declined by around 4 % in 2018.

The USA was the world's largest natural gas producer, ahead of the Russian Federation and Iran (Tab. A-18 in the Appendix). The USA was able to cover all of its natural gas consumption from its domestic production, and has been a net exporter since 2017. The share of shale gas of total US-American gas production rose again and accounted for 69 % in 2018 (EIA, 2019e). Apart from the USA, the only other countries with commercial shale gas production are Canada, China and Argentina, albeit at a much lower level than found in the USA.

Global natural gas consumption rose by 4 % compared to the previous year. The USA continues to be the world's largest natural gas consumer with 849 bcm, followed by the Russian Federation (488 bcm), and China (280 bcm) (Tab. A-19 in the Appendix). The highest percentage increase of the top three natural gas consuming countries came from China at 19 %. Natural gas consumption in the EU declined by around 3 % year-on-year to 523 bcm, to reverse the trend seen in recent years.

Around 1.3 tcm natural gas, and thus 30 % of worldwide natural gas production (around 4 tcm) was traded internationally in 2018. There was a strong increase in interregional natural gas trading. This was primarily attributable to the continuing rapid expansion of liquefied natural gas (LNG). Natural gas imports thus rose by around 2 % worldwide. Europe and North America imported slightly less natural gas than in the previous year (minus 2 %), whilst the decline in Africa was much stronger at minus 35 %. The CIS and Middle East imported

Table 6: The world's largest natural gas fields (1 to 5) and selected examples in various countries

	Field name	Country	Location	Year of discovery	Initial Reserves* [bcm]	Remaining Reserves* [bcm]	Annual production** [bcm]
1	North Dome South Pars	Qatar Iran	Persian Gulf – Offshore	1971 1990	38,000	35,800	255
2	Galkynysh	Turkmenistan	Onshore	1970 2006	21,000	20,500	40
3	Urengoy	Russian Federation	Western Siberia – Onshore	1966	9,500	2,500	77
4	Yamburg	Russian Federation	Western Siberia – onshore	1969	6,200	1,500	60
5	Shtokman	Russian Federation	Barents Lake - Offshore	1988	3,800	3,800	–
	Hassi R'Mel	Algeria	Great Erg – Onshore	1956	2,800	< 500	50
	Groningen	Netherlands	Onshore	1959	2,800	600	19
	Troll	Norway	North Sea – Offshore	1979	1,625	823	36
	Zohr	Egypt	East. Mediterranean – Offshore	2015	700	700	12
	Leviathan	Israel	East. Mediterranean – Offshore	2010	538	538	–
	Aphrodite	Cyprus	East. Mediterranean – Offshore	2011	125	125	–
	Calypso	Cyprus	East. Mediterranean – Offshore	2017	100	100	–
	Coral (Area 4)	Mozambique	West. Indian Ocean – Offshore	2011	2,123	2,123	–
	Snøhvit	Norway	Barents Lake – Offshore	1984	224	182	6
	Salzwedel	Germany	Saxony-Anhalt Onshore	1968	200	2	0.4

*estimated values, partly including resources; **predominant estimated values

slightly more gas than the previous year (3 %), whilst Latin America and Austral-Asia imported a great deal more at 8 % and 11 % respectively. Europe accounted for around 45 % of global natural gas imports. Germany's share of global natural gas imports was 9.5 %, increasing by around 11 bcm compared to the previous year. At a global scale, China became the world's largest gas importing country for the first time in 2018, followed by Germany and Japan. Unlike China and Japan, Germany re-exported a significant proportion of the gas to neighbouring countries: around 40 bcm in 2018 compared to its consumption of around 85 bcm, which makes it the eighth largest consumer in the world (Tab. A-19 in the Appendix).

>> China is the largest natural gas importer for the first time

Whilst Germany imports all of its natural gas via pipelines, Japan (the world's third largest natural gas importing country) imports all of its natural gas in liquefied form (LNG).

The global trade in LNG increased again by around 8 % this time (compared with 10 % in 2017) (GIIGNL, 2019), and accounted for a 46 % share of total natural gas trading (BP, 2019).

42 LNG-importing countries are now served by 20 LNG-exporting countries. New liquefaction plants were commissioned in 2018 in Australia (Ichthys LNG Train 1 & 2, and Wheatstone LNG Train 2), in the USA (Corpus Christi LNG Train 1, Cove Point LNG, and Sabine Pass Train 5), and in the Russian Federation (Yamal LNG Train 2 & 3). A floating liquefaction plant (FLNG) was commissioned in 2018 in Cameroon (Kribi).

>> Trading in liquefied gas (LNG) rose by around 8 %

The largest share of LNG was transported to Asia (76 %). In terms of LNG imports, China (75 bcm) has now overtaken South Korea (61 bcm), and now lies in second place worldwide behind Japan (114 bcm) (GIIGNL, 2019).

Although its export volume shrank slightly to 106 bcm, Qatar was again the world's largest LNG exporting country in 2018 (24.5 % share). Australia followed in second place with 92 bcm and a global share of 21.2 %. Malaysia lies in third place (34 bcm) followed by the USA (28 bcm). The largest increases in exports by the most important countries are reported by Australia (27 %) and the USA (69 %) (GIIGNL, 2019).

With its growing supply network, Europe is connected to a large proportion of the global natural gas reserves, either via pipelines or via LNG terminals in neighbouring countries.

LNG exports to Europe in 2018 came primarily from Qatar (23 bcm), Algeria (13 bcm), and Nigeria (13 bcm). The share from the USA rose year-on-year to 3.7 bcm, which is less than the amount imported from the Russian Federation which totalled 6 bcm (GIIGNL, 2019).

Along with the rise in the price of crude oil in 2018 natural gas prices increased. Natural gas continues to be relatively cheap in the USA because of the large amount of gas available on the supply side. The annual average price (Henry Hub spot price) in the USA was 3.13 USD/MMBtu (previous year 2.96 USD/MMBtu).

The prices for LNG imports to Japan rose by 1.95 USD/MMBtu on average to 10.05 USD/MMBtu. Imported natural gas to Germany cost on average 6.62 USD/MMBtu, and thus around 18 % more than the previous year (BP, 2019).

Tables A-15 to A-21 in the Appendix provide a list of country-specific production, consumption, imports and exports, as well as resources and reserves of natural gas.

3.4 Coal

With a share of 27.2 % of global PEC, coal was the second most important energy resource behind crude oil in 2018 (BP, 2019). With a share of 38.3 %, coal accounted for the largest share of power generation around the world (IEA, 2019b). Of the fossil fuels, coal has the highest specific CO_2 emissions, as well as easily the largest global reserves and resources.

To improve the comparability of the data, this study only differentiates between lignite and hard coal. Hard coal with an energy content of ≥ 16,500 kJ/kg includes sub-bituminous coal, bituminous coal and anthracite. Hard coals are frequently differentiated in coal trading depending on their use as either coking coal or steam coal. Because of its relatively high energy content, hard coal is economical to transport and therefore traded worldwide. Lignite on the other hand (energy content < 16,500 kJ/kg) is primarily used in the vicinity of the lignite field and therefore usually used in power plants because of the lower energy and higher water content.

Total coal resources (total of reserves and resources) shrank significantly by around 10 % compared to the previous year, which is exclusively attributable to the changes in the resource figures (Tab. 7). The global coal reserves at the end of 2018 totalled around 1,070 Gt, split up as follows: 749 Gt hard coal, and 320 Gt lignite. Changes in the resource figures compared to 2017 (BGR, 2019) came about via re-evaluations of the prognostic resources in the Russian Federation (Russian Ministry of Energy, 2019a).

>> Global coal production rose by around 4 % in 2018

Global coal production increased in 2018 to around 8,000 Mt. This represents a rise of 4.1 % year-on-year. Of this, 6,983 Mt (plus 4.9 %) were accounted for by hard coal, and the remaining 1,017 Mt (minus 1.6 %) by lignite.

Tables A-22 to A-33 in the Appendix list the country-specific production, consumption, imports, exports, as well as the reserves and resources of hard coal and lignite.

Table 7: Production of reserves of lignite and hard coal in 2018, as well as year-on-year changes

	Lignite		Hard coal	
Production	1,017 Mt	- 1.6 % →	6,983 Mt	+ 4.9 % →
Reserves	320 Gt	+ 0.2 % →	749 Gt	+ 1.9 % →
Resources	3,672 Gt	- 17.0 % ↓	16,190 Gt	- 8.6 % ↘

Hard coal

The regional distribution of hard coal reserves, resources, and the estimated cumulative production since 1950 is shown in Figure 3-8. The largest remaining potential for hard coal lies in the Austral-Asian region where there is 7,540 Gt, followed by North America with 6,871 Gt, and the CIS with around 1,464 Gt. The world's largest hard coal reserves are found in the USA with around 220 Gt (29.3 % global share). The ranking is followed by China with 133 Gt (17.8 %), ahead of India with 101 Gt (13.5 %). These countries are followed by Australia (9.7 %), and the Russian Federation (9.6 %). In terms of resources, the USA alone has 6,459 Gt, accounting for 39.9 % of global hard coal resources, followed by China (32.9 %) and Australia (9.6 %).

>> Half of global hard coal production takes place in China

The three largest hard coal producers (Fig. 3-9) in 2018 were China, with a share of 50.6 % (3,530 Mt), India (10.5 %) and the USA (9.1 %). Whilst China (plus 4.4 %) and India (plus 8.1 %) expanded their production in 2018, the United States reported a production decline of 1.1 %. The European Union (EU-28) accounted for around 77 Mt − and thus around 5 Mt less than the previous year − and an overall share of 1.1 % of global hard coal production.

Around 20 % of the hard coal produced worldwide was traded in 2018, with a total of 1,412 Mt, of which 1,210 Mt was transported by sea (VdKi, 2019a). This represents a 4.8 % rise in the volume of hard coal traded worldwide compared with the previous year. Indonesia dominated the hard coal world market with exports totalling 429.1 Mt (30.4 %), followed by Australia (27.4 %), and the Russian Federation (14.1 %).

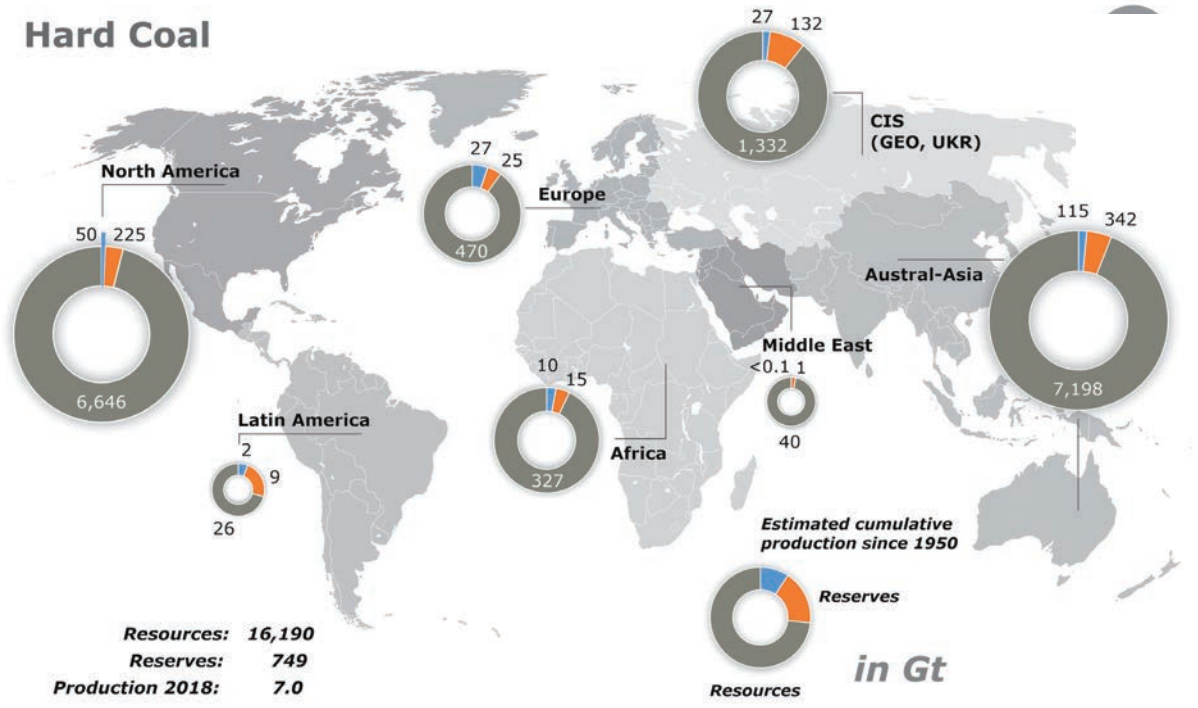


Figure 3-8: Regional distribution of the total hard coal potential 2018 (16,939 Gt).

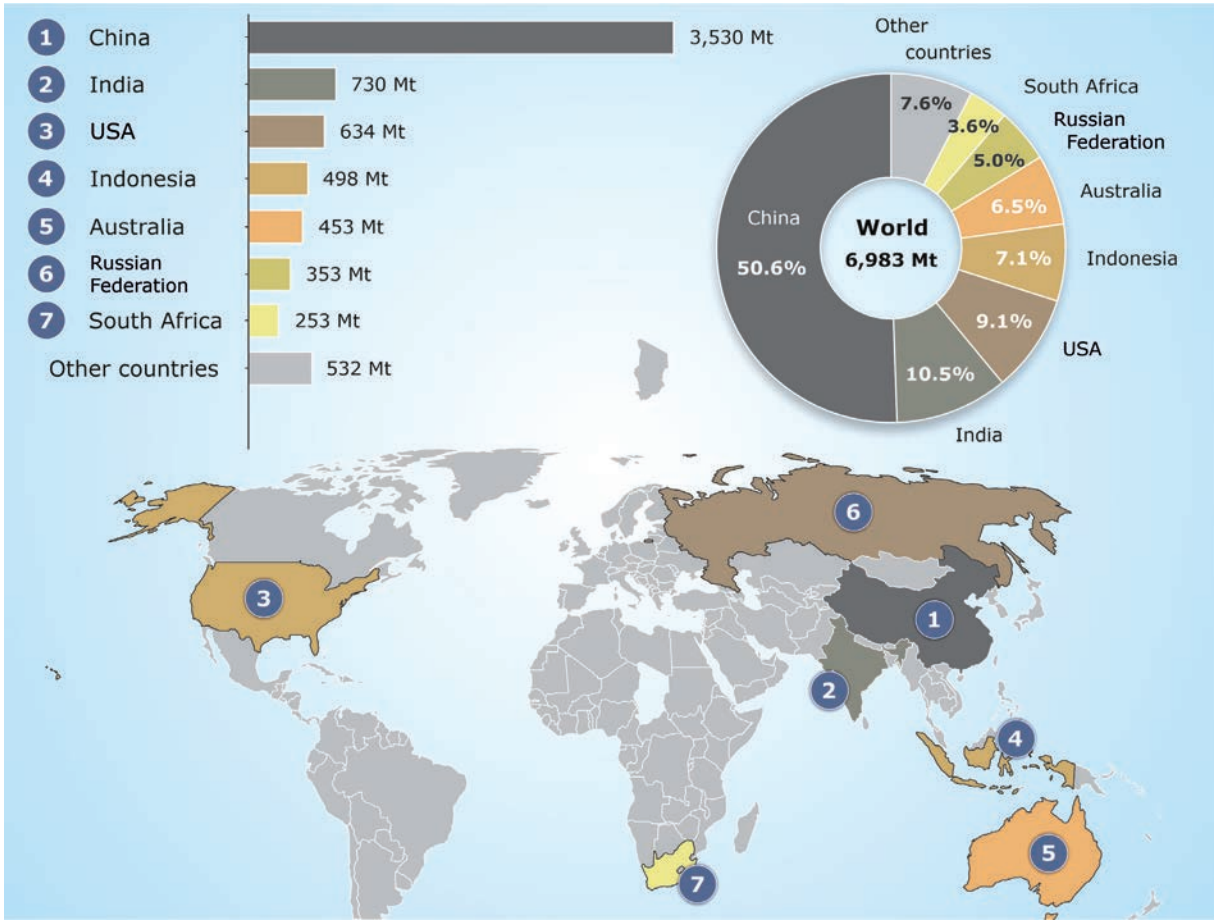


Figure 3-9: The largest hard coal production countries 2018 (> 200 Mt/a) 2018.

>> *Three quarters of imports accounted for by Asia*

Asia dominates the hard coal imports with a share of around 75 % (1,072 Mt). China as well as India increased their imports in 2018 compared with the previous year to 281 Mt (plus 4 %), and around 235 Mt (plus 13 %) respectively. With 165 Mt − and thus around 6 Mt or 3.5 % down on the previous year – the European Union (EU-28) only accounted for slightly more than one ninth of the global hard coal imports, with which it covered around 71 % of its hard coal requirements in 2018.

The Northwest European annual average spot price for steam coal (ports of Amsterdam, Rotterdam and Antwerp; cif ARA) rose by around 10 USD/tce (plus 9.5 %) from 98.38 USD/tce in 2017, to 107.73 USD/tce in 2018. The prices dropped significantly during the course of 2019 to 65.52 USD/tce in November 2019 (Fig. 3-10) (VDKI, 2019b).

>> *Coal prices declining since the beginning of 2019*

Coking coal prices developed similarly to steam coal spot market prices (Fig. 3-10). The

annual average spot prices for high quality Australian coking coal increased by around 10 % from around 189 USD/t in 2017 to around 208 USD/t in 2018. Coking coal prices maintained a level slightly over 200 USD/t until the beginning of summer 2019, before declining continuously to almost 135 USD/t in November 2019 (IHS Markit, 2019).

The development in coal prices in 2019 is explained by the expansion of the trade conflict between the USA and China (and other countries) and the associated cooling effect on the global economy.

Because of the global rise in the demand for energy, the demand for coal has been on the rise again since 2017 (Fig. 3-11) after shrinking significantly from 2013 to 2017 (BGR, 2019). According to the Stated Policies Scenario from the latest World Energy Outlook 2019 from the International Energy Agency (IEA, 2019a; Information on the IEA scenarios: https://www.iea.org/commentaries/understanding-the-world-energy-outlook-scenarios), the absolute global coal demand will remain at around today's level for the next two decades.

Regional changes, such as the halving of demand in Europe, or in North America, are compensated for by growth in Asia in particular, according to the Stated Policies Scenario.

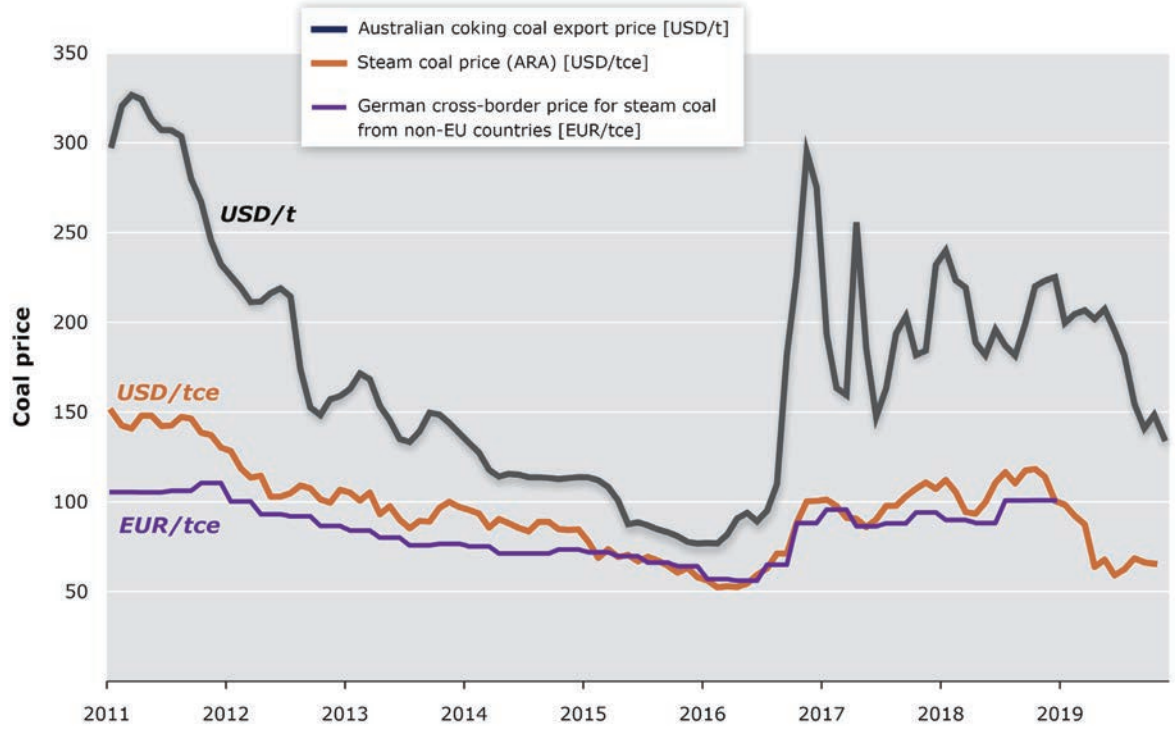


Figure 3-10: Development of Australian export prices for prime hard coking coals, as well as Northwest European and German steam coal import prices from January 2011 to November 2019 (Data: BAFA, 2019c, IHS Markit, 2019, VDKI, 2019b).

The future regional change in demand in the Stated Policies Scenario is also reflected in the expansion or shrinkage in the coal production in the most important coal producing countries (Fig. 3-12): whilst countries like the United States and other countries/regions (including Europe) will probably significantly reduce their shares in global coal production until 2040 – and therefore also in absolute quantities – there will only be minor reductions in South Africa and the Asian producing countries of China and Indonesia, whilst the Russian Federation, Australia and India in particular (BGR, 2019) are expected to experience higher levels of production in future (IEA, 2019a).

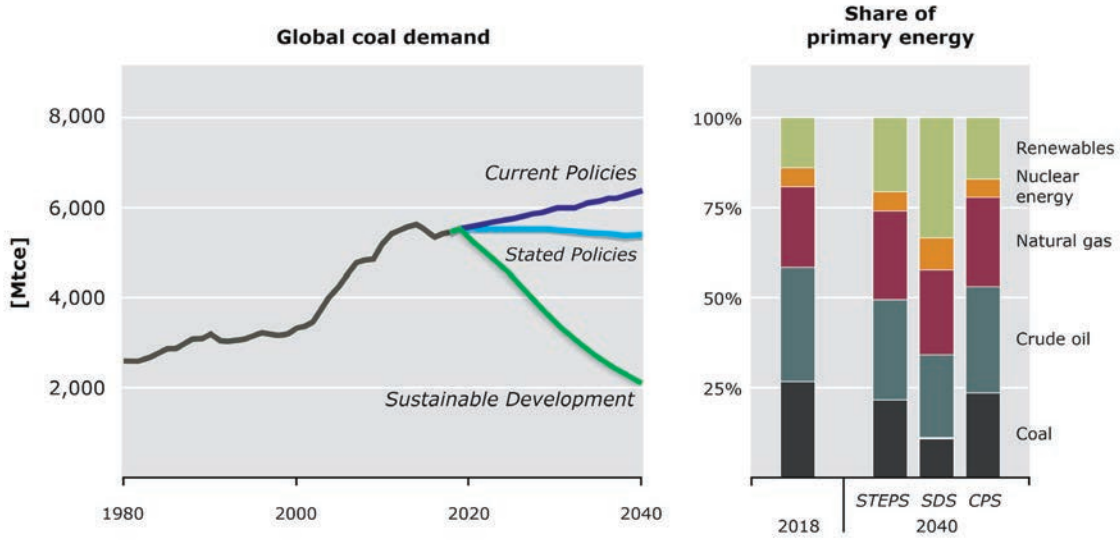


Figure 3-11: Three potential scenarios for the development of future global coal demand (left), as well as the associated pro-rata shares of the energy resources in global PEC (right) (IEA, 2019a).

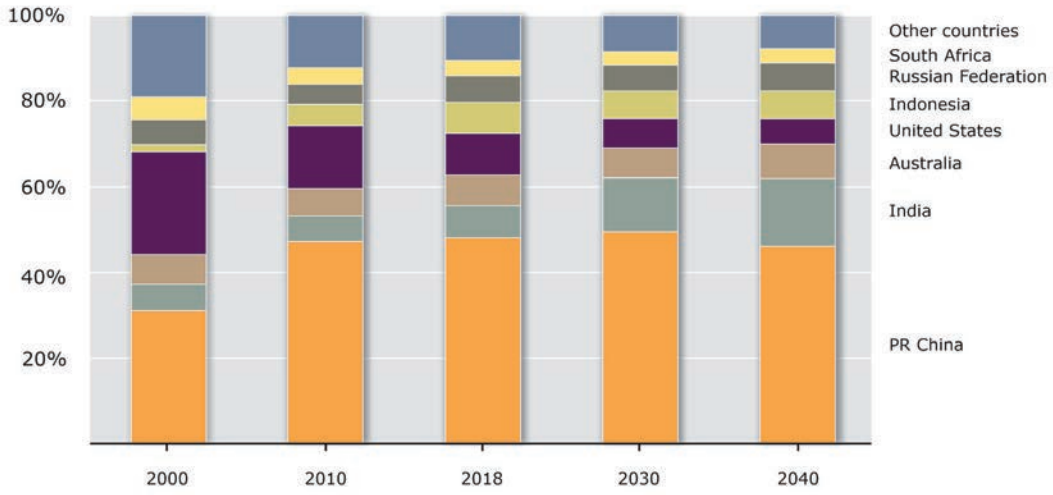


Figure 3-12: The development of coal production according to countries in the Stated Policies Scenario (IEA, 2019a).

Lignite

With around 1,519 Gt, North America has the largest remaining lignite potential, followed by Austral-Asia (1,413 Gt), and the CIS (641 Gt, including sub-bituminous coal) (Fig. 3-13). Of the 320 Gt known global reserves of lignite in 2018, 90.5 Gt (including sub-bituminous coal) or more than one quarter, are found in the Russian Federation (28.2 % global share), followed by Australia (23.9 %), Germany (11.2 %), the USA (9.4 %) and Indonesia (3.7 %). The largest resources of lignite are located in the USA with around 1,368 Gt (37.3 % global share), followed by the Russian Federation (14.7 %, including sub-bituminous coal) and Australia (11 %). More than three quarters of the global lignite production of 1,017 Mt produced in 2018 came from only 10 of the total of 38 producing countries. Global lignite production declined by 1.6 % compared to the previous year. Domestic lignite production in Germany declined by 2.9 % year-on-year, and with a share of 16.3 % (166 Mt) was the world's largest lignite producer, ahead of China (14.7 %), and the Russian Federation (8.4 %).

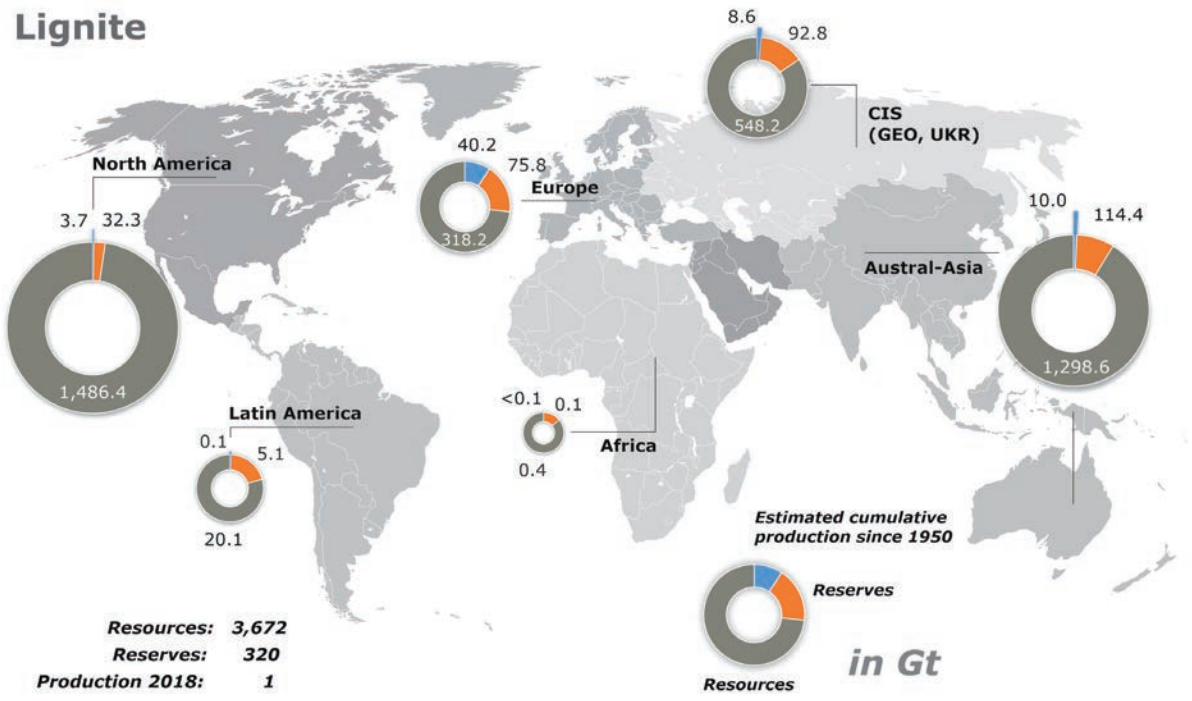


Figure 3-13: Regional distribution of total lignite potential 2018 (3,992 Gt).

3.5 Nuclear fuels

Uranium

After the German government's decision to withdraw from nuclear power, this energy resource continued to decline in significance in Germany, but from a global point of view, it is still an energy resource of high relevance. The demand for uranium will probably sink further in Europe in future, but a rise in uranium consumption can be expected primarily in Asia and the Middle East. (IAEA 2019, OECD-NEA/IAEA 2019, WNA 2019a).

>> In Asia, 142 reactors were in operation, and another 32 under construction in 2018

Global uranium resources[2] are very comprehensive at 12.5 Mt and have therefore risen slightly compared to the previous year. As in previous years, the changes in uranium resources are mainly attributable to only a few countries. As a consequence of the continuing recession in the uranium market (BGR 2017), the growth in global uranium resources remained low in 2018.

Apart from the renewed reporting-related reductions in US-American resources (BGR, 2017), there were significant increases in resources in the Russian Federation and Australia in 2018. Re-evaluations have taken place in these countries in the light of the exploration activities that have taken place there in recent years. Paraguay reported uranium resources in 2018 for the first time since 1986. The volume of resources declined because of the transfer of resources into reserves, mainly in Spain and Kazakhstan. Kazakhstan, the Russian Federation and Australia, are major uranium producing countries (Tab. A-38 in the Appendix) and regularly re-asses their reserves and resources.

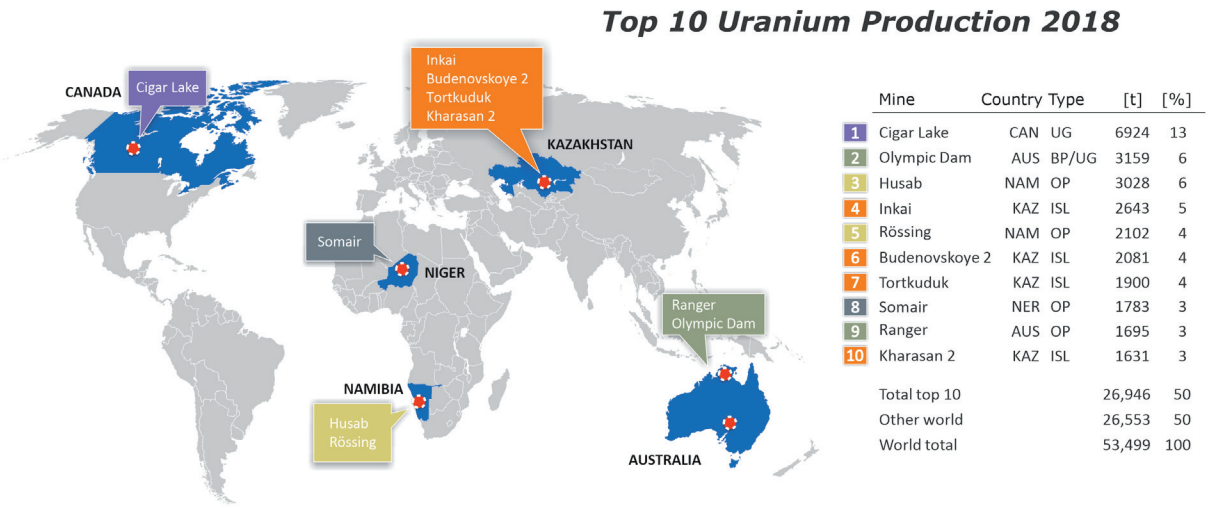
With respect to the reporting of uranium reserves, a purely statistical consideration of the economically recoverable reserves in the cost category < 80 USD/kg U only partially reflects the real situation (BGR, 2014). The production costs of many mines in 2018 continued to be higher than the market price. In the sense of the conservative approach of this Energy Study (cf. BGR, 2014), only uranium deposits in the production class < 80 USD/kg U are counted as reserves. All other potential with higher production costs is reported in this study as resources, even if it is already being mined (Tab. A-37 in the Appendix).

In a similar way to uranium resources, there were only slight changes to uranium reserves compared to the previous year (plus 3 %; Tab. A-36 in the Appendix). Significant rises in reserves were reported for Canada (plus 20 %) and Kazakhstan (plus 18 %), where, on the one hand, the results of exploration in recent years were incorporated in re-evaluations, and on the other hand, resources were transferred into the assured reserves category. Production-related decreases, as well as re-evaluations, led to an overall reduction in reserves in Niger. Global uranium reserves in the < 80 USD/kg U category totalled 1.3 Mt (2017: 1.2 Mt) (Fig. 3-14).

>> Around 93 % of uranium reserves in only 10 countries

Global uranium production continues to decline. Production in 2018 decreased by around 6,100 t U to 53,499 t U overall (minus 10 %). This is attributable to production cuts in some mines implemented as a market regulatory measure, with the aim of counteracting the current oversupply of uranium on the world market (BGR, 2019).

2 Unlike other energy resources, the stocks of uranium (reserves and resources) are divided up according to their extraction costs. The definition for uranium reserves limits extraction costs to < 80 USD/kg U (see definition in the Appendix).



	Mine	Country	Type	[t]	[%]
1	Cigar Lake	CAN	UG	6924	13
2	Olympic Dam	AUS	BP/UG	3159	6
3	Husab	NAM	OP	3028	6
4	Inkai	KAZ	ISL	2643	5
5	Rössing	NAM	OP	2102	4
6	Budenovskoye 2	KAZ	ISL	2081	4
7	Tortkuduk	KAZ	ISL	1900	4
8	Somair	NER	OP	1783	3
9	Ranger	AUS	OP	1695	3
10	Kharasan 2	KAZ	ISL	1631	3
	Total top 10			26,946	50
	Other world			26,553	50
	World total			53,499	100

Figure 3-14: Top 10 global uranium production sites in 2018. The largest single production site was the Canadian Cigar Lake mine with 6,924 t U, and a market share of 13 %. Ranking after amount of Uranium. OP: open pit, UG: Underground, ISL: in-situ leaching, BP: by-product (Data: WNA, 2019b).

Around 82 % of global production is generated in only five countries (Fig. 3-15). Kazakhstan was again the country with the largest volume of production. Although the country again significantly reduced its production compared to the previous year to 21,705 t U (2017: 23,391 t U), as a response to the situation in the global market, it still dominated production with a share of over 40 % of global uranium production. The annual production in Kazakhstan has risen more than five times in the last ten years.

The world mine production of uranium in the last five years lay at around 60,000 t U, compared to an annual consumption of around 65,000 t U. The gap between annual demand and primary production is covered by civil and military inventories, in particular in the Russian Federation and the USA. These inventories were derived from the overproduction of uranium in the period from 1945 to 1990 in the expectation of a growth in civilian demand, as well as for military reasons. The military inventories in particular were successively reduced. The basis for this reduction was the START treaties closed in 1992 between the USA and the Russian Federation, and which covered the conversion of highly enriched weapons uranium (HEU) to low enriched uranium (LEU).

In addition to mine production, this means that uranium from inventories and the dismantling of atomic weapons is available to cover future demand. Another source of uranium is the reprocessing of nuclear fuel elements. The industry here is currently working on increasing the efficiency of reprocessed material. The lifetime of material (reusability), as well as material enhancement (reduction in resource use), are the main priorities of these activities. Reprocessing is controversial because the first fuel cycle (nuclear fission) generates by-products (including plutonium) which have much higher toxic and radioactive properties, and can make reprocessing difficult and more expensive. Around 8 % of the nuclear power plants operating worldwide currently use reprocessed material (so-called MOX fuel) (OECD-NEA/IAEA, 2019).

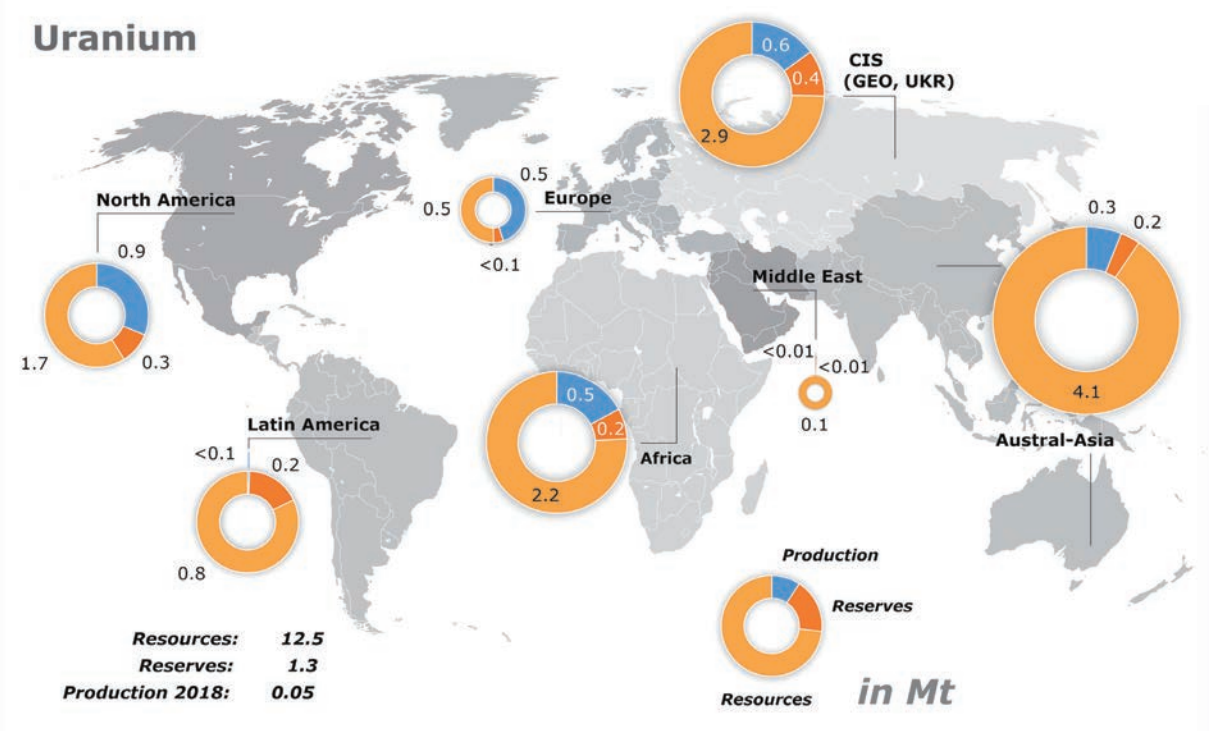


Figure 3-15: Total uranium potential 2018: regional distribution.

Uranium consumption is concentrated in only a few countries. The global demand for uranium was 67,244 t U in 2018 (2017: 65,014 t U), and therefore up 3 % compared to the previous year. Higher consumption of uranium mainly occurred in Asia and the Middle East (Tab. A-39 in the Appendix), and this will probably rise further in the future, particularly in China and India.

Uranium is traded worldwide via long-term supply contracts in most cases. Uranium supplies to EU member countries in 2018 were 12,835 t U (minus 10 %) and thus below the previous year's level (2017: 14,312 t U). As is usual in Europe, the share of supplies based on spot market contracts was only 5 % (European Union, 2019). The uranium market continues to be affected by relatively low spot market prices which continue to jeopardise the profitability of various mines and exploration projects (BGR, 2019).

A growing demand for uranium is expected worldwide in the medium to long term. The growing demand for energy in Asia especially will probably give rise to a higher demand for uranium. Several Asian countries have ambitions to add nuclear power to their energy mixes (BGR, 2019). In Europe as well, uranium will continue to be used as an energy resource in the long term, despite the expected decline in demand due to Germany's and Belgium's withdrawal from nuclear energy, and the moratoria on expansion plans in Italy and Switzerland. Other countries though, such as Finland, France, Rumania, Sweden, Slovakia, Slovenia, Spain, the Czech Republic, Turkey and the United Kingdom, continue to see nuclear power as an important part of their national energy mixes. Poland plans to build its first nuclear power plant by 2033.

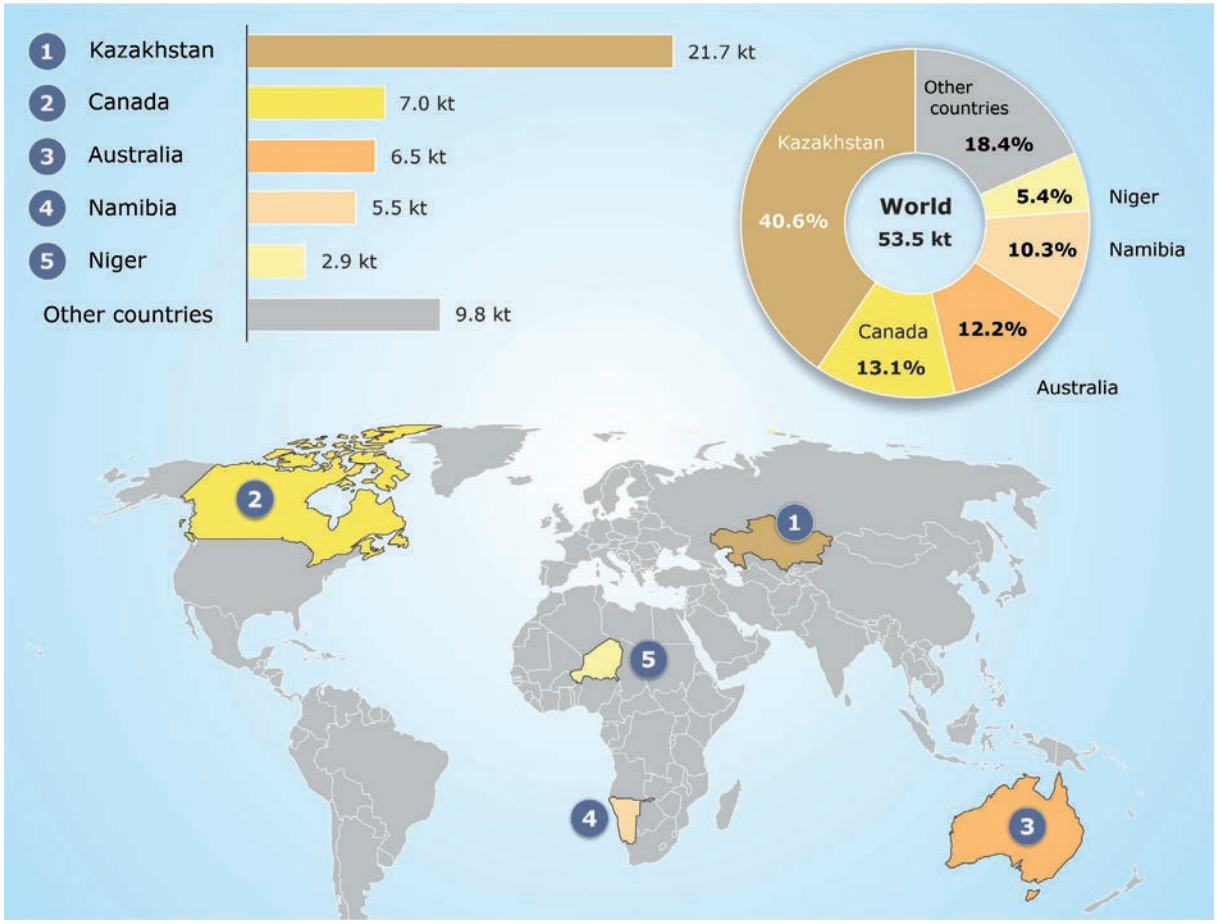


Figure 3-16: The largest uranium production countries 2018.

>> Uranium will continue to have a future as an energy resource in the long term in Europe as well

55 nuclear power plants were under construction in 18 countries at the end of 2018, of which 11 are in China alone. Since the use of nuclear reactors began, over 115 commercial reactors (plus 48 prototypes and 250 research reactors) have been decommissioned worldwide (as at August 2019). Of these, 17 reactors (including research reactors and prototypes) have been completely dismantled (WNA, 2019c). Four decommissioning projects have been completely implemented in Europe, of which three alone in Germany (BfS, 2015). Of the nine nuclear power plants commissioned in 2018, eight were in China and one in the Russian Federation.

From a geological point of view, there is adequate potential available to guarantee long-term global supplies of uranium. The current closure of several mines and the reduction of exploration projects is exclusively attributable to temporary economic conditions. However, the development of new mining projects will become increasingly time and cost intensive (BGR, 2019). Whilst the

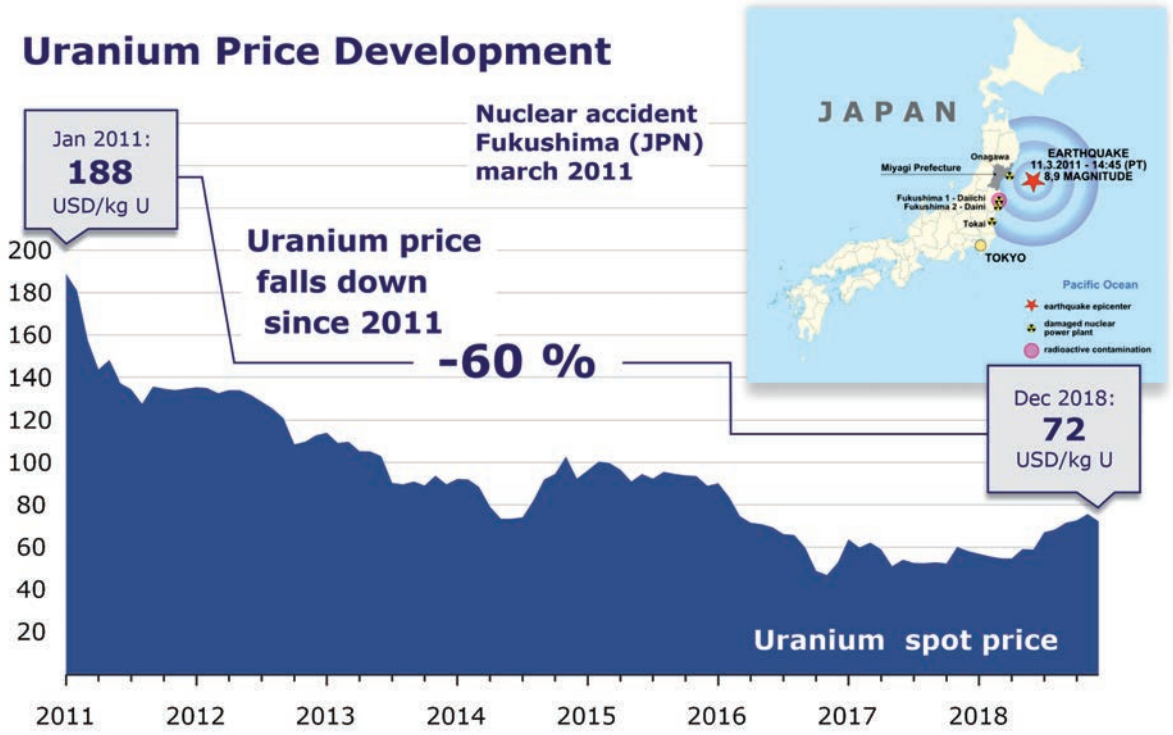


Figure 3-17: Uranium spot market prices from 2011 to 2018. As a result of the reactor accidents in Fukushima in 2011, there was an economic downturn in the global uranium market with falling uranium prices (Data: Cameco, 2019).

development of a new deposit in the 1970s took five to seven years on average, the time period required today is fifteen to twenty years (URAM, 2014).

Tables A-34 to A-39 in the Appendix provide an overview of the country-specific production, consumption, reserves and resources of uranium.

Thorium

Thorium is considered by the scientific community to be a potential alternative to uranium. However, it is currently not used for power generation. There are no commercial reactors operating anywhere in the world using thorium as a fuel. Nevertheless, thorium deposits have been discovered and evaluated in recent years as a by-product of the increasing exploration for other elements (uranium, rare earths, phosphate). The concentration of thorium in the earth's crust averages between 6 g/t to 10 g/t, and is therefore three to four times higher than uranium. Resources reported in 2017 totalled more than 6.35 Mt.

3.6 Deep geothermal energy

Deep geothermal energy is the only geological energy resource which can be counted as a renewable resource. This is due to the fact that the decrease in geothermal energy in the earth's subsurface as a consequence of geothermal exploitation is negligible on human time scales. It is therefore documented separately from the other renewables (see Chapter 3.7).

In the year 2018, there was a growth of four per cent in geothermal power production. The total installed electrical capacity worldwide amounts to 13.2 GW_e[3] (IRENA, 2019; REN21, 2019). However, the share of worldwide geothermally generated power (0.3 %) remains quite low when compared to the total power production. Unchanged to previous years, the major proportion of power generation continues to be covered by non-renewable energy resources (REN21, 2019).

>> The enormous amount of global geothermal potential remains unutilised

In 2018, an installed capacity plus of around 0.5 GW_e was newly commissioned, mainly in Turkey and Indonesia. Together with projects in the USA and the Philippines, the installed geothermal power production reaches a worldwide capacity of now more than 1 GW_e. Countries along the East-African rift system, such as Ethiopia and Kenya, feature major geothermal potentials. However, high costs, project risks, and the absence of a legal basis for the exploitation hinder faster and intensifying expansion. Globally, geothermal power production is still led by the USA, amounting here to 2.5 GW_e. It is noteworthy that the use of so-called "doublettes" is expanding. This reflects the trend towards an increasing use of resources with lower temperatures (REN21, 2019). In addition, combined power plants are gaining significance, i.e. exploiting both hot steam and hot brine for power generation and thermal uses, respectively.

As of yet, data for the year 2018 is currently not completely available for all countries. Figure 3-18 provides an overview of the 27 countries which utilise deep geothermal energy for their power production. Data is mainly based on information from IRENA, EGEC, und REN21.

The installed capacity within the EU-28 reaches 0.9 GW_e. The number of EU countries producing geothermal power remains unchanged at six (Portugal, France, Germany, Italy, Austria, and Hungary). Italy, with 916 MW_e, is still the largest producer of geothermal power within the EU-28. Considering the whole of Europe, i.e. including Turkey and Iceland, it presents a different picture. Similar to Italy, the latter two countries can exploit their geothermal energy in a more intense way because of their favourable geological conditions: Iceland produced 753 MW_e and Turkey 1,283 MW_e (IRENA, 2019). Herewith, the installed capacity of the whole of Europe approaches 3 GW_e. It is expected that the installed capacity will achieve over 3.8 GW_e by 2025 (Sanner, 2019).

The global market for geothermal energy heat utilisation continues to remain stable. In 2018, there was an increase of approximateley 1.4 GW_{th}, bringing the total to around 26 GWth. In particular, activities in Europe and China intensified (REN21, 2019). China, Turkey, Iceland, and Japan remain the leading countries in regard to the use of geothermal energy for heat generation. In addition to employing heat in swimming pools or greenhouses, the largest share is accounted for by the heating (and cooling) of buildings.

Europe, besides China, is one of the most active markets for the use of geothermal heat.

3 A direct comparison is not always possible with the figures from previous years because of delays in announcing data and data publications.

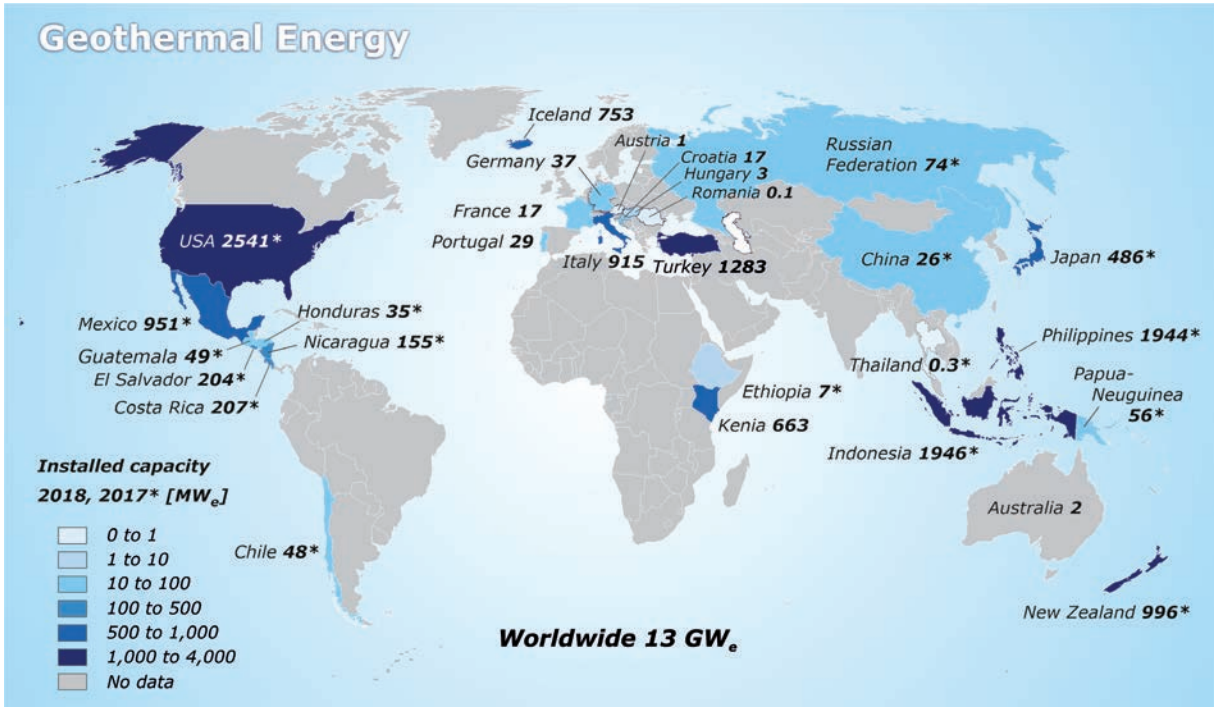


Figure 3-18: Countries using geothermal energy for electricity production. Due to the limited data for 2018, some data as of 2017 were presented.

Despite the fact that its expansion dropped slightly compared to the two other geothermawith its demand for heating greenhouses, France is also worth mentioning. It increasingly used geothermal energy for heating in and around Paris. Nevertheless, the expectations with regard to the further expansion in the future are not quite as ambitious as in previous years. Stated reasons are attributable to the general economic situation, as well as more realistic predictions (Sanner, 2019).

>> *Europe's ambitions regarding the further expansion of geothermal energy to generate heat decreased*

As is also the case with power generation, no comprehensive global country data is available covering the use of geothermal energy for heating in 2018. A data compilation is given in the Tables A-40 to A-42 in the Appendix. They provide the available country-specific installed capacity (electrical and thermal), consumption (electrical), as well as the technical potential (resources) of deep geothermal energy.

Despite positive growth figures, expansion still fails to match the potential. Higher drilling costs and exploration risks often scare off potential investors. Despite that geothermal energy could make a large contribution to achieving the climate protection goals, particular in the district heating sector.

3.7 Renewable energy resources

At the end of 2015, the international community initiated an internationally binding climate treaty at the UN Climate Conference in Paris, with the intention of restricting global warming to a level well below 2 °C (UNFCCC 2015). This treaty comes into force if ratified by at least 55 countries which are responsible in total for at least 55 % of total global greenhouse gas emissions. After ratification by the USA[4] and China on 3 September 2016, as well as the European Union (including Germany), Canada and Nepal on 5 October 2016 (UNFCCC 2019), the conditions were satisfied for the treaty to come into force on 4 November 2016. The treaty has currently been ratified by 187 countries (as at: November 2019). The energy transition with an expansion of renewable energy as the central energy resource, and other accompanying measures, is indispensable to achieve the targets formulated in the Paris Treaty.

>> Paris Climate Agreement signed by 187 countries

Around 18 % of global primary energy consumption in 2018 was covered by renewable energy (Fig. 3-2 PEC WORLD). Over half is provided by biogenic energy resources, of which the main proportion accounting for around 40 % is solid biomass, and particularly firewood. In developing countries in particular, the production of energy still primarily involves the use of wood and charcoal. However, in industrial countries as well, there is a rise in the number of privately used systems such as wood stoves and pellet heating systems for the generation of heat. After biomass, hydroelectric power is another "classic" renewable energy resource, and accounts for a share of around 3.6 % of global primary energy consumption, and is therefore the second most important renewable. "Modern" renewables such as solar power and windpower still only cover around 2 % of global primary energy consumption. However, their expansion has enjoyed the highest growth rates in recent years.

>> Renewable energy accounts for 64 % of new power generation capacities installed around the world

As in the previous year, the new power generation capacities installed around the world are primarily accounted for by the expansion of renewable energy resources. Their share in 2018 totalled around 64 % (2017: 70 %). This means that the annual increase in renewables exceeds the expansion of fossil fuels for power generation by a factor of almost two (REN21, 2019). The reasons include the changing political frameworks which favour the expansion of renewables. Another factor is the technology costs, particularly for solar and windpower, which have dropped significantly in recent years, and thus improved the competitiveness of renewables. Photovoltaics in particular dominated the installation of new capacities in the power sector in 2018. Around 55 % of the newly commissioned capacity for renewables was accounted for by the expansion of photovoltaic systems. This expansion approximately corresponds to the net nominal capacity of conventional power plants in Germany totalling 113 GW (BNetzA, 2019). Around half (45 GW) of the newly installed photovoltaic plants were installed in China. With respect to windpower and hydroelectric power, the new capacities installed worldwide totalled 51 GW and 20 GW respectively in 2018.

The global capacity for power generation from renewables is around 2,351 GW (Fig. 3-19). This compares to the global capacity for nuclear power available in 2018 of around 425 GW (gross). With over one quarter of the globally installed capacity (696 GW), China is the leading country in renewable power generation (Tab. A-44 in the Appendix). 352 GW of this is accounted for in

4 President Donald Trump in the USA announced in June 2017 that the country would withdraw from the Paris ClimateTreaty. However, the withdrawal of the USA from the Treaty cannot come into force until 2020.

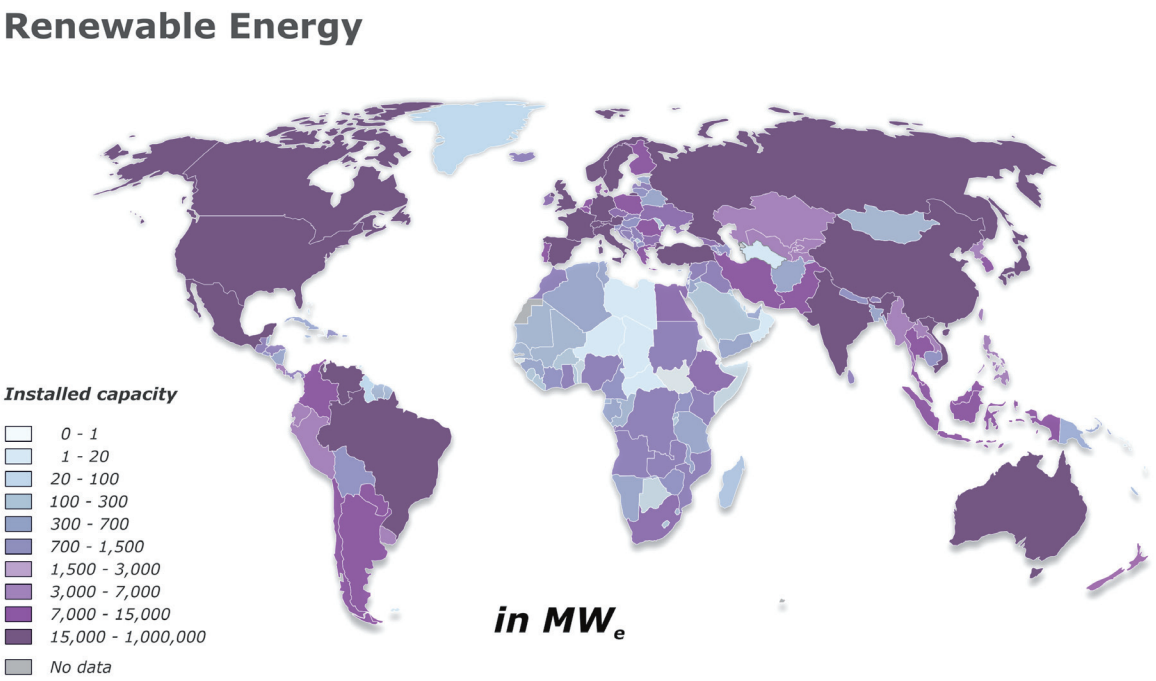


Figure 3-19: Total potential of the installed capacity of renewables for power generation (2,351 GW): regional distribution (Data: IRENA, 2019).

China by hydroelectric power alone, plus another 185 GW windpower and 175 GW photovoltaics.

Windpower and photovoltaic power are being expanded extensively. However, the amount of power actually generated from these sources is relatively low. Although the total share of renewables is already 26 % of global power generation, this is dominated by hydroelectric power. Windpower, photovoltaics and biomass only accounted for a total of around 10 % of power generation in 2018 (REN21, 2019). Power generation from renewables is dominated worldwide by hydroelectric power. In Germany, however, over half of the power generated from renewables came from windpower (111 billion kWh; 17.3 % of German power production), whilst photovoltaics accounted for 46 kWh (7.1 %) (see Chapter 2.2).

Over half of the energy from renewables used for power generation worldwide is accounted for by China, USA, Brazil and Canada (Fig. 3-20).

The expected further expansion of capacities will enable the share of renewables in power generation capacities to grow further in future. In addition to geographical factors, country-specific strategies and targets of countries in particular will be crucial in determining in which direction the expansion of renewables heads in future. Already, over 20 % of the electricity demand in Denmark, Germany, Greece, the United Kingdom, Honduras, Ireland, Portugal, Spain and Uruguay is covered by windpower and photovoltaics (REN21, 2019). 100 % of Iceland's electricity needs are covered by renewables (79,2 % hydropower; 20,7 % geothermal energy; 0.06 % windpower) (IEA, 2019b). Around 35 % of the

demand for electricity in Germany in 2018 was covered by renewables (2017: 33 %) (see Chapter 2.2).

>> *Germany is the biggest producer of biodiesel in Europe*

Renewable energy resources are also gaining in importance in the mobility and transport sectors in the form of biofuels (ethanol and biodiesel), although at a much slower rate than in the electricity generation sector. Biofuels currently account for 0.9 % of global end energy consumption. Global production in the last 14 years has increased more than four times from around 30 billion litres (2004) to around 153 billion litres (2018) (REN21, 2019), and a further rise is expected. The leading producers are the USA and Brazil. Over 60 % of ethanol fuels and biodiesel are sourced from these two countries. Germany as well is a major producer of biodiesel: with 3.5 billion litres in 2018 (3 % global share) it is Europe's biggest biodiesel producer. The integration of e-mobility in the mobility and transport sector, including the already global use of rail

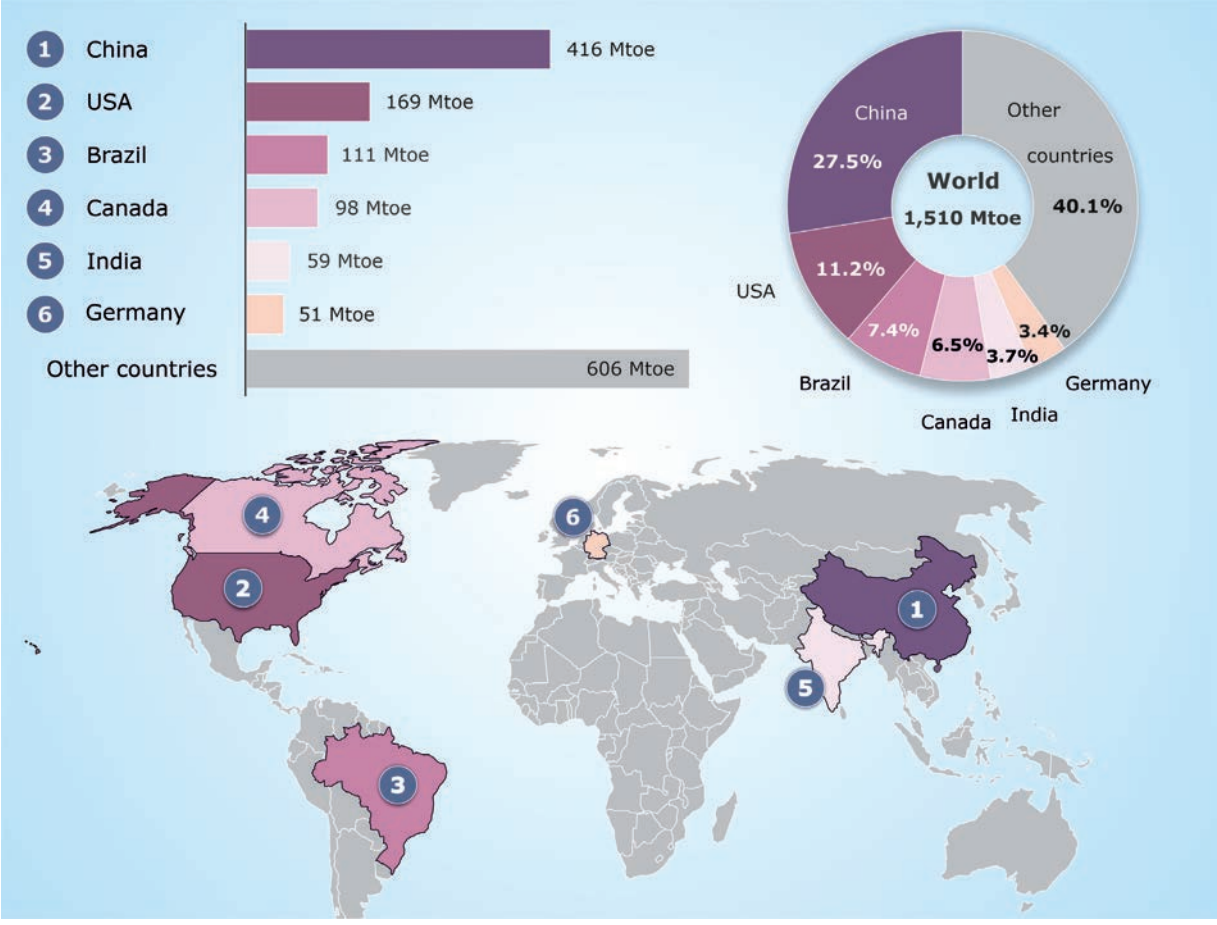


Figure 3-20: The largest users of renewables for power generation 2018.

transport, is being further expanded. Norway and China are today's leading countries in the use of e-mobility. Around 5.1 million electric cars (2017: 3 million) and over 260 million two-wheeled electric vehicles, are currently being used worldwide – and the trend is rising (REN21, 2019). Its use in heavy goods vehicles on the roads, as well as in ships, is also being developed and/or expanded. The share of renewables in transport sector consumption currently accounts for around 3.3 %.

Tables A-43 to A-44 in the Appendix list the country-specific installed electrical capacities as well as the power consumption from renewables.

4 Energy resources in focus (special topic)

4.1 China's growing demand for hydrocarbons

The energy needs in China have risen considerably in recent decades because of the country's enormous economic development. The country has had to come to terms for many years now with a rapid increase on its dependence on imports, particularly for crude oil and natural gas.

Consumption of natural gas in particular has risen considerably in recent years. This is attributable amongst other things to the measures implemented by the government to restructure the coal sector. This strategy is aimed at closing small mines with low production capacities, and increasingly replacing coal with natural gas (coal-to-gas switch), primarily with the aim of getting to grips with air pollution.

According to the China Energy Outlook 2050 (CNPC, 2018), there will be a further increase in the consumption of crude oil and natural gas. According to the outlook the demand for oil products will reach a peak in 2040 with a demand of 690 Mt, followed by a decline to 570 Mt by 2050. The domestic production of crude oil remains relatively constant at around 200 Mt/a. Compensating for the decline in production from mature oilfields means a major programme of development of new oilfields, as well as the use of modern production technologies to enhance the recovery rates from existing fields. Crude oil is also produced to a minor extent from very low permeability rocks (tight oil) (CNPC, 2018).

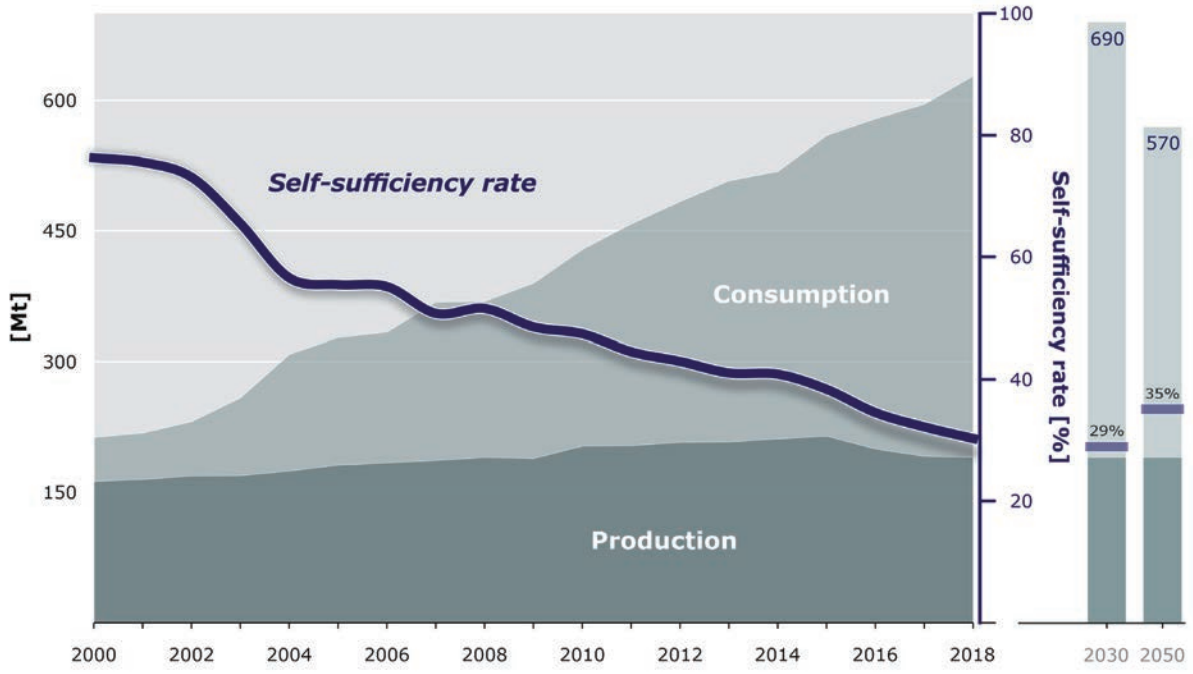


Figure 4-1: Crude oil production and consumption from 2000 to 2018 in China, as well as projections to 2030 and 2050 (Data: CNPC, 2018).

The growth in the consumption of natural gas is expected to continue beyond 2050, although growth is expected to flatten out considerably beyond 2040. Forecast natural gas consumption in 2035 is 620 bcm, and 650 bcm in 2050. The domestic production of natural gas is expected to grow to 300 bcm by 2035 (and to 350 bcm by 2050). The production of natural gas from unconventional deposits such as shale gas, coal bed methane (CBM), and, to a lesser extent, methane from marine gas hydrates, is expected to have a share of around 50 % of total production from 2035 (CNPC, 2018).

>> Massive rise in China's natural gas needs forecast

Import situation

China was the world's largest importer of crude oil and natural gas in 2018. Although the country imports hydrocarbons from numerous countries, the main supplier regions were the Middle East and Central Asia (Fig. 4-3).

The most significant importing region for crude oil for China is the Middle East, which accounts for around 38 % of total imports. However, the most important single supply source of crude oil is the Russian Federation (16 %).

Unlike crude oil, which China has imported (net) for many decades, the country only became a (net) importer of natural gas in the middle of the 2000s. The first large-scale imports of LNG began in 2006, and the first pipeline gas imports in 2010. In recent years, China has rapidly

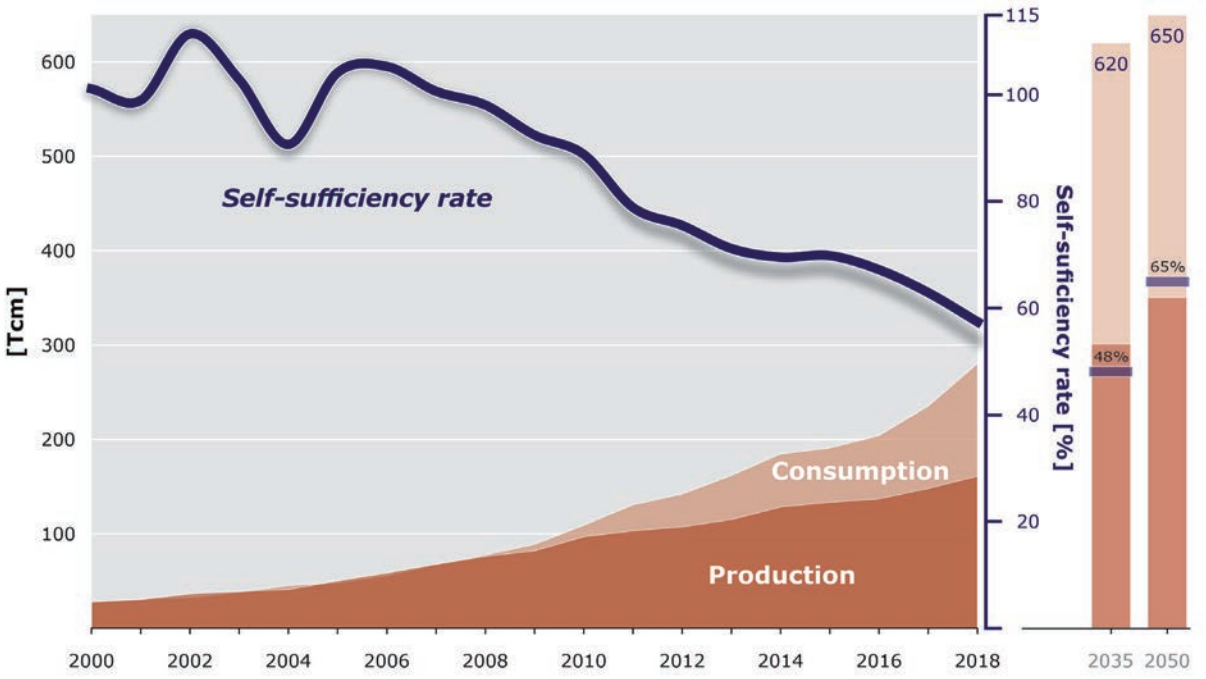


Figure 4-2: Natural gas production and consumption from 2000 to 2018 in China, as well as projections to 2030 and 2050 (Data: CNPC, 2018).

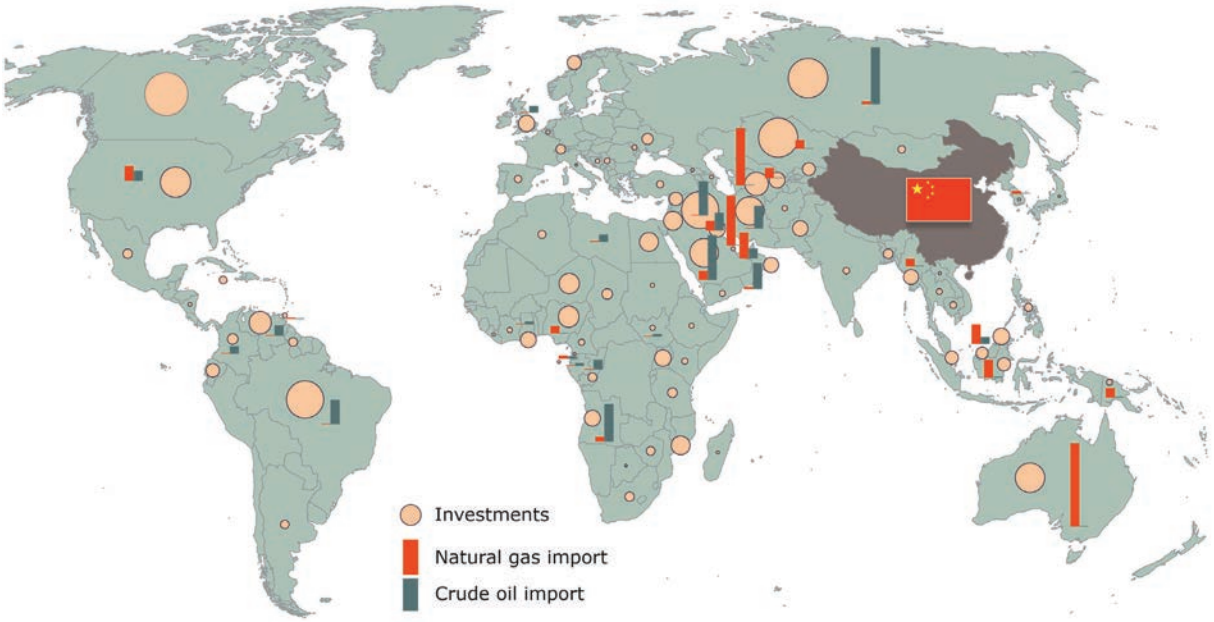


Figure 4-3: Relative size of country-specific crude oil imports, as well as natural gas imports in China in 2018 (ITC, 2019), and overseas investment in the hydrocarbons sector since 2005 (Data: AEI, 2019).

expanded its LNG import infrastructure in particular because LNG has the advantage of enabling China to import the natural gas it requires quickly and flexibly. Around 60 % of China's gas imports in 2018 were accounted for by LNG. With 54 Mt[5], the country was the world's second largest LNG importer behind Japan (GIIGNL, 2019). The most important natural gas supplying country is Australia (23.1 bcm).

At the end of 2019, the Russian "Power of Siberia" gas pipeline was commissioned to export natural gas to China. This pipeline has an export capacity of 38 bcm per year. With this pipeline, the Russian Federation will probably develop into China's most important natural gas supplier in a few years' time.

>> Russian Federation most important supplier for crude oil and natural gas in the future

Collaboration on energy policy matters between the Russian Federation and China has intensified in the past ten years. This is highlighted by the increase in infrastructure projects and joint ventures in the oil and gas sector. For instance, China has a 20 % share (held by CNPC and CNOOC with 10 % each) in the Russian Arctic-LNG-2 project currently under construction, which will produce up to 20 Mt LNG[6] per annum in future (NOVATEK, 2019). In addition, the country already has a stake of around 30 % (20 % held by CNPC, and 9.9 % by the Silk Road Fund) in the Yamal-LNG project, which has a capacity of 16.5 Mt LNG[7] (YAMAL LNG, 2019).

The Strait of Malacca, the narrow marine passage between the Malaysian peninsula and the northeast coast of Sumatra, is of enormous strategic importance for China, because an estimated 75 % of its crude oil imports, and 30 % of its natural gas imports, in the form of LNG, pass through this narrow stretch of water. It is therefore important for China that it also diversifies its energy imports geographically, and for it to avoid importing a substantial part of its resources by ship. It will therefore probably push ahead further in particular with the construction of new natural gas pipelines from the Central Asian region and the Russian Federation. Chinese-Russian negotiations on the construction of another gas pipeline, either via Mongolia (Trans-Mongolian-Pipeline) or across the shared border in the west of the country (Altaia-Pipeline) already took place in 2019 (Petroleum Economist, 2019a).

Strategies for covering its demand

The existing, and increasingly growing dependence on imports in future, has consequences for the country's energy policies. With the aim of also being able to cover its future hydrocarbon requirements, the country is pushing ahead with the expansion of domestic crude oil and natural gas production, and pursues a strategic policy to secure and diversify its oil and gas imports. The latter is realised via direct and indirect investment in oil and gas projects overseas. Notwithstanding the fact that boosting domestic production can make a significant contribution to securing its oil and gas supplies, China also considers securing its imports in the foreseeable future to be a high priority. It is unlikely that the additional amounts it will require in future can be purely satisfied by increasing domestic production alone.

>> China involved in oil and gas projects worldwide

The Chinese oil and gas sector has been dominated to date by three major national oil companies: CNPC[8], CPC[9] and CNOOC. Major investments in the E&P sector will be necessary

5 Corresponds to 74.5 bcm natural gas under standard conditions
6 Corresponds to around 27.6 bcm methane under standard conditions
7 Corresponds to 22.7 bcm methane under standard conditions
8 Parent company of Petrochina
9 Parent company of Sinopec

to be able to produce the volumes of crude oil and natural gas stipulated in the China Energy Outlook 2050 (CNPC, 2018). The complete opening of the Chinese oil and gas market on 1 May 2020 should be seen in this context (Xinhuanet, 2020), as this measure enables private and foreign companies to become actively involved in the Chinese E&P sector for the first time. Although the prices for crude oil are at a relatively low level, the national oil companies considerably expanded their investments in the Chinese E&P sectors since 2016. The trade conflict with the USA, and the slow-down in economic growth, add additional pressures to safeguard future energy production from domestic sources by investing in the sector, and thus also to support the economy overall (Kawase, 2019).

China has made impressive progress in recent years in the development of poorly accessible oil and gas resources, such as in ultra-deep basins[10], shale gas deposits, and methane hydrates. China is also continually expanding its coal liquefaction capacities.

The exploration and development of deep oil and gas reservoirs is one of the most important future plays for the Chinese oil and gas industry. It is estimated that 27 % of Chinese crude oil resources and 49 % of the country's natural gas resources lie in ultra-deep basins (Pang et al., 2015). China achieved a number of breakthroughs in recent years in the exploration and development of oil and gas in ultra-deep sedimentary basins (including in Tarim and Sichuan basins (Guo et al., 2019, Xu et al., 2018). In addition to new discoveries and a greater understanding of the relevant geology, successful production tests have also been carried out with high production rates at depths of around 8,000 m (Reuters, 2019a). In addition to conventional reservoirs, the country is increasingly also developing its unconventional oil and gas resources. China has been producing shale gas since 2014, and boasts significant shale gas resources. Production in 2018 was around 10 bcm, and therefore already accounts for more than 6 % of Chinese natural gas production (PESGB, 2019). Most of this production has been achieved to date in the Sichuan Basin.

After almost two decades of research activity on gas hydrates in the South China Sea, natural gas from methane hydrates was produced for the first time in 2017 over a period of 60 days (Li et al., 2018). This represents a major development milestone towards commercial development of this energy resource, whose potential has so far never been realised. Despite major uncertainties in the estimates, the total volume of natural gas bound up in gas hydrates is enormous, and many times higher than conventional natural gas reserves. Most of this potential is found in marine sediments (BGR, 2008). Methane from marine gas hydrates could contribute a growing share to Chinese natural gas production from the middle of the 2030s (CNPC, 2018).

Because liquid and gaseous hydrocarbons, as well as numerous chemical raw materials, can be extracted from coal via various technical conversion methods, and because China has the world's second largest reserves of hard coal, the country has been carrying out research for many decades on coal refining methods, including coal gasification and liquefaction. These activities received a boost from the climb in crude oil prices since the middle of the 2000s, as well as the country's increasing dependence on oil and gas imports. China's coalfields lie primarily in the northern and western part of the country, while the coal is mainly consumed in the densely populated and strongly industrialised eastern and southern parts of the country. Locating the coal liquefaction industry in the northern part of the country also harmonises with the Chinese government's strategy of improving the economic prospects of other parts of the country, and combatting the existing economic imbalance in the country (Rong & Victor, 2011). China's

10 > 6,000 m depth

production capacity for oil products from coal liquefaction plants rose to 9.21 Mt/a in 2018 (sx-coal, 2018). This places China ahead of South Africa in having the largest coal liquefaction capacities in the world.

The share of synthetic natural gas which is generated by coal gasification, has also increased significantly in China in recent years, and already accounts for 1.7 % of total Chinese natural gas production. It is probable that synthetic natural gas production will increase further.

Internationally, China has so far had relatively minor natural gas storage capacities in geological formations[11], with 8 bcm storage capacity (corresponds to around 3 % of annual consumption) (Petroleum Economist, 2019b). China's strategic crude oil reserves are stored in tank farms and caverns, and can cover Chinese needs for 80 days[12], and therefore lie slightly below the 90-day average recommended by the International Energy Agency (IEA) (Reuters, 2019b).

The acquisition and participation in oil and gas projects overseas continues to be an important element in China's strategy of diversifying and safeguarding its energy imports (Vasquez, 2019). In addition to direct investments in foreign oil and gas projects, China holds numerous contracts for the construction of oil and gas infrastructure, including pipelines, tank farms and refineries outside the country. The volume of publicly known overseas investments in the oil and gas sector since 2005 runs to USD 260 billion, of which USD 169.5 billion are in direct holdings, and USD 91 billion in oil and gas infrastructure (AEI, 2019). These investments are made in precisely those countries, which currently supply China with significant proportions of its oil and gas imports, or are the locations of infrastructure important for safeguarding Chinese oil and gas supplies (cf. Fig. 4-3).

4.2 The development of coal production in the Russian Federation

The Russian Federation is currently the world's sixth largest coal producer with a share of 5.4 % of global coal production (hard coal plus lignite). Around four fifths (352.6 Mt) of the coal produced in 2018 was hard coal. The Russian Federation is thus the world's sixth largest hard coal producer and the fourth largest lignite producer. Around 27 % (94 Mt) of Russian hard coal production involves coking coal (Russian Ministry of Energy, 2019b), making the Russian Federation the third largest coking coal producer behind China and Australia (IEA, 2019c).

>> The Russian Federation today is the world's sixth largest hard coal producer and third largest exporter

Around three quarters of Russian coal production comes from surface mines, whose share has been successively increased since the 1990s. As per 01.01.2019, coal production came from 166 active mines of which 57 were deep mines and 109 were surface mines. Together they have a production capacity of 470 Mt/a (Russian Ministry of Energy, 2019c). The Kuznetsk Basin (Kuzbass for short) in the West Siberian Kemerowo region is the most important Russian coalfield, with a share of around 72 % of hard coal production and around 77 % of coking coal production, as well as almost 60 % of Russian hard coal reserves. Kuzbass boasted the highest production in 2018 with 255.3 Mt of all of the Russian production regions/coalfields (Fig. 4-44) (Russian Ministry of Energy, 2019b). In addition to Kuzbass, other major coking coal reserves are found in the Pechora Basin located in the European part of the Russian Federation, and the South Jakutia Basin located in the Far

11 Germany has a gas storage capacity of more than 24.6 bcm (corresponds to 28 % of annual consumption)

12 Arithmetically around 766 MMbbl

East – both major production regions for coking coal. The most important Russian lignite basin is the East Siberian Kansk-Achinsk Basin, which contains around three quarters of Russian lignite reserves, and which currently accounts for half of Russian lignite production.

After the break-up of the Soviet Union, Russian coal production suffered a significant decline. This downturn hit bottom in 1998 with a production of 232 Mt (Fig.4-4, Schmidt et al., 2006). Production has risen almost continuously ever since over the last 20 years to eventually beat the old Russian production record from three decades earlier in 2018, with the production of around 425 Mt total coal (Fig. 4-4). The almost continuous upswing in Russian coal production since 1999 is primarily attributable to the continuous growth in hard coal exports. These have risen more than eight times from around 24 Mt (1998) to around 200 Mt (2018) over this period. This means the Russian Federation is the world's third biggest hard coal exporter behind Australia and Indonesia, with a global share of around 14 %. Europe is the main destination of Russian hard coal exports, although the share going to Asia has risen steadily over recent years (Fig. 4-5).

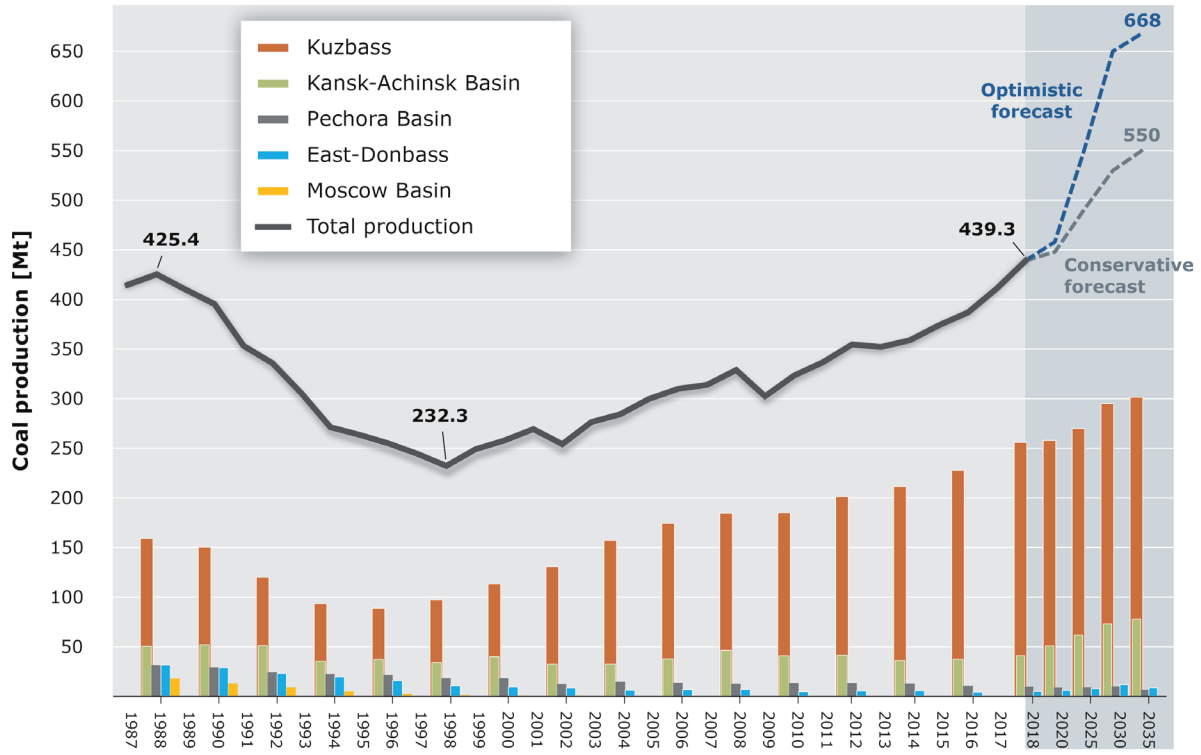


Figure 4-4: The development of Russian coal production from 1987 to 2018 according to the major coalfields/regions, as well as forecasts to 2035 (Data: Klimov, 2003, Russisches Energieministerium, 2019d, UGOL, 2006 to 2019, ZDU TEK, 2018).

The Russian Federation also imports coal to a relatively minor extent because of the geographic proximity of consumers in the Russian Ural region to the Ekibastus coalfield in Kazakhstan. Russia imported around 22 Mt hard coal in 2018.

>> 43 % of German hard coal imports from the Russian Federation

The Russian Federation has been Germany's most important source of hard coal for many years. 19 Mt, almost 43 % of German hard coal imports, came from the Russian Federation in 2018.

Outlook – Coal production in the Russian Federation is scheduled to grow further in the years to come primarily because of the growing export/sales potential in Asia. The biggest growth in production is therefore expected in the East Siberian and Far East regions (Fig. 4-6). The draft programme for the development of the Russian coal industry for the period up to 2035 (Russian Ministry of Energy, 2019d), published in August 2019 contains a conservative forecast for Russian coal production to expand to 550 Mt by 2035, and even as high as 668 Mt according to the optimistic forecast (Fig. 4-4). Exports could rise accordingly up to 313 Mt (conservative forecast) or 375 Mt (optimistic forecast), although the Russian coal companies forecast an even higher export potential of 530 Mt by 2035. In the Stated Policies Scenario, the IEA (IEA, 2019a) assumes that the Russian Federation will become the world's second largest coal exporter behind Australia in 2040 (IEA, 2019e).

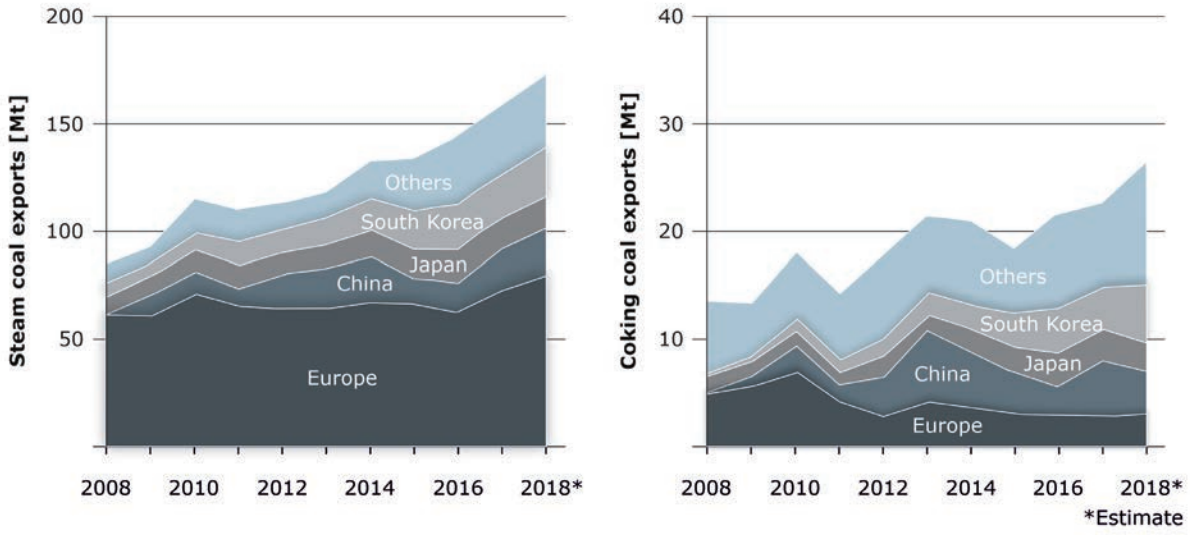


Figure 4-5: The development of Russian steam (left) and coking coal (right) exports from 2008 to 2018 (IEA, 2019d).

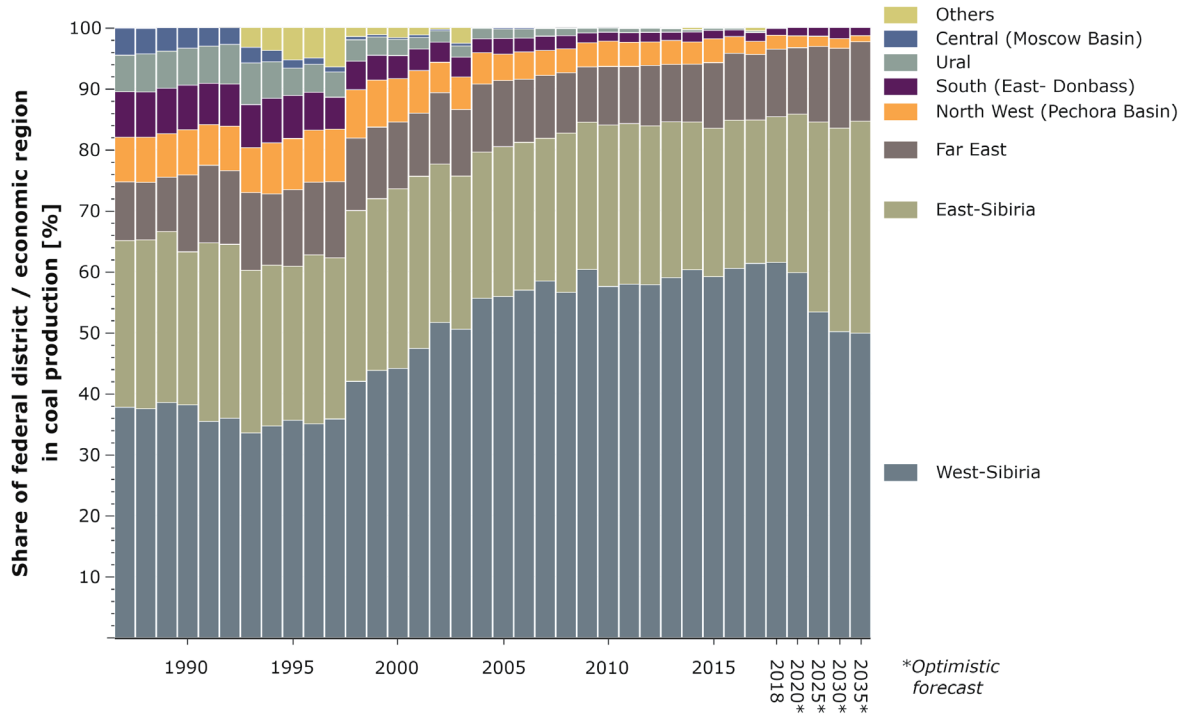


Figure 4-6: Relative development of Russian coal production from 1987 to 2018 according to major economic regions/federal districts, as well as up to 2035 according to optimistic forecast (after Klimov, 2003, Russisches Energieministerium, 2019d, UGOL, 2006 to 2019, ZDU TEK, 2018).

5 Future availability of fossil energy resources and deep geothermal energy

5.1 Supply situation and future demand

The reliable and uninterrupted provision of energy is essential for the proper functioning of our modern societies today. Global energy supplies are characterised by continuous change, and renewable energy is an integral part of energy supplies. There are even countries today which can already cover most of their energy requirements from renewables. In Germany as well, 35 % of the consumed power already came from renewable energy resources in 2018, and the share of renewables of German primary energy consumption (14 %) has also grown from year to year, and has almost quadrupled since 2001.

From a global perspective, these are special cases. The major challenge for the decades to come is therefore the conversion of energy systems. Many industrial countries, and developing and emerging economies in particular, with a foreseeable rise in energy demand, will initially continue to rely on crude oil, natural gas, coal and nuclear power in their future energy mixes, alongside solar power, windpower and hydroelectric power, which are enjoying the strongest growth globally. The major challenge against this background is to harmonise economic growth − as a major condition for growing prosperity in emerging economies − with climate protection.

The focus of this study, which analyses the global capacities and potential for energy resources, therefore also continues to be on presenting the non-renewable energy resources. The quantities in which they can be extracted and consumed in future are dependent on many factors, and only foreseeable to a limited extent. The projected consumption of these energy resources until 2040 according to the IEA's Stated Policies Scenario (2019a) can be used as the basis for the long-term comparison of supply and demand (Fig. 5-1). This reveals a comfortable situation from a geological point of view for the energy resources uranium, coal and natural gas, because the projected demand only encompasses a small proportion of the currently known natural resource inventories, and can even be covered solely from today's known reserves. Coal in particular stands out with comprehensive resources that indicate the existence of major potential. Unconventional hydrocarbon deposits as well underpin the relatively comfortable supply situation. However, the resource figures also include numbers on energy resources which cannot yet be exploited economically, such as the production of crude oil from oil shales, natural gas in aquifers and from gas hydrates. Their potential is also incorporated in the analysis independent of whether and to what extent they can be economically exploited in the foreseeable future. According to the information currently available, the only energy resource with restricted future availability from a geological point of view is crude oil. According to the IEA scenario, around half of the crude oil reserves identified today will have been consumed by 2040 (Fig.5-1).

>> Many countries continue to rely primarily on fossil fuels to cover their growing demand

This study cannot answer the question of which natural resources will be used in which quantities and under which conditions in future. Answers to these questions need to be sought elsewhere, particularly against the background of the COVID-19 pandemic in early 2020, and the targets involved in the German energy transition

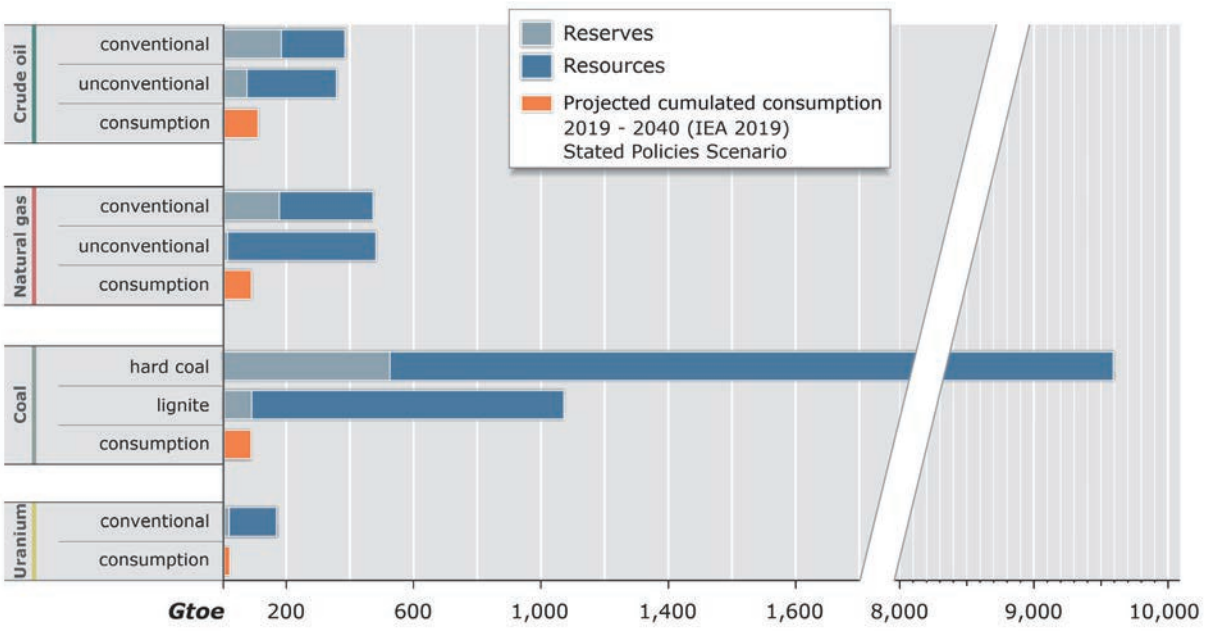


Figure 5-1: Supply situation for non-renewable energy resources end 2018.

and the agreed international climate treaty. Because of the collapse in energy demand during the COVID-19 pandemic, there has also been an associated cut in greenhouse gas emissions. However, global energy demand will probably continue to rise further in the medium to long term.

5.2 Summary and Outlook

Crude Oil

With respect to primary energy demand, crude oil is the most important energy resource worldwide. Both production and consumption have risen to a new all-time record high. The increase in production mainly comes from US-American shale oil production, which has reached a new high. The global demand for petroleum products is predicted to increase further in the decades to come as well. There was a rise in global crude oil resources, which was mainly attributable to the improvement in the data available from the Russian Federation and Australia. Although all countries use petroleum products, there is a strong concentration in production as well as exports on only a few countries. The ten largest crude oil producing countries alone account for around 71 % of the production, and the five biggest exporting countries account for almost half of exports. Although crude oil prices rose by around 28 % during the course of the year, they remain at a relatively low level. Global investment in the E&P sector continues to be relatively low. Supplies of crude oil can be guaranteed in the coming years from a geological point of view, even in the face of a moderate rise in consumption. However, this situation does not necessarily mean that the availability of crude oil can be assured in future. In the short to medium term, the installed production capacities, their degree of utilisation, as well as the planning horizon for the initiation of new oil production projects to compensate for the declining production from mature oilfields, are more important than the mere existence of crude oil in geological formations. OPEC countries and Saudi Arabia in particular, have the largest free production capacities. The USA as well, with thousands of already drilled but still uncompleted shale oil wells, also has capacities to expand its production volumes within a relatively short period. A large part of global crude oil production as well as exports comes from regions affected by growing geopolitical tension. As one of the largest petroleum consuming regions in the world, the EU-28, and Germany in particular, will likely face a high level of import dependency. There continues to be basically no extensive alternative to crude oil in terms of its fundamental role as an energy resource and basic raw material.

Natural gas

Again, in 2018, natural gas was the third most important energy resource world-wide behind crude oil and coal in terms of primary energy consumption.

Global natural gas consumption rose by around 4 % in 2018. Continued growth in worldwide natural gas consumption is expected in the medium to long term. The world can be supplied with this natural resource for many decades to come thanks to the high levels of remaining natural gas potential. There has been hardly any change in global natural gas reserves compared to the previous year. The global trade in natural gas increased further in 2018. Thanks to the rise in the availability of LNG, there has been a further rise in the interconnectedness of the global natural gas markets. 20 exporting countries now supply 42 importing nations. The USA reported the biggest rise in LNG exports (plus 12 bcm), and Australia reported a major rise as in the previous year (plus 15 bcm). With their integrated and growing supply grids, Germany and Europe are connected to a major share of global natural gas reserves via pipelines, as well as LNG terminals, and are therefore in a relatively secure position. This means that geopolitical risks in particular play a key role in safeguarding natural gas supplies.

Coal

The global reserves of hard coal and lignite can cover the foreseeable demand for many decades from a geological point of view. Global coal production rose during the reporting period by around 4.1 % year-on-year, and totalled around 8,000 Mt in 2018. Whilst the major producing countries like China and India expanded their production in 2018, production declines were recorded in the USA and the European Union (EU-28). Therefore, a comparison of production as well as consumption at a regional level reveals that growth is primarily associated with the Austral-Asian region and the CIS, whilst the North America and European regions are associated with declines.

The global trade in hard coal grew strongly again by almost 5 % compared to the previous year. In terms of shares in global coal imports, the importance of the Pacific market remains strong as in previous years (Asia: 75 %), and is rising continuously. China is easily the world's largest hard coal producer and consumer, and has been the world's biggest hard coal importer since 2011, followed closely by India and Japan. These three countries alone, with imports of around 700 Mt, accounted for almost half of global hard coal imports in 2018. With 165 Mt, the European Union (EU-28), which covered around 71 % of its hard coal demand in this way accounted for only slightly more than one ninth of global hard coal imports. The three largest hard coal exporting countries, Indonesia, Australia and the Russian Federation, boosted their export levels again to a combined 1,015 Mt, corresponding to a share of almost 72 % of global hard coal exports. The development of global coal prices, and therefore European coal prices, continues to be dominated by the actual situation in Asia, and primarily in China. Whilst European, as well as German, coal import prices rose again slightly year-on-year in 2018, they decreased significantly during the course of 2019.

Nuclear fuels

The global reserves for uranium are very comprehensive. From a geological point of view, no shortage in supplies of nuclear fuels is expected in the foreseeable future. However, the uranium market continues to be dominated by relatively low spot market prices which jeopardise the economic viability of various mines and exploration projects. The reduction in uranium production in 2019 compared to the previous year is mainly attributable to the current recession in the uranium market, and is intended to stimulate a rise in uranium prices on the world market. Regulatory measures of this kind, such as reducing or shutting down production in the market-dominating production sites, are to be withdrawn slowly. In this context, Kazakhstan, easily the world's largest uranium-producing country, has made strong cuts to its production in recent years, but will increase its production again step-wise in the near future. However, in Canada and Namibia, the market-regulatory measures will be maintained into the next few years as well (BGR, 2019). In Namibia, the extraction of other natural resources as by-products (e.g. vanadium) is currently under consideration as a possible economic measure to justify the renewed start-up of production.

Growth in production is expected again in the medium term against the background of a foreseeable rise in the global demand. Whilst the demand in Europe and North America will probably decrease in future because a significant number of reactors will reach the end of their operating periods by 2030, a rise in uranium consumption is expected in emerging economies and developing countries in the Asia and Middle Eastern regions in particular. 55 reactors are currently under construction world-wide, 35 of them in Asia alone. The growing energy demand in Asia has already led to an expansion in nuclear power in the past, particularly in China, Japan, India and

South Korea. This will also spread to other Asian countries in the future. Nuclear power will also play a larger role in the Middle East in future. In addition to Iran and the United Arab Emirates, Saudi Arabia and Jordan will probably integrate nuclear power within their national energy mixes within the next few years. In Europe as well, numerous countries are targeting nuclear power as an important part of their national energy mixes.

Deep geothermal energy

Despite major potentials, the developing of the use of geothermal energy in Germany, Europe, and the rest of the world remains slowl. Deep geothermal energy faces many challenges. Among them are uncertainties in predicting the relevant parameters of the subsurface, which are required for successful geothermal energy projects, exploration risks, and significant maintenance costs. However, the increase in the popularity of renewables observed in societies around the world can also have a positive influence on the flattened out geothermal energy trend. Here, new impulses are expected from the World Geothermal Congress taking place in Iceland in 2021.

Renewable energy resources

The proportion of renewables rose further in 2018, especially for power generation. Photovoltaics in particular again boasted the largest growth rates world-wide in terms of the expansion of renewable energy resources. The global installed capacity for power generation today totals 2,351 GW_e. Increased investment has been made here in developing countries and emerging economies in particular. The global volume of financial investments in renewables has risen in the past ten years from 177 billion USD/a to almost 289 billion USD/a, whereby almost a third of all investments in renewables is accounted for by China. Here, capital expenditure is particularly directed at photovoltaics and windpower, which also reflects the global trend.

Further expansion here is expected around the world as well in future, not to mention in all other areas of energy supply, associated with the development of significant new markets in Africa, Asia and Latin America. 187 countries have now formulated targets for the expansion of renewables. Technological advances, investments and the expansion of capacity will further increase the global influence of renewables, particularly in the electricity sector, as well as their influence in the thermal and transport sectors in the medium term. The major challenge is the discrepancy between the available potential and the actual output generated by renewables, which meant that only around 18 % of global primary energy consumption has so far been covered by renewable energy to date. The limiting factors continue to be the restricted technical effectiveness (efficiency), availability (storage technology), and the integration of renewables into existing global energy markets (infrastructure, investment, economic efficiency, and acceptance).

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7 Appendix

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Table A-1: Reserves of non-renewable fuels 2018: Regional distribution [EJ]

Region	Cude oil		Natural gas		Coal		Uranium	Total	Share [%]
	conven-tional	non-conven-tional	conven-tional	non-conven-tional	Hard coal	Lignite			
Europe	87	7	95	< 0.5	654	678	25	1,547	3.8
CIS (+ GEO, UKR)	825	–	2,403	2	3,333	1,350	204	8,117	19.9
Africa	711	–	662	–	347	1	103	1,824	4.5
Middle East	4,675	–	2,999	–	30	–	–	7,705	18.9
Austral-Asia	268	–	642	58	8,386	1,154	77	10,584	26.0
North America	278	1,213	154	382	5,660	382	144	8,213	20.1
Latin America	386	1,751	287	–	223	43	88	2,779	6.8
World	7,230	2,971	7,243	442	18,634	3,608	640	40,769	100.0
OECD	375	1,220	350	416	8,277	1,743	169	12,550	30.8
EU-28	35	7	32	< 0.5	627	478	21	1,201	2.9
OPEC	5,518	1,751	3,601	–	59	1	–	10,929	26.8

[1] including tight gas

Table A-2: Ressources of non-renewable fuels 2018: Regional distribution [EJ]

Region	Cude oil		Natural gas		Coal		Uranium	Thorium	Total	Share [%]
	conven-tional	non-conven-tional	conven-tional	non-con-ventional	Hard coal	Lignite				
Europe	203	209	285	538	12,566	2,970	255	286	17,310	3.5
CIS (+ GEO, UKR)	3,025	1,245	4,978	1,572	32,719	8,003	1,472	103	53,116	10.7
Africa	1,171	443	1,332	1,611	7,687	4	1,118	264	13,630	2.7
Middle East	1,276	254	1,681	521	1,008	–	56	–	4,797	1.0
Austral–Asia	1,152	1,160	1,676	3,141	176,182	12,315	2,062	771	198,460	39.9
North America	1,082	6,576	1,547	2,635	166,910	17,549	858	427	197,582	39.8
Latin America	1,034	2,159	814	1,570	686	173	417	466	7,319	1.5
World	8,942	12,046	12,314	11,587	401,583	41,014	6,238	3,178	496,901	100.0
OECD	1,455	7,266	2,118	4,148	220,725	24,029	2,126	1,010	262,876	52.9
EU–28	95	162	189	494	12,527	2,684	255	55	16,462	3.3
OPEC	1,881	2,160	1,866	1,717	1,220	3	22	150	9,019	1.8

[1] without natural gas in gas hydrates and aquifer gas (7,904 EJ)

[2] including hard coal in the Antarctic (3,825 EJ)

[3] including Thorium resources without country allocation (863 EJ)

Table A-3: Production of non-renewable fuels 2018: Regional distribution [EJ]

Region	Crude oil	Natural gas	Hard coal	Lignite	Uranium	Total	Share [%]
Europe	7.3	9.3	2.1	4.6	–	23.2	4.3
CIS (+ GEO, UKR)	29.3	35.0	12.4	1.3	14.1	92.2	16.9
Africa	16.3	9.5	6.5	< 0.05	4.4	36.6	6.7
Middle East	62.2	26.1	< 0.05	–	< 0.05	88.4	16.2
Austral–Asia	14.7	24.6	129.4	3.4	4.4	176.5	32.4
North America	43.2	40.9	17.2	0.7	3.8	105.8	19.4
Latin America	13.4	6.6	2.4	< 0.05	–	22.5	4.1
World	186.5	152.0	170.0	10.0	26.7	545.2	100.0
OECD	50.9	55.4	31.4	4.7	7.1	149.4	27.4
EU–28	3.3	4.7	2.0	3.3	–	13.3	2.4
OPEC	77.3	31.0	0.1	–	< 0.05	108.5	19.9

Table A-4: Consumption of non-renewable fuels 2018: Regional distribution [EJ]

Region	Crude oil	Natural gas	Hard coal	Lignite	Uranium	Total	Share [%]
Europe	28.5	19.9	7.2	4.6	9.6	69.7	12.5
CIS (+ GEO, UKR)	8.2	24.7	8.2	1.3	3.8	46.1	8.3
Africa	8.3	5.5	4.7	< 0.05	0.1	18.7	3.4
Middle East	17.1	21.4	0.3	–	0.3	39.1	7.0
Austral–Asia	68.7	30.7	134.0	3.4	9.0	245.7	44.2
North America	50.9	39.2	14.4	0.7	10.5	115.7	20.8
Latin America	13.3	6.1	1.1	< 0.05	0.3	20.8	3.7
World	195.1	147.5	169.9	9.9	33.6	556.0	100.0
OECD	94.2	67.2	32.4	4.6	22.8	221.2	39.8
EU–28	25.2	17.5	6.1	3.3	9.4	61.5	11.1
OPEC	19.0	22.1	0.1	–	0.3	41.6	7.5

– no reserves, resources, production or consumption

Table A-5: Germany: Supply of crude oil 2017 / 2018 [kt]

Country / Region	2017	2018*	[%]	Change 2017 / 2018	[%]
Russian Federation	33,512	30,969	36.3	-2,543	-7.6
Norway	10,303	10,044	11.8	-259	-2.5
Libya	6,915	7,205	8.5	290	4.2
Kazakhstan	8,114	6,821	8.0	-1,293	-15.9
United Kingdom	8,555	6,685	7.8	-1,870	-21.9
Nigeria	4,916	5,494	6.4	578	11.8
USA	868	3,886	4.6	3,018	347.7
Azerbaijan	2,451	3,063	3.6	612	25.0
Iraq	4,675	3,031	3.6	-1,644	-35.2
Saudi Arabia	1,021	1,425	1.7	404	39.6
Egypt	1,737	1,092	1.3	-645	-37.1
Ghana	662	747	0.9	85	12.8
Algeria	1,958	688	0.8	-1,270	-64.9
Côte d'Ivoire	460	673	0.8	213	46.3
Venezuela	654	666	0.8	12	1.8
Denmark	612	621	0.7	9	1.5
Netherlands	440	360	0.4	-80	-18.2
Kuwait	176	353	0.4	177	100.6
Iran	794	273	0.3	-521	-65.6
Poland	219	241	0.3	22	10.0
Canada	0	238	0.3	238	
Mexico	345	191	0.2	-154	-44.6
Italy	316	121	0.1	-195	-61.7
Cameroon	0	98	0.1	98	
Angola	205	85	0.1	-120	-58.5
Equatorial Guinea	180	58	0.1	-122	-67.8
Sweden	30	48	0.1	18	60.0
Guatemala	14	27	0.0	13	92.9
France	3	4	0.0	1	33.3
South Africa	87	0	0.0	-87	-100.0
Colombia	138	0	0.0	-138	-100.0

continuation of table A-5
[kt]

Country / Region	2017	2018*	[%]	Change 2017 / 2018	[%]
other countries	82	0	0.0	-82	-100.0
Brazil	97	0	0.0	-97	-100.0
Tunisia	160	0	0.0	-160	-100.0
Congo, Rep.	39	0	0.0	-39	-100.0
Total imports	90,738	85,207	100.0	-5,531	-6.1
OPEC		19,278	22.6		
Middle East	6,666	5,082	6.0	-1,584	-23.8
Africa	17,319	16,140	18.9	-1,179	-6.8
CIS (+ GEO, UKR)	44,077	40,853	47.9	-3,224	-7.3
Europe	20,478	18,124	21.3	-2,354	-11.5

* Date for 2018 are partly preliminary

Source: BAFA (2019)

Table A-6: Germany: Origin of consumed natural gas 2017 / 2018 [bcm]

Origin	2017	[%]	2018	[%]	Changes 2017 / 2018	[%]
import	104.0	92.9	114.0	94.3	10.1	9.7
domestic production*	7.9	7.1	6.9	5.7	-1.0	-13.2
total	111.9	100.0	120.9	100.0	9.0	8.0
re-export	29.0	25.9	39.3	32.5	10.3	35.5
storage change	0.4	0.3	-2.6	-2.1	-3.0	-801.3
total consumption	83.3	74.4	79.0	65.3	-4.3	-5.1
domestic production‘s share in total consumption		9.5		8.7		

* Raw gas excluding petroleum gas and mine gas

Sources: BAFA 2019b (original numbers in TJ), LBEG 2019

Translating energy units into volume units is based on conversion factors by IEA 2019.

Annotation: An umambiguous conversion into volume units (m^3) is not possible owing to the varying energy contents of natural gas from different producing regions.

Table A-7: Germany: Imports of hard coal and coke by supplying countries [kt]

Country / Region	2014	2015	2016	2017	2018	Change 2017/2018	[%]
EU	11,024	8,248	7,209	6,009	4,988	-1,021	-17.0
hard coal	8,817	6,651	5,502	4,112	3,053	-1,059	-25.8
coke	2,207	1,597	1,707	1,897	1,935	38	2.0
Non-EU	45,182	49,262	49,835	45,291	41,652	-3,639	-8.0
hard coal	44,854	48,894	49,584	44,927	41,320	-3,607	-8.0
coke	328	368	251	364	332	-32	-8.8
Australia	5,673	5,737	6,608	5,635	5,162	-473	-8.4
hard coal	5,673	5,737	6,608	5,635	5,162	-473	-8.4
coke	0	0	0	0	0	0	
Indonesia	0	53	180	0	0	0	
hard coal	0	53	180	0	0	0	
coke	0	0	0	0	0	0	
Canada	1,462	1,316	1,487	1,523	1,590	67	4.4
hard coal	1,462	1,316	1,487	1,481	1,552	71	4.8
coke	0	0	0	42	38	-4	-9.5
Colombia	7,381	9,948	10,745	6,511	3,820	-2,691	-41.3
hard coal	7,381	9,948	10,711	6,469	3,786	-2,683	-41.5
coke	0	0	34	42	34	-8	-19.0
Norway	435	561	636	171	73	-98	-57.3
hard coal	435	561	636	171	73	-98	-57.3
coke	0	0	0	0	0	0	
Poland	4,389	4,096	3,705	2,678	1,731	-947	-35.4
hard coal	2,931	3,098	2,421	1,253	246	-1,007	-80.4
coke	1,458	998	1,284	1,425	1,485	60	4.2
CIS (+ GEO, UKR)	13,722	16,724	17,943	19,780	19,158	-622	-3.1
hard coal	13,495	16,528	17,854	19,682	19,037	-645	-3.3
coke	227	196	89	98	121	23	23.5
South Africa	5,082	3,400	2,003	1,630	1,044	-586	-36.0
hard coal	5,082	3,400	2,003	1,630	1,044	-586	-36.0
coke	0	0	0	0	0	0	

continuation of table A-7
[kt]

Country / Region	2014	2015	2016	2017	2018	Change 2017/2018	[%]
Czech Republic	659	832	539	441	289	-152	-34.5
hard coal	362	566	393	160	18	-142	-88.8
coke	297	266	146	281	271	-10	-3.6
United States	11,099	10,913	9,547	9,142	9,751	609	6.7
hard coal	11,099	10,913	9,547	9,142	9,747	605	6.6
coke	0	0	0	0	4	4	
Venezuela, Bolivarian Republic	0	0	0	0	0	0	
hard coal	0	0	0	0	0	0	
coke	0	0	0	0	0	0	
China	124	91	140	184	145	-39	-21.2
hard coal	23	16	12	12	10	-2	-16.7
coke	101	75	128	172	135	-37	-21.5
other Non-EU	204	519	546	717	908	191	26.6
hard coal	204	422	546	707	908	201	28.4
coke	0	97	0	10	0	-10	-100.0
total	56,206	57,510	57,044	51,300	46,639	-4,661	-9.1
hard coal	53,671	55,545	55,086	49,039	44,372	-4,667	-9.5
coke	2,535	1,965	1,958	2,261	2,267	6	0.3

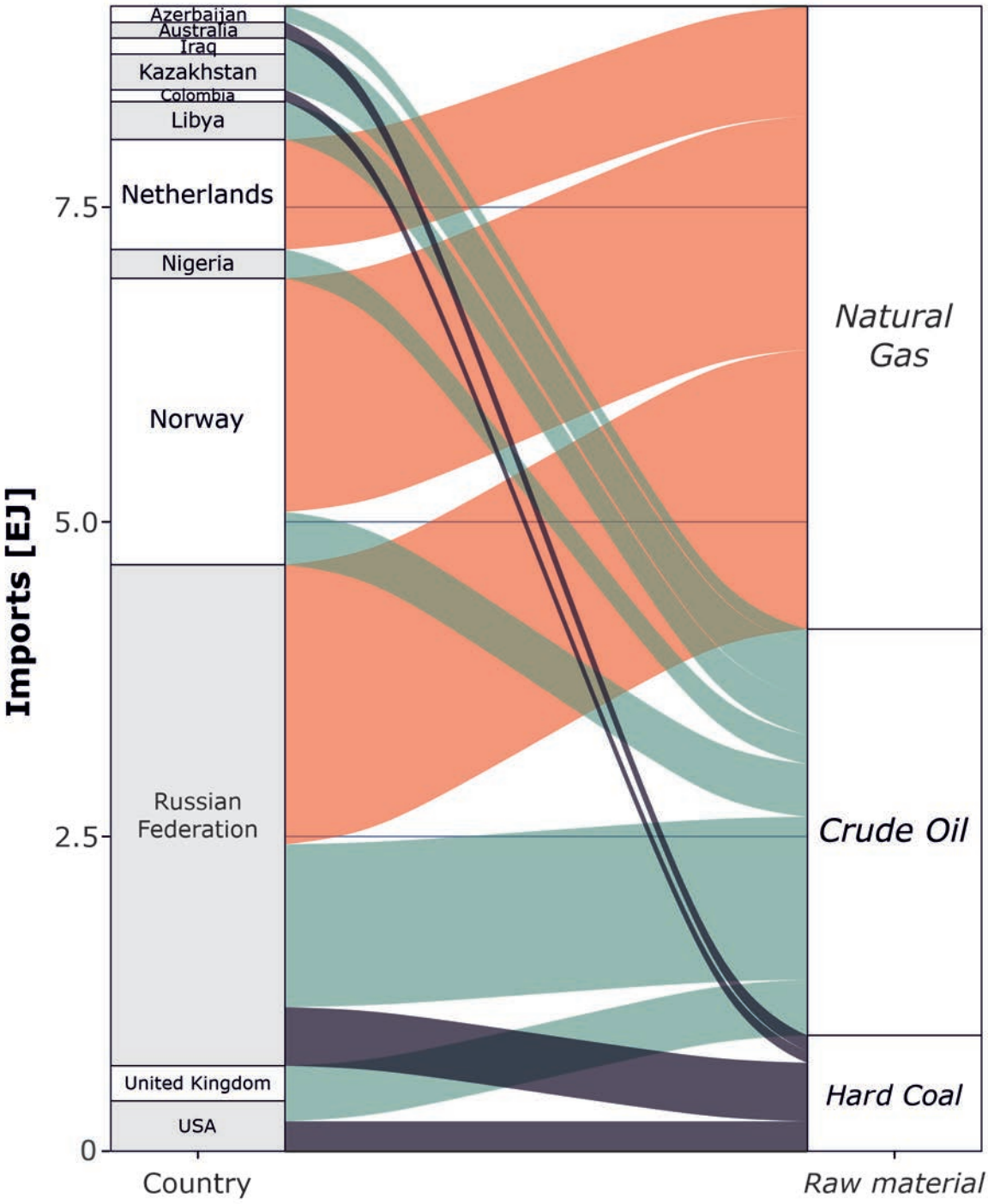

Figure A-1: German energy resource imports according to country of origin 2018.

Table A-8: Crude oil 2018 [Mt]

	Country / Region	Produktion	cum. Production	Reserves	Resources	EUR	Remaining Potential
EUROPE	Albania	0.9	61	20	56	138	76
	Austria	0.7	127	6	10	142	16
	Bosnia & Herzegovina	–	–	–	10	10	10
	Bulgaria	0.3	10	2	34	46	36
	Croatia	0.9	107	10	16	132	26
	Cyprus	–	–	–	35	35	35
	Czechia	0.6	14	1	27	43	29
	Denmark	5.7	374	58	187	619	245
	Estonia	1.1	10	172	455	637	627
	Finland	0.8	7	–	–	7	–
	France	0.8	130	8	801	939	809
	Germany	2.1	311	29	240	580	269
	Greece	0.2	17	1	35	54	36
	Hungary	1.3	106	3	16	125	19
	Ireland	–	–	–	245	245	245
	Italy	4.7	209	76	1,540	1,825	1,616
	Lithuania	0.2	5	2	60	67	62
	Malta	–	–	–	5	5	5
	Netherlands	2.5	155	10	455	620	465
	Norway	92.0	4,016	1,179	2,415	7,611	3,594
	Poland	0.9	68	14	259	340	272
	Romania	3.7	787	82	200	1,069	282
	Serbia	0.9	50	11	220	280	231
	Slovakia	0.5	4	1	5	11	6
	Slovenia	< 0.05	n. s.	n. s.	n. s.	n. s.	n. s.
	Spain	0.1	39	20	43	102	63
	Sweden	–	–	–	112	112	112
	Turkey	3.6	157	44	980	1,181	1,024
	United Kingdom	51.2	3,812	507	1,378	5,697	1,885
CIS (+ GEO, UKR)	Armenia	–	–	–	6	6	6
	Azerbaijan	38.7	2,006	952	1,245	4,204	2,197
	Belarus	1.6	145	27	158	330	185
	Georgia	< 0.05	24	5	51	79	55
	Kazakhstan	90.3	2,039	4,082	12,933	19,054	17,015

continuation of table A-8
[Mt]

	Country / Region	Produktion	cum. Production	Reserves	Resources	EUR	Remaining Potential
CIS (+ GEO, UKR)	Kyrgyzstan	< 0.05	12	5	10	27	15
	Moldova, Republic	–	–	–	10	10	10
	Russian Federation	555.8	24,929	14,452	84,799	124,180	99,251
	Tajikistan	< 0.05	8	2	60	69	62
	Turkmenistan	10.6	598	82	1,700	2,379	1,782
	Ukraine	2.5	375	54	377	806	431
	Uzbekistan	2.3	209	81	800	1,090	881
AFRICA	Algeria	65.3	3,295	1,660	1,483	6,439	3,143
	Angola	74.6	1,891	1,141	5,095	8,126	6,236
	Benin	–	4	1	70	75	71
	Cameroon	3.4	203	27	350	580	377
	Chad	5.3	93	216	2,365	2,673	2,581
	Congo, DR	1.1	50	24	1,980	2,054	2,004
	Congo, Rep.	17.0	427	218	519	1,164	737
	Côte d'Ivoire	1.6	36	14	300	350	314
	Egypt	32.7	1,755	418	2,280	4,454	2,698
	Equatorial Guinea	8.7	266	150	250	666	400
	Eritrea	–	–	–	15	15	15
	Ethiopia	–	–	–	60	60	60
	Gabon	9.7	591	272	1,400	2,264	1,672
	Gambia	–	–	–	20	20	20
	Ghana	8.6	46	90	210	346	300
	Guinea	–	–	–	150	150	150
	Guinea-Bissau	–	–	–	40	40	40
	Kenya	–	–	–	300	300	300
	Liberia	–	–	–	160	160	160
	Libya	47.5	3,938	6,580	4,750	15,268	11,330
	Madagascar	–	n. s.	n. s.	2,131	2,131	2,131
	Mali	–	–	–	128	128	128
	Mauritania	0.2	8	3	184	195	187
	Morocco	< 0.05	2	< 0.5	2,607	2,609	2,607
	Mozambique	n. s.	n. s.	2	2,300	2,302	2,302
	Namibia	–	–	–	300	300	300
	Niger	0.8	n. s.	20	30	50	50

continuation of table A-8
[Mt]

	Country / Region	Produktion	cum. Production	Reserves	Resources	EUR	Remaining Potential
AFRICA	Nigeria	98.4	4,869	5,030	5,378	15,277	10,408
	São Tomé and Príncipe	–	–	–	180	180	180
	Senegal	–	–	–	136	136	136
	Seychelles	–	–	–	470	470	470
	Sierra Leone	–	–	60	260	320	320
	Somalia	–	–	–	300	300	300
	South Africa	0.2	17	2	502	521	504
	South Sudan	6.4	–	476	365	841	841
	Sudan	4.9	–	204	365	569	569
	Sudan & South Sudan	11.3	210	680	730	1,621	1,410
	Tanzania	–	–	–	500	500	500
	Togo	–	–	–	70	70	70
	Tunisia	2.3	217	55	300	572	355
	Uganda	–	–	340	300	640	640
	Zimbabwe	–	–	–	10	10	10
MIDDLE EAST	Bahrain	9.6	291	15	200	506	215
	Iran	220.4	10,574	21,170	7,200	38,944	28,370
	Iraq	226.1	6,009	19,730	6,320	32,060	26,050
	Israel	0.2	3	2	970	975	972
	Jordan	< 0.05	–	< 0.5	1,912	1,912	1,912
	Kuwait	146.8	6,802	13,810	700	21,311	14,510
	Lebanon	–	–	–	150	150	150
	Oman	47.8	1,634	731	1,540	3,905	2,271
	Palestinian territories	–	–	–	60	60	60
	Qatar	78.8	1,988	3,435	700	6,122	4,135
	Saudi Arabia	578.3	22,059	38,886	11,800	72,745	50,686
	Syrian	1.4	749	363	400	1,512	763
	U. Arab Emirates	177.7	5,374	13,306	4,160	22,840	17,466
	Yemen	1.9	404	393	500	1,298	893
AUSTRAL-ASIA	Afghanistan	–	–	12	80	92	92
	Australia	13.3	1,092	337	14,594	16,023	14,931
	Bangladesh	0.2	5	4	30	39	34
	Brunei	5.4	543	150	160	853	310

continuation of table A-8
[Mt]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
AUSTRAL-ASIA	Cambodia	–	–	–	25	25	25
	China	190.0	7,089	3,540	29,001	39,630	32,541
	India	34.6	1,442	594	1,840	3,876	2,434
	Indonesia	38.3	3,559	428	3,572	7,559	4,000
	Japan	0.4	54	6	24	84	30
	Korea, DPR	–	–	–	50	50	50
	Korea, Rep.	< 0.05	n. s.	< 0.5	n. s.	< 0.5	< 0.5
	Laos	–	–	–	< 0.5	< 0.5	< 0.5
	Malaysia	31.5	1,224	490	850	2,563	1,340
	Mongolia	1.0	8	35	1,015	1,059	1,050
	Myanmar	0.6	59	19	595	673	614
	New Zealand	1.1	66	9	250	326	259
	Pakistan	4.9	122	47	1,342	1,511	1,389
	Papua New Guinea	2.2	78	23	290	391	313
	Philippines	0.7	21	14	270	305	284
	Sri Lanka	–	–	–	90	90	90
	Taiwan	< 0.05	5	< 0.5	5	10	5
	Thailand	11.3	240	44	452	736	496
	Timor-Leste	1.6	56	51	175	282	226
	Viet Nam	14.0	398	599	600	1,597	1,199
N-AMERICA	Canada	232.5	6,562	26,366	57,170	90,098	83,536
	Greenland	–	–	–	3,500	3,500	3,500
	Mexico	102.8	6,883	1,102	4,760	12,745	5,862
	USA	698.4	34,284	8,193	117,768	160,245	125,961
LATIN AMERICA	Argentina	25.2	1,678	274	4,183	6,135	4,457
	Barbados	< 0.05	3	< 0.5	30	33	30
	Belize	0.1	2	1	15	17	16
	Bolivia	3.9	98	29	280	407	309
	Brazil	130.2	2,661	1,853	15,206	19,720	17,059
	Chile	0.2	63	20	330	414	351
	Colombia	45.8	1,429	242	1,790	3,461	2,032
	Cuba	2.5	78	17	1,145	1,240	1,162
	Dominican Rep.	–	–	–	150	150	150

continuation of table A-8
[Mt]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
LATIN AMERICA	Ecuador	25.7	878	1,126	107	2,111	1,232
	Falkland Islands	–	–	–	800	800	800
	(French) Guiana	–	–	–	800	800	800
	Guatemala	0.5	23	20	40	83	60
	Guyana	–	–	–	450	450	450
	Haiti	–	–	–	100	100	100
	Panama	–	–	–	122	122	122
	Paraguay	–	–	–	575	575	575
	Peru	6.4	412	134	2,321	2,868	2,455
	Puerto Rico	–	–	–	75	75	75
	Suriname	0.8	17	12	700	729	712
	Trinidad and Tobago	4.3	539	33	67	640	101
	Uruguay	–	–	–	275	275	275
	Venezuela	75.0	10,353	47,385	46,820	104,558	94,205
	World	4,460.6	196,754	244,049	502,104	942,907	746,152
	Europe	175.4	10,577	2,255	9,840	22,672	12,096
	CIS (+ GEO, UKR)	701.9	30,345	19,741	102,148	152,234	121,890
	Africa	388.8	17,920	17,003	38,613	73,536	55,616
	Middle East	1,489.1	55,887	111,841	36,612	204,340	148,453
	Austral-Asia	351.2	16,062	6,401	55,311	77,774	61,712
	North America	1,033.8	47,728	35,661	183,198	266,588	218,859
	Latin America	320.6	18,235	51,146	76,381	145,762	127,527
	OPEC	1,850.1	79,315	173,897	96,682	349,894	270,579
	OPEC-Gulf	1,428.1	52,806	110,337	30,880	194,022	141,217
	OECD	1,217.9	58,568	38,167	208,631	305,366	246,798
	EU-28	78.1	6,292	1,001	6,159	13,452	7,161

n. s. not specified
– no production, reserves or resources

Table A-9: Crude oil resources 2018 [Mt]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional	non-conventional			
				shale oil	oil sand	extra heavy oil	tight oil
1	USA	117,768	15,900	10,600	1,237	50	89,981
2	Russian Federation	84,799	64,721	10,300	5,225	3	4,550
3	Canada	57,170	3,500	3,390	50,000	–	280
4	Venezuela	46,820	3,000	1,820	–	42,000	–
5	China	29,001	16,200	4,380	2,300	121	6,000
6	Brazil	15,206	13,000	720	–	–	1,486
7	Australia	14,594	3,334	10,000	–	–	1,260
8	Kazakhstan	12,933	4,000	1,440	7,441	–	52
9	Saudi Arabia	11,800	11,800	–	–	–	–
10	Iran	7,200	7,200	–	–	–	–
11	Iraq	6,320	6,100	220	–	–	–
12	Nigeria	5,378	5,300	–	78	–	–
13	Angola	5,095	5,000	–	95	–	–
14	Mexico	4,760	2,980	1,780	–	< 0.5	–
15	Libya	4,750	1,200	3,550	–	–	–
16	Argentina	4,183	500	3,675	–	–	8
17	U. Arab Emirates	4,160	1,100	3,060	–	–	–
18	Indonesia	3,572	2,400	1,075	97	–	–
19	Greenland	3,500	3,500	–	–	–	–
20	Morocco	2,607	1,600	27	–	–	980
84	Germany	240	20	70	–	–	150
	other countries [123]	60,248	41,562	11,196	162	86	7,241
	World	502,104	213,917	67,303	66,635	42,261	111,988
	Europe	9,840	4,850	2,181	46	33	2,731
	CIS (+ GEO, UKR)	102,148	72,356	11,890	12,667	23	5,213
	Africa	38,613	28,012	7,391	276	8	2,926
	Middle East	36,612	30,532	4,134	–	< 0.5	1,946
	Austral-Asia	55,311	27,548	17,827	2,397	121	7,418
	North America	183,198	25,880	15,770	51,237	50	90,261
	Latin America	76,381	24,739	8,110	13	42,025	1,494
	OPEC	96,682	45,008	9,425	242	42,007	–
	OPEC-Gulf	30,880	27,600	3,280	–	–	–
	OECD	208,631	34,810	28,338	51,283	77	94,123
	EU-28	6,159	2,284	1,541	46	27	2,261

– no resources

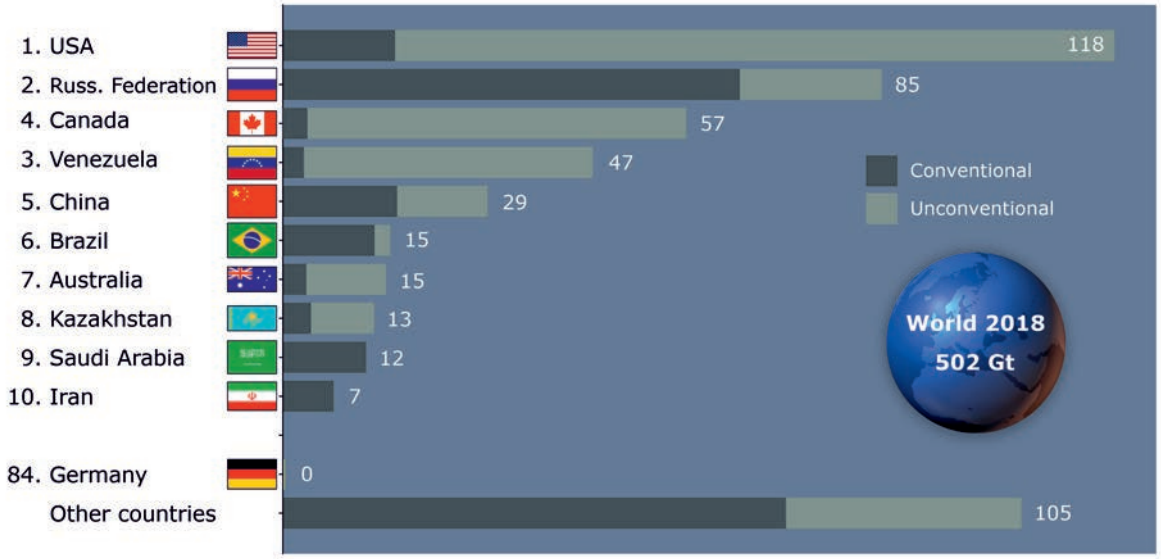

Figure A-2: Crude oil resources – top 10 countries 2018.

Table A-10: Crude oil reserves 2018 [Mt]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional	non-conventional			
				shale oil[1]	oil sand	extra heavy oil	oil shale
1	Venezuela	47,385	5,485	–	–	41,900	–
2	Saudi Arabia	38,886	38,886	–	–	–	–
3	Canada	26,366	475	68	25,823	–	–
4	Iran	21,170	21,170	–	–	–	–
5	Iraq	19,730	19,730	–	–	–	–
6	Russian Federation	14,452	14,452	–	–	–	–
7	Kuwait	13,810	13,810	–	–	–	–
8	U. Arab Emirates	13,306	13,306	–	–	–	–
9	USA	8,193	5,070	3,120	–	3	–
10	Libya	6,580	6,580	–	–	–	–
11	Nigeria	5,030	5,030	–	–	–	–
12	Kazakhstan	4,082	4,082	–	–	–	–
13	China	3,540	3,540	–	–	n. s.	–
14	Qatar	3,435	3,435	–	–	–	–
15	Brazil	1,853	1,853	–	–	–	n. s.
16	Algeria	1,660	1,660	–	–	–	–
17	Norway	1,179	1,179	–	–	–	–
18	Angola	1,141	1,141	–	–	–	–
19	Ecuador	1,126	1,126	–	–	n. s.	–
20	Mexico	1,102	1,102	–	–	–	–
59	Germany	29	29	–	–	–	–
	other countries [84]	9,995	9,824	–	–	–	172
	World[2]	244,049	172,963	3,188	25,823	41,903	172
	Europe	2,255	2,084	–	–	–	172
	CIS (+ GEO, UKR)	19,741	19,741	–	–	–	–
	Africa	17,003	17,003	–	–	–	–
	Middle East	111,841	111,841	–	–	–	–
	Austral-Asia	6,401	6,401	–	–	–	–
	North America	35,661	6,647	3,188	25,823	3	–
	Latin America	51,146	9,246	–	–	41,900	–
	OPEC	173,897	131,997	–	–	41,900	–
	OPEC-Gulf	110,337	110,337	–	–	–	–
	OECD	38,167	8,981	3,188	25,823	3	172
	EU-28	1,001	830	–	–	–	172

[1] crude oil from tight reservoirs
[2] including the oil shale reserves of Estonia

n. s. not specified
– no reserves

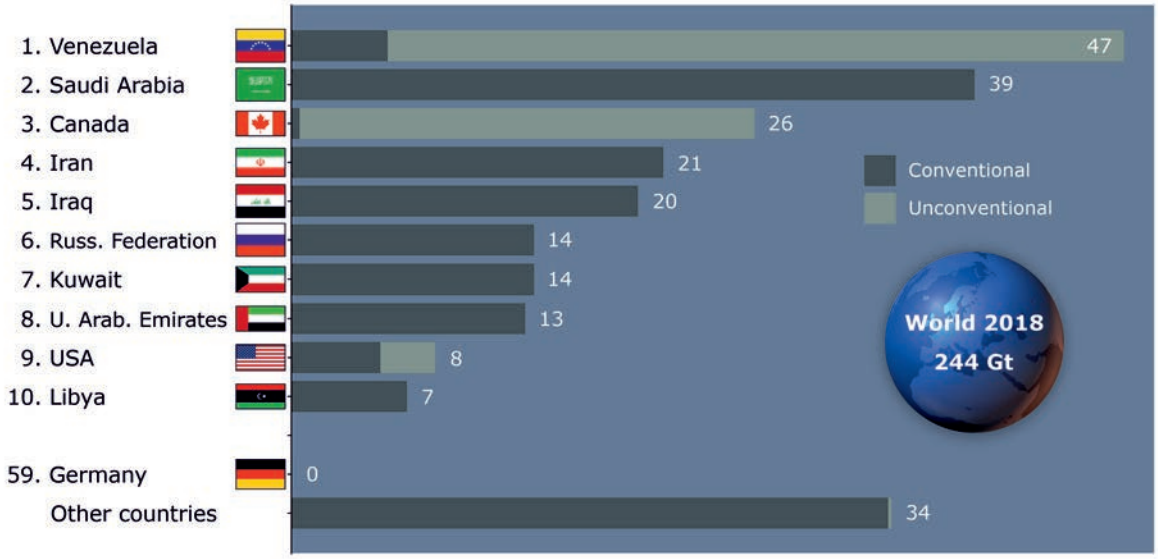

Figure A-3: Crude oil reserves – top 10 countries 2018.

Table A-11: Crude oil production 2013 to 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2013	2014	2015	2016	2017	2018	Share [%]		Change	
		[Mt]						country	cum.	2017/2018	[%]
1	USA	485.2	519.9	567.2	543.0	595.0	698.4	15.7	15.7	103.4	17.4
2	Saudi Arabia	523.6	530.1	565.3	589.1	555.1	578.3	13.0	28.6	23.3	4.2
3	Russian Federation	522.6	526.7	533.6	547.5	546.7	555.8	12.5	41.1	9.1	1.7
4	Canada	192.4	208.0	215.1	218.2	224.0	232.5	5.2	46.3	8.6	3.8
5	Iraq	152.6	160.3	197.0	218.9	222.2	226.1	5.1	51.4	3.9	1.8
6	Iran	177.7	169.2	182.6	216.4	234.6	220.4	4.9	56.3	-14.2	-6.1
7	China	208.1	211.4	214.6	199.7	191.5	190.0	4.3	60.6	-1.5	-0.8
8	U. Arab Emirates	165.7	167.3	175.5	182.4	176.3	177.7	4.0	64.5	1.4	0.8
9	Kuwait	151.3	150.1	149.1	152.7	146.0	146.8	3.3	67.8	0.8	0.5
10	Brazil	105.0	118.5	125.6	125.0	130.2	130.2	2.9	70.8	0.0	0.0
11	Mexico	143.5	137.1	128.8	121.0	110.6	102.8	2.3	73.1	-7.8	-7.0
12	Nigeria	118.3	120.4	113.0	98.8	95.3	98.4	2.2	75.3	3.1	3.3
13	Norway	90.2	93.1	94.8	98.5	97.7	92.0	2.1	77.3	-5.8	-5.9
14	Kazakhstan	83.8	82.1	80.2	79.3	86.2	90.3	2.0	79.4	4.1	4.8
15	Qatar	84.2	83.5	79.3	79.4	79.9	78.8	1.8	81.1	-1.1	-1.4
16	Venezuela	155.0	149.5	148.6	134.2	115.4	75.0	1.7	82.8	-40.4	-35.0
17	Angola	87.4	83.0	88.7	87.9	81.8	74.6	1.7	84.5	-7.2	-8.8
18	Algeria	72.6	70.6	68.1	67.8	66.6	65.3	1.5	85.9	-1.3	-2.0
19	United Kingdom	40.6	39.6	45.7	47.9	47.0	51.2	1.1	87.1	4.2	9.0
20	Oman	46.1	46.2	48.0	49.3	47.6	47.8	1.1	88.2	0.2	0.4
58	Germany	2.6	2.4	2.4	2.4	2.2	2.1	< 0.05	99.4	-0.2	-7.0
	other countries [81]	574.8	555.5	538.8	515.6	527.6	526.0	11.8	100.0	-1.7	-0.3
	World	4,183.5	4,224.7	4,362.0	4,375.0	4,379.5	4,460.6	100.0	–	81.1	1.9
	Europe	164.4	167.4	173.2	176.8	176.8	175.4	3.9	–	-1.4	-0.8
	CIS (+ GEO, UKR)	671.3	671.8	674.4	687.2	690.4	701.9	15.7	–	11.5	1.7
	Africa	430.7	407.3	397.9	374.7	384.6	388.8	8.7	–	4.2	1.1
	Middle East	1,320.1	1,324.9	1,410.4	1,501.2	1,473.6	1,489.1	33.4	–	15.5	1.0
	Austral-Asia	384.4	387.6	391.9	377.1	361.1	351.2	7.9	–	-9.9	-2.7
	North America	821.1	865.1	911.1	882.2	929.6	1,033.8	23.2	–	104.2	11.2
	Latin America	391.5	400.6	402.8	375.7	363.5	320.6	7.2	–	-42.9	-11.8
	OPEC	1,805.0	1,779.9	1,853.3	1,910.7	1,875.8	1,850.1	41.5	–	-25.7	-1.4
	OPEC-Gulf	1,255.1	1,260.5	1,348.7	1,438.9	1,414.1	1,428.1	32.0	–	14.1	1.0
	OECD	996.9	1,044.6	1,096.0	1,070.4	1,115.8	1,217.9	27.3	–	102.1	9.2
	EU-28	69.6	69.3	73.2	73.1	73.9	78.1	1.7	–	4.2	5.7

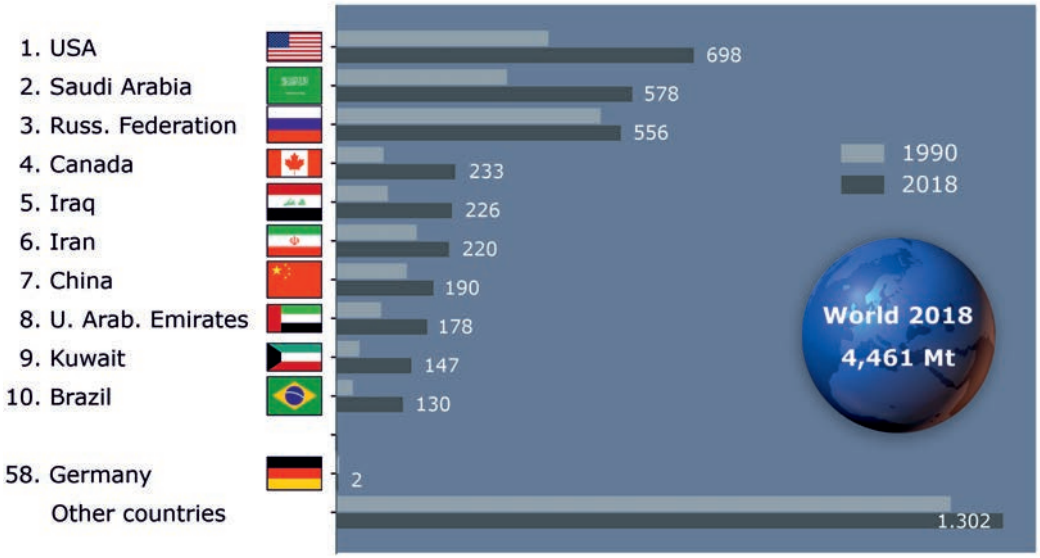

Figure A-4: Crude oil production – top 10 countries 1990 and 2018.

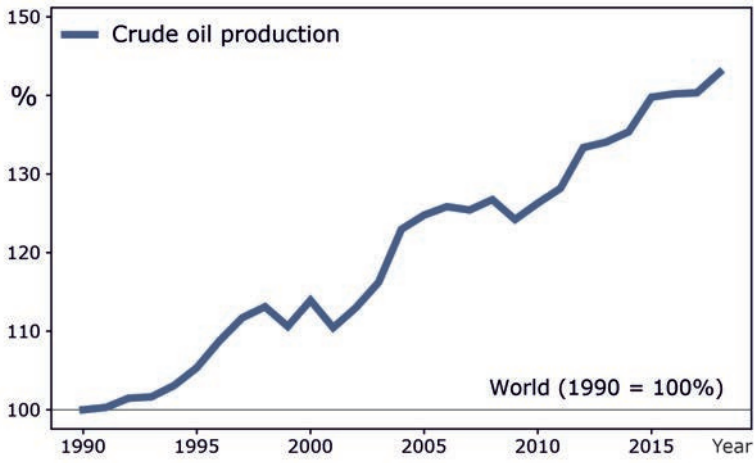

Figure A-5: Development of global crude oil production from 1990 to 2018.

Table A-12: Petroleum consumption 2018[1]

The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%]	
			country	cumulative
1	USA	1,015.7	21.8	21.8
2	China	628.0	13.5	35.2
3	India	236.6	5.1	40.3
4	Japan	173.4	3.7	44.0
5	Saudi Arabia	154.2	3.3	47.3
6	Russian Federation	146.3	3.1	50.4
7	Brazil	141.3	3.0	53.5
8	Korea, Rep.	126.8	2.7	56.2
9	Canada	105.2	2.3	58.4
10	Germany	101.5	2.2	60.6
11	Mexico	97.7	2.1	62.7
12	Iran	92.1	2.0	64.7
13	France	80.4	1.7	66.4
14	Singapore	75.2	1.6	68.0
15	Thailand	70.8	1.5	69.5
16	Indonesia	70.1	1.5	71.0
17	United Kingdom	69.8	1.5	72.5
18	Spain	60.0	1.3	73.8
19	Italy	59.0	1.3	75.1
20	Australia	51.7	1.1	76.2
	other countries [180]	1,111.9	23.8	100.0
	World	4,667.6	100.0	
	Europe	680.9	14.6	
	CIS (+ GEO, UKR)	196.4	4.2	
	Africa	198.6	4.3	
	Middle East	408.8	8.8	
	Austral-Asia	1,644.4	35.2	
	North America	1,218.8	26.1	
	Latin America	318.1	6.8	
	OPEC	454.6	9.7	
	OPEC-Gulf	360.2	7.7	
	OECD	2,253.4	48.3	
	EU-28	602.9	12.9	

[1] also includes consumption of biofuels and synthetic fuels based on coal and natural gas, as well as withdrawals from stocks and strategic stocks.

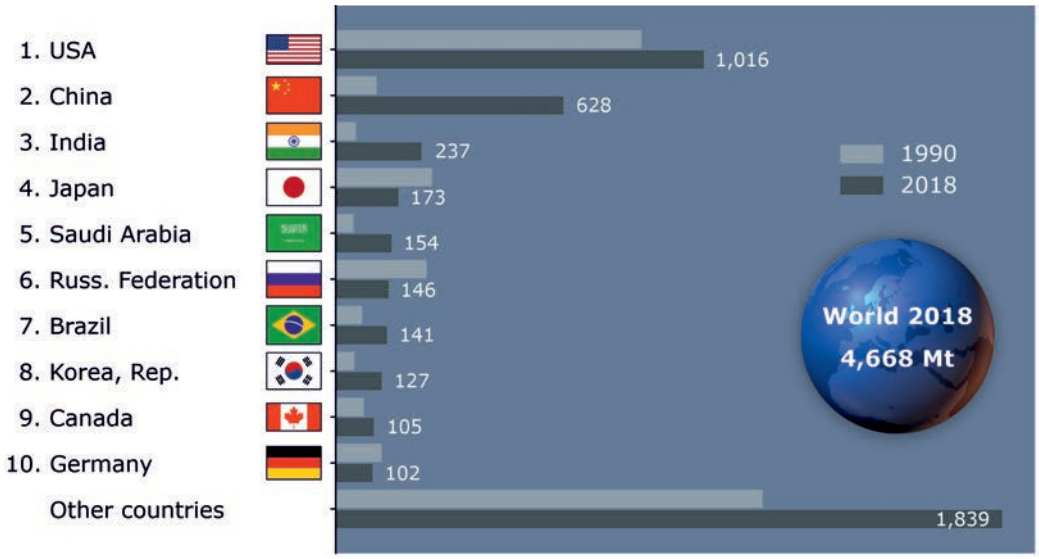

Figure A-6: Petroleum consumption – top 10 countries 1990 and 2018.

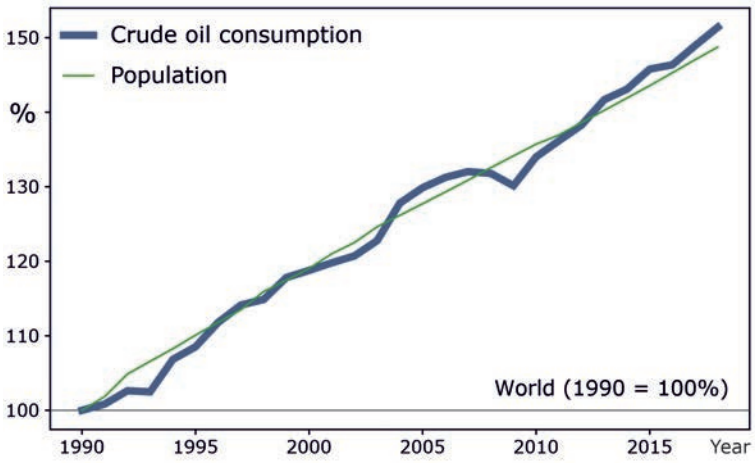

Figure A-7: Growth of global petroleum consumption and global population from 1990 to 2018.

Table A-13: Crude oil exports 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	Saudi Arabia	366.3	15.9	15.9
2	Russian Federation	257.5	11.1	27.0
3	Iraq	191.9	8.3	35.3
4	Canada	186.0	8.1	43.4
5	U. Arab Emirates	114.1	4.9	48.3
6	Kuwait	101.9	4.4	52.7
7	USA	99.5	4.3	57.0
8	Nigeria	98.4	4.3	61.3
9	Iran	91.9	4.0	65.3
10	Norway	75.0	3.2	68.5
11	Kazakhstan	71.5	3.1	71.6
12	Angola	70.6	3.1	74.7
13	Venezuela	63.3	2.7	77.4
14	Mexico	59.0	2.6	80.0
15	Brazil	55.8	2.4	82.4
16	Libya	49.3	2.1	84.5
17	United Kingdom	42.7	1.8	86.3
18	Oman	40.1	1.7	88.1
19	Azerbaijan	32.7	1.4	89.5
20	Colombia	29.4	1.3	90.8
71	Germany	< 0.05	< 0.05	100.0
	other countries [59]	213.2	9.2	100.0
	World	2,309.8	100.0	
	Europe	131.9	5.7	
	CIS (+ GEO, UKR)	365.8	15.8	
	Africa	308.5	13.4	
	Middle East	930.0	40.3	
	Austral-Asia	58.4	2.5	
	North America	344.4	14.9	
	Latin America	170.8	7.4	
	OPEC	1,250.8	54.2	
	OPEC-Gulf	889.9	38.5	
	OECD	488.7	21.2	
	EU-28	56.3	2.4	

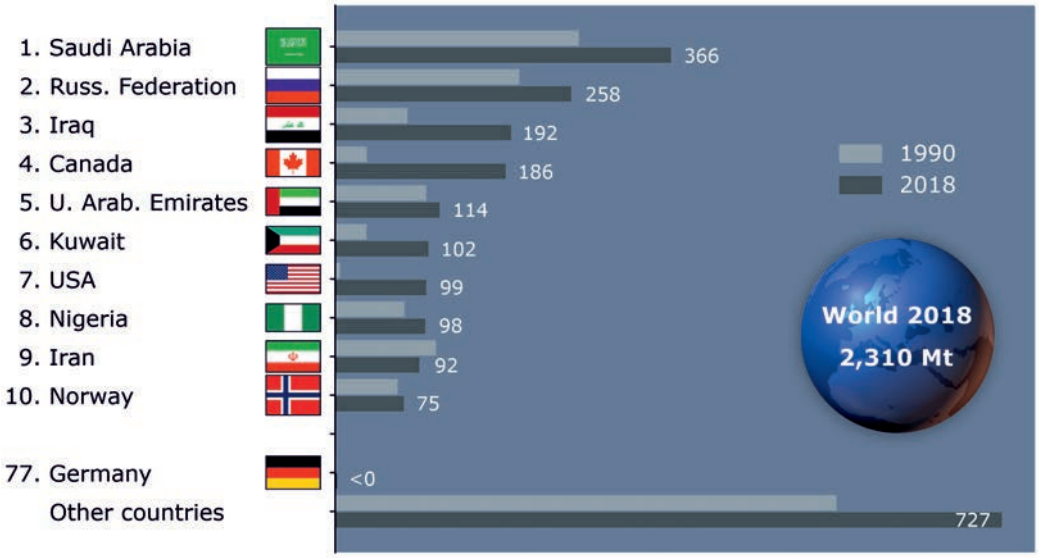

Figure A-8: Crude oil exports – top 10 countries 1990 and 2018.

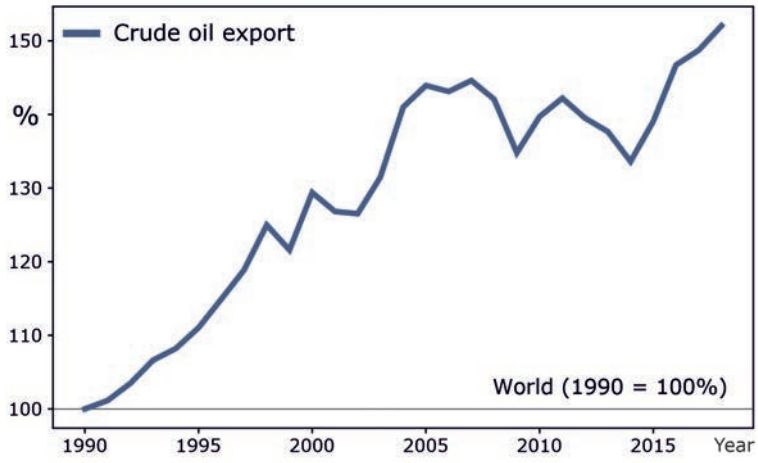

Figure A-9: Development of global crude oil exports from 1990 to 2018.

Table A-14: Crude oil imports 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	China	460.0	19.7	19.7
2	USA	385.2	16.5	36.1
3	India	225.8	9.6	45.8
4	Korea, Rep.	151.9	6.5	52.3
5	Japan	151.9	6.5	58.8
6	Germany	85.2	3.6	62.4
7	Spain	67.6	2.9	65.3
8	Italy	62.2	2.7	67.9
9	Singapore	57.2	2.4	70.4
10	France	56.3	2.4	72.8
11	Netherlands	54.7	2.3	75.1
12	Thailand	47.2	2.0	77.1
13	United Kingdom	46.0	2.0	79.1
14	Taiwan	43.7	1.9	81.0
15	Belgium	33.1	1.4	82.4
16	Canada	32.9	1.4	83.8
17	Greece	30.3	1.3	85.1
18	Poland	27.5	1.2	86.3
19	Turkey	21.0	0.9	87.2
20	Sweden	20.9	0.9	88.1
	other countries [63]	279.5	11.9	100.0
	World	2,339.8	100.0	
	Europe	603.8	25.8	
	CIS (+ GEO, UKR)	20.7	0.9	
	Africa	11.9	0.5	
	Middle East	28.8	1.2	
	Austral-Asia	1,211.8	51.8	
	North America	418.9	17.9	
	Latin America	43.8	1.9	
	OECD	1,351.7	57.8	
	EU-28	574.1	24.5	

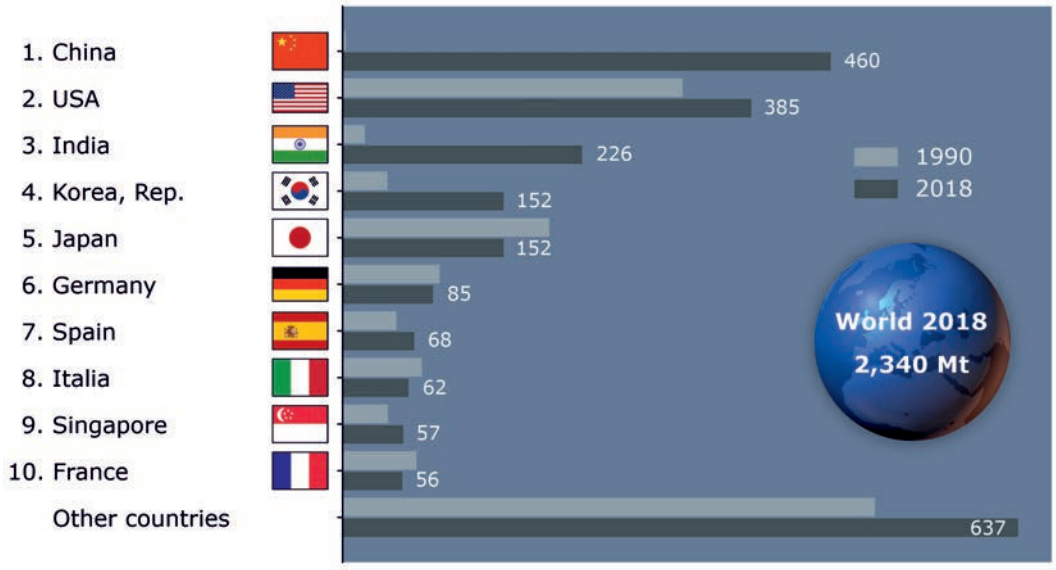

Figure A-10: Crude oil imports – top 10 countries 1990 and 2018.

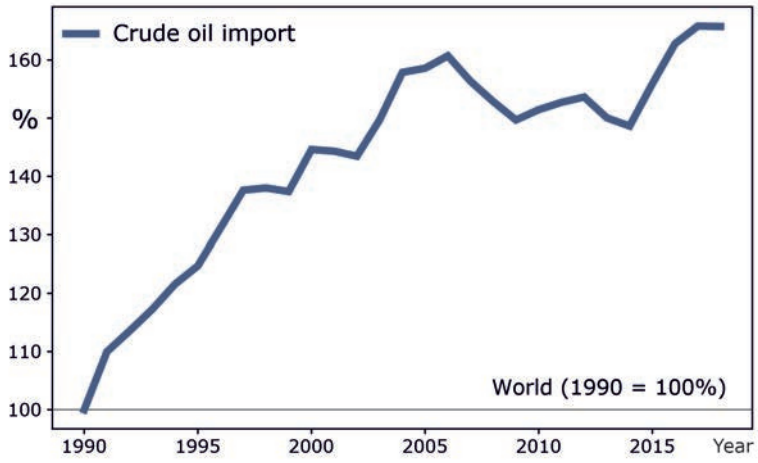

Figure A-11: Development of global crude oil imports and global population from 1990 to 2018.

Table A-15: Natural Gas 2018 [bcm]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
EUROPE	Albania	0.1	8	1	50	59	51
	Austria	1.0	103	8	244	355	251
	Belgium	–	–	–	85	85	85
	Bulgaria	0.2	8	6	575	589	581
	Croatia	1.2	78	25	50	153	75
	Cyprus	–	–	–	500	500	500
	Czechia	0.3	16	4	181	201	185
	Denmark	4.0	200	27	236	464	264
	France	0.1	229	8	3,984	4,221	3,992
	Germany	7.2	1,053	30	1,360	2,443	1,390
	Greece	< 0.05	1	1	10	12	11
	Hungary	1.9	236	6	173	415	179
	Ireland	3.4	66	10	50	126	60
	Italy	5.6	772	45	405	1,221	449
	Lithuania	–	–	–	14	14	14
	Malta	–	–	–	10	10	10
	Netherlands	42.7	3,705	209	512	4,425	720
	Norway	119.2	2,467	1,611	2,445	6,523	4,056
	Poland	5.1	278	88	1,250	1,616	1,338
	Portugal	–	–	–	148	148	148
	Romania	9.5	1,338	105	1,142	2,586	1,248
	Serbia	0.5	35	48	10	93	58
	Slovakia	0.1	26	14	10	50	24
	Slovenia	< 0.05	n. s.	1	30	31	31
	Spain	0.1	12	3	653	667	655
	Sweden	–	–	–	48	48	48
	Turkey	0.4	16	5	1,153	1,173	1,158
	United Kingdom	40.9	2,664	264	6,311	9,239	6,575
CIS (+ GEO, UKR)	Armenia	–	–	< 0.5	18	18	18
	Azerbaijan	17.9	632	1,269	1,900	3,801	3,169
	Belarus	0.2	14	3	10	27	13
	Georgia	< 0.05	3	8	102	113	110
	Kazakhstan	24.4	625	1,885	4,179	6,689	6,064
	Kyrgyzstan	< 0.05	8	6	20	33	26

continuation of table A-15
[bcm]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
CIS (+ GEO, UKR)	Moldova, Republic	–	–	–	20	20	20
	Russian Federation	725.5	24,382	47,811	145,200	217,392	193,011
	Tajikistan	–	9	6	20	34	26
	Turkmenistan	80.7	2,874	9,805	15,000	27,679	24,805
	Ukraine	20.0	2,080	950	4,495	7,525	5,445
	Uzbekistan	53.0	2,480	1,542	1,400	5,422	2,942
AFRICA	Algeria	95.9	2,674	4,504	26,720	33,898	31,224
	Angola	9.6	38	383	800	1,221	1,183
	Benin	–	–	< 0.5	100	100	100
	Botswana	–	–	–	1,840	1,840	1,840
	Cameroon	0.8	n. s.	135	250	385	385
	Chad	–	–	–	1,455	1,455	1,455
	Comoros	–	–	–	10	10	10
	Congo, DR	n. s.	n. s.	1	50	51	51
	Congo, Rep.	0.9	n. s.	109	350	459	459
	Côte d'Ivoire	2.5	37	28	350	415	378
	Egypt	62.3	1,026	2,138	12,380	15,543	14,518
	Equatorial Guinea	7.8	78	42	180	300	222
	Eritrea	–	–	–	29	29	29
	Ethiopia	–	–	35	151	186	186
	Gabon	0.5	7	26	650	683	676
	Gambia	–	–	–	25	25	25
	Ghana	1.2	n. s.	23	275	298	298
	Guinea	–	–	–	160	160	160
	Guinea-Bissau	–	–	–	50	50	50
	Kenya	–	–	–	330	330	330
	Liberia	–	–	–	225	225	225
	Libya	13.9	355	1,505	4,650	6,510	6,155
	Madagascar	–	–	–	4,500	4,500	4,500
	Mali	–	–	–	30	30	30
	Mauritania	n. s.	n. s.	28	900	928	928
	Morocco	0.1	3	5	2,170	2,178	2,175
	Mozambique	4.7	51	2,832	3,160	6,043	5,992
	Namibia	–	–	62	300	362	362

continuation of table A-15
[bcm]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
AFRICA	Niger	–	–	–	250	250	250
	Nigeria	44.3	664	5,346	3,300	9,309	8,646
	Rwanda	n. s.	n. s.	1	157	158	158
	São Tomé and Príncipe	–	–	–	100	100	100
	Senegal	–	–	–	500	500	500
	Seychelles	–	–	–	600	600	600
	Sierra Leone	–	–	–	197	197	197
	Somalia	–	–	6	255	261	261
	South Africa	0.9	48	10	7,277	7,335	7,287
	Sudan & South Sudan	n. s.	n. s.	85	300	385	385
	Tanzania	1.6	n. s.	37	1,500	1,537	1,537
	Togo	–	–	–	80	80	80
	Tunisia	2.0	63	65	750	878	815
	Uganda	–	–	14	90	104	104
	Zimbabwe	–	–	–	10	10	10
MIDDLE EAST	Bahrain	14.8	341	182	400	924	582
	Iran	248.5	3,252	33,813	10,000	47,065	43,813
	Iraq	11.1	162	3,557	5,000	8,719	8,557
	Israel	10.3	69	412	1,700	2,181	2,112
	Jordan	0.1	6	6	270	282	276
	Kuwait	17.7	404	1,784	500	2,688	2,284
	Lebanon	–	–	–	850	850	850
	Oman	36.0	542	664	3,085	4,292	3,750
	Palestinian territories	–	–	–	380	380	380
	Qatar	181.6	2,117	23,846	2,000	27,963	25,846
	Saudi Arabia	112.1	2,229	8,035	25,664	35,928	33,699
	Syrian	5.8	154	269	300	722	569
	U. Arab Emirates	47.6	1,424	6,091	7,315	14,829	13,406
	Yemen	0.6	53	267	500	820	767
AUSTRAL-ASIA	Afghanistan	0.2	58	50	400	507	450
	Australia	131.1	1,477	3,230	31,687	36,395	34,917
	Bangladesh	27.5	455	169	800	1,424	969
	Brunei	12.5	459	240	200	899	440
	Cambodia	–	–	–	50	50	50

continuation of table A-15
[bcm]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
AUSTRAL-ASIEA	China	176.0	2,086	6,021	63,400	71,507	69,421
	India	31.7	885	1,289	7,039	9,213	8,328
	Indonesia	69.9	2,364	2,761	9,980	15,105	12,741
	Japan	2.8	147	21	10	178	31
	Korea, Rep.	0.3	n. s.	7	50	57	57
	Laos	–	–	–	10	10	10
	Malaysia	72.5	1,555	2,348	1,900	5,803	4,248
	Mongolia	–	–	–	133	133	133
	Myanmar	17.8	253	637	2,000	2,891	2,637
	New Zealand	4.4	180	28	353	561	381
	Pakistan	36.9	998	402	4,560	5,960	4,962
	Papua New Guinea	9.7	13	182	1,000	1,196	1,182
	Philippines	4.3	56	99	502	656	600
	Sri Lanka	–	–	–	300	300	300
	Taiwan	0.2	53	6	5	64	11
	Thailand	36.1	727	188	740	1,654	928
	Timor-Leste	5.0	n. s.	88	300	388	388
	Viet Nam	9.6	141	646	1,355	2,142	2,001
NORTH AMERICA	Canada	172.7	6,655	2,040	26,801	35,496	28,841
	Mexico	40.2	1,789	185	17,720	19,694	17,905
	USA	863.0	37,428	11,888	65,531	114,847	77,420
LATIN AMERICA	Argentina	47.2	1,299	346	23,710	25,355	24,056
	Barbados	n. s.	n. s.	< 0.5	100	100	100
	Belize	–	–	–	10	10	10
	Bolivia	16.0	337	292	1,620	2,250	1,912
	Brazil	28.0	391	370	18,446	19,207	18,816
	Chile	1.2	113	–	1,745	1,858	1,745
	Colombia	9.6	301	106	2,307	2,714	2,413
	Cuba	1.0	20	71	400	490	471
	Ecuador	0.3	9	11	20	39	31
	Falkland Islands	–	–	–	1,500	1,500	1,500
	(French) Guiana	–	–	–	400	400	400
	Grenada	–	–	–	25	25	25
	Guatemala	–	–	–	10	10	10

continuation of table A-15
[bcm]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
LATIN AMERICA	Guyana	–	–	–	300	300	300
	Haiti	–	–	–	40	40	40
	Paraguay	–	–	–	2,420	2,420	2,420
	Peru	12.8	169	351	1,340	1,859	1,691
	Puerto Rico	–	–	–	30	30	30
	Suriname	–	–	–	350	350	350
	Trinidad and Tobago	34.0	771	310	–	1,081	310
	Uruguay	–	–	–	828	828	828
	Venezuela	24.8	1,218	5,708	7,130	14,055	12,838
	World	3,999.7	124,616	202,239	628,979	955,834	831,218
	Europe	243.5	13,310	2,519	21,639	37,468	24,157
	CIS (+ GEO, UKR)	921.8	33,105	63,284	172,364	268,753	235,648
	Africa	248.8	5,042	17,420	77,456	99,917	94,875
	Middle East	686.4	10,753	78,928	57,964	147,644	136,891
	Austral-Asia	648.4	11,907	18,412	126,774	157,093	145,186
	North America	1,075.9	45,872	14,113	110,052	170,037	124,165
	Latin America	175.0	4,627	7,564	62,731	74,922	70,295
	OPEC	816.6	14,630	94,760	94,279	203,668	189,038
	OPEC-Gulf	618.7	9,588	77,127	50,479	137,194	127,605
	OECD	1,458.1	59,701	20,145	164,899	244,745	185,044
	EU-28	123.3	10,784	854	17,981	29,619	18,835

n. s. not specified
– no production or reserves

Table A-16: Natural gas resources 2018 [bcm]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional	unconventional		
				tight gas	shale gas	CBM
1	Russian Federation	145,200	110,000	20,000	9,500	5,700
2	USA	65,531	31,970	11,815	17,276	4,470
3	China	63,400	20,000	10,500	22,000	10,900
4	Australia	31,687	6,090	8,000	11,756	5,841
5	Canada	26,801	6,500	–	16,230	4,071
6	Algeria	26,720	1,200	5,500	20,020	–
7	Saudi Arabia	25,664	20,000	–	5,664	–
8	Argentina	23,710	1,000	–	22,710	–
9	Brazil	18,446	11,500	–	6,940	6
10	Mexico	17,720	2,250	–	15,440	30
11	Turkmenistan	15,000	15,000	–	–	–
12	Egypt	12,380	9,550	–	2,830	–
13	Iran	10,000	10,000	–	–	–
14	Indonesia	9,980	5,500	–	1,300	3,180
15	U. Arab Emirates	7,315	1,500	–	5,815	–
16	South Africa	7,277	1,000	–	5,707	570
17	Venezuela	7,130	2,400	–	4,730	–
18	India	7,039	2,000	–	2,720	2,319
19	United Kingdom	6,311	2,738	–	3,543	30
20	Iraq	5,000	5,000	–	–	–
46	Germany	1,360	20	90	800	450
	other countries [123]	95,308	58,833	1,567	27,995	6,914
	World	628,979	324,050	57,472	202,976	44,481
	Europe	21,639	7,488	527	12,416	1,207
	CIS (+ GEO, UKR)	172,364	130,988	20,000	11,274	10,102
	Africa	77,456	35,064	5,500	35,482	1,410
	Middle East	57,964	44,250	670	13,044	–
	Austral-Asia	126,774	44,115	18,690	40,996	22,973
	North America	110,052	40,720	11,815	48,946	8,571
	Latin America	62,731	21,425	270	40,818	218
	OPEC	94,279	49,100	5,500	39,679	–
	OPEC-Gulf	50,479	39,000	–	11,479	–
	OECD	164,899	55,728	20,577	73,027	15,566
	EU-28	17,981	4,984	327	11,746	924

– no resources or no information

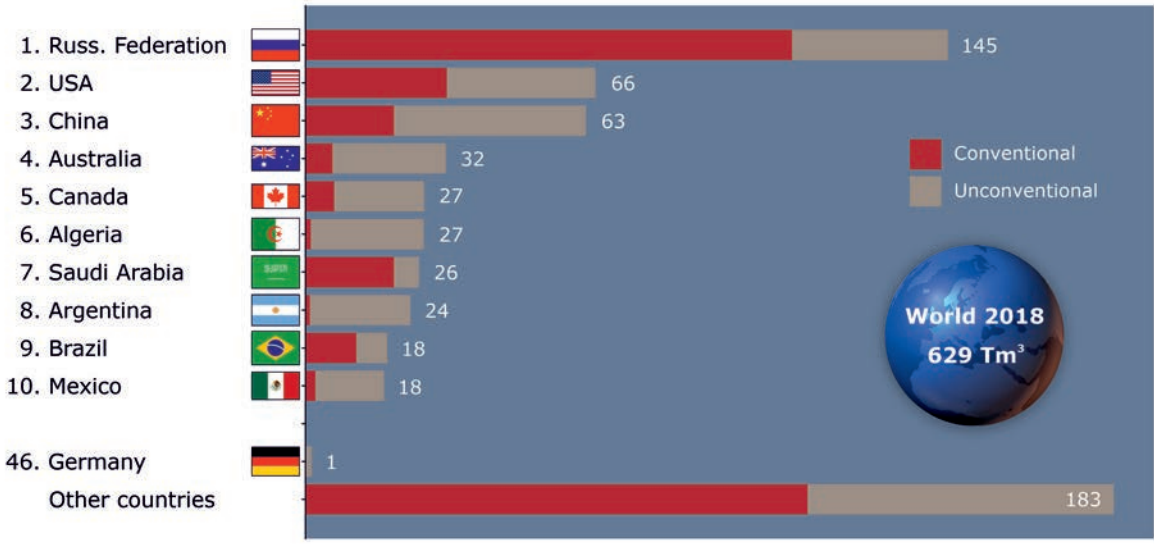

Figure A-12: Natural gas resources – top 10 countries 2018.

Table A-17: Natural gas reserves 2018 [bcm]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional[1]	unconventional	
				shale gas	CBM
1	Russian Federation	47,811	47,762	–	49
2	Iran	33,813	33,813	–	–
3	Qatar	23,846	23,846	–	–
4	USA	11,888	1,863	9,689	336
5	Turkmenistan	9,805	9,805	–	–
6	Saudi Arabia	8,035	8,035	–	–
7	U. Arab Emirates	6,091	6,091	–	–
8	China	6,021	5,483	198	340
9	Venezuela	5,708	5,708	–	–
10	Nigeria	5,346	5,346	–	–
11	Algeria	4,504	4,504	–	–
12	Iraq	3,557	3,557	–	–
13	Australia	3,230	2,351	n. s.	879
14	Mozambique	2,832	2,832	–	–
15	Indonesia	2,761	2,761	–	–
16	Malaysia	2,348	2,348	–	–
17	Egypt	2,138	2,138	–	–
18	Canada	2,040	2,005	n. s.	35
19	Kazakhstan	1,885	1,885	–	–
20	Kuwait	1,784	1,784	–	–
65	Germany	30	30	–	–
	other countries [81]	16,766	16,651	–	115
	World	202,239	190,598	9,887	1,754
	Europe	2,519	2,512	–	6
	CIS (+ GEO, UKR)	63,284	63,236	–	49
	Africa	17,420	17,420	–	–
	Middle East	78,928	78,928	–	–
	Austral-Asia	18,412	16,886	198	1,327
	North America	14,113	4,053	9,689	372
	Latin America	7,564	7,564	–	–
	OPEC	94,760	94,760	–	–
	OPEC-Gulf	77,127	77,127	–	–
	OECD	20,145	9,200	9,689	1,257
	EU-28	854	847	–	6

[1] including tight gas

n. s. not specified
– no reserves

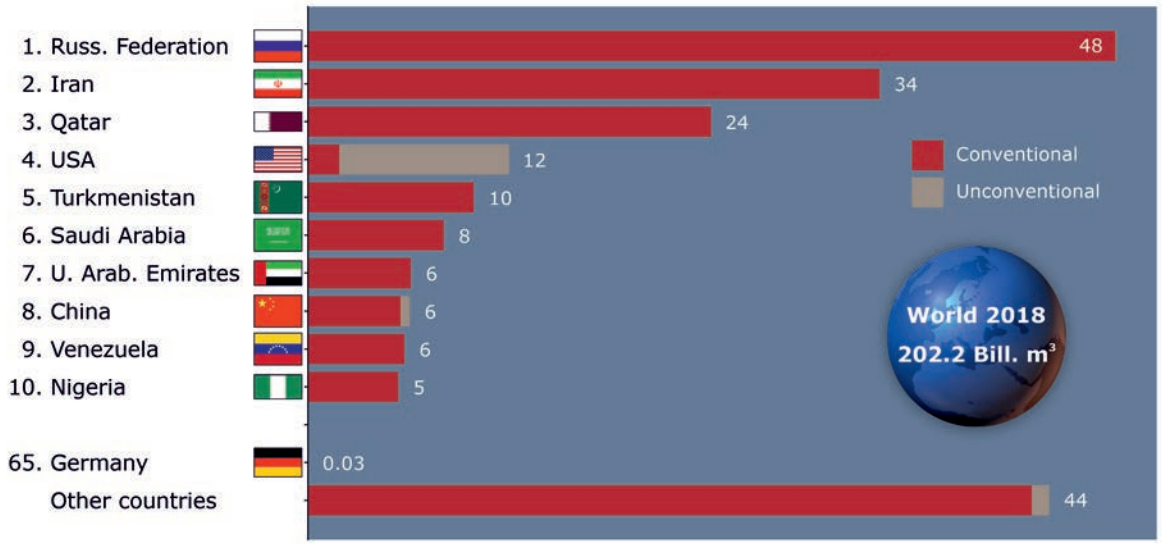

Figure A-13: Natural gas reserves – top 10 countries conventional and unconventional 2018.

Table A-18: Natural gas production 2013 to 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2013	2014	2015	2016	2017	2018	Share [%]		Change	
		[Mt]						Country	cum.	2017/2018	[%]
1	USA	687.2	729.1	768.1	755.8	761.1	863.0	21.6	21.6	101.9	13.4
2	Russian Federation	627.6	610.1	636.0	640.7	691.6	725.5	18.1	39.7	33.9	4.9
3	Iran	159.1	172.6	183.9	202.4	238.0	248.5	6.2	45.9	10.5	4.4
4	Qatar	158.5	160.0	171.3	165.4	163.6	181.6	4.5	50.5	18.0	11.0
5	China	119.3	132.8	138.2	141.9	154.0	176.0	4.4	54.9	22.0	14.3
6	Canada	154.8	161.3	154.8	157.1	176.3	172.7	4.3	59.2	-3.6	-2.0
7	Australia	50.1	55.3	69.9	88.2	113.9	131.1	3.3	62.5	17.2	15.1
8	Norway	107.1	108.8	121.3	121.2	124.2	119.2	3.0	65.4	-5.0	-4.0
9	Saudi Arabia	103.0	108.2	106.4	109.4	111.4	112.1	2.8	68.3	0.7	0.6
10	Algeria	79.6	79.7	82.3	93.2	94.8	95.9	2.4	70.6	1.1	1.2
11	Turkmenistan	62.3	69.3	80.2	77.0	80.5	80.7	2.0	72.7	0.3	0.3
12	Malaysia	69.1	66.4	68.2	73.8	78.4	72.5	1.8	74.5	-5.9	-7.6
13	Indonesia	70.4	71.8	72.7	74.0	70.4	69.9	1.7	76.2	-0.6	-0.8
14	Egypt	56.1	48.7	44.3	41.8	51.9	62.3	1.6	77.8	10.4	20.0
15	Uzbekistan	58.7	59.3	58.8	51.6	52.1	53.0	1.3	79.1	0.9	1.8
16	U. Arab Emirates	56.0	55.6	55.8	61.9	54.1	47.6	1.2	80.3	-6.5	-12.0
17	Argentina	41.7	41.5	42.9	45.0	44.6	47.2	1.2	81.5	2.6	5.8
18	Nigeria	36.1	40.3	43.7	41.2	43.0	44.3	1.1	82.6	1.2	2.9
19	Netherlands	84.5	66.3	51.2	47.4	43.9	42.7	1.1	83.7	-1.2	-2.6
20	United Kingdom	38.5	38.7	41.3	42.0	42.3	40.9	1.0	84.7	-1.4	-3.4
48	Germany	11.1	10.5	9.7	9.0	8.3	7.2	0.2	98.4	-1.1	-13.0
	other countries [70]	600.3	608.7	585.5	581.8	596.8	605.7	15.1	100.0	8.8	1.5
	World	3,431.1	3,495.0	3,586.5	3,621.8	3,795.3	3,999.7	100.0		204.4	5.4
	Europe	276.3	258.2	256.5	253.2	253.7	243.5	6.1		-10.2	-4.0
	CIS (+ GEO, UKR)	817.1	807.6	832.5	826.9	884.6	921.8	23.0		37.2	4.2
	Africa	202.3	200.9	202.7	208.1	230.5	248.8	6.2		18.3	7.9
	Middle East	566.0	587.2	605.4	628.6	656.1	686.4	17.2		30.3	4.6
	Austral-Asia	498.5	520.5	541.2	570.7	613.4	648.4	16.2		35.0	5.7
	North America	887.8	935.2	968.9	960.1	978.1	1,075.9	26.9		97.8	10.0
	Latin America	183.1	185.5	179.2	174.3	179.0	175.0	4.4		-4.0	-2.2
	OPEC	662.5	689.5	711.4	740.0	789.2	816.6	20.4		27.4	3.5
	OPEC-Gulf	498.0	520.0	540.6	563.4	595.1	618.7	15.5		23.6	4.0
	OECD	1,216.4	1,251.7	1,298.9	1,307.7	1,352.5	1,458.1	36.5		105.7	7.8
	EU-28	168.0	148.3	134.3	130.9	128.6	123.3	3.1		-5.3	-4.1

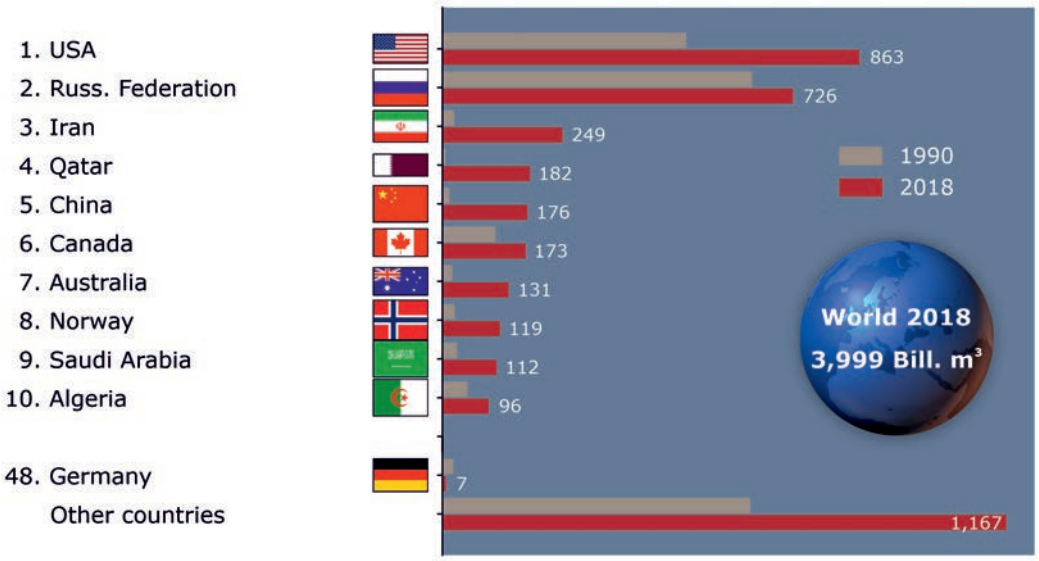

Figure A-14: Natural gas production – top 10 countries 1990 and 2018.

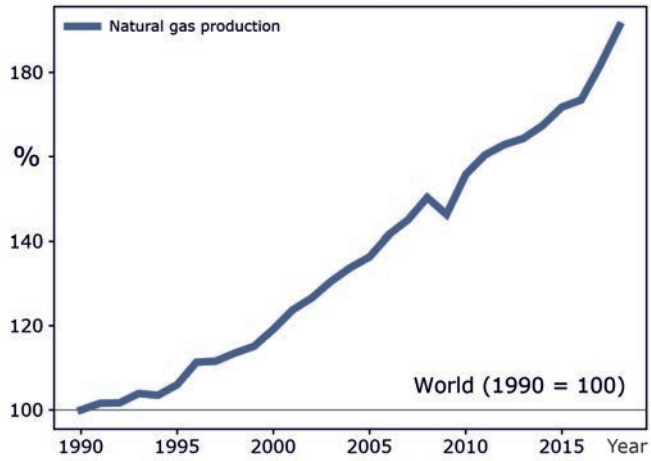

Figure A-15: Development of global natural gas production from 1990 to 2018.

Table A-19: Natural gas consumption 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[bcm]	Share [%] country	Share [%] cumulative
1	USA	848.6	21.9	21.9
2	Russian Federation	487.8	12.6	34.4
3	China	280.3	7.2	41.7
4	Iran	242.4	6.2	47.9
5	Japan	115.7	3.0	50.9
6	Saudi Arabia	112.1	2.9	53.8
7	Canada	102.4	2.6	56.4
8	Germany	85.0	2.2	58.6
9	Mexico	81.2	2.1	60.7
10	United Kingdom	76.2	2.0	62.7
11	U. Arab Emirates	70.0	1.8	64.5
12	Italy	69.2	1.8	66.2
13	Egypt	62.0	1.6	67.8
14	India	58.1	1.5	69.3
15	Korea, Rep.	55.9	1.4	70.8
16	Argentina	50.5	1.3	72.1
17	Thailand	49.9	1.3	73.4
18	Turkey	49.6	1.3	74.6
19	Algeria	44.4	1.1	75.8
20	Pakistan	43.6	1.1	76.9
	other countries [90]	896.0	23.1	100.0
	World	3,880.9	100.0	
	Europe	522.9	13.5	
	CIS (+ GEO, UKR)	649.6	16.7	
	Africa	145.7	3.8	
	Middle East	563.1	14.5	
	Austral-Asia	808.2	20.8	
	North America	1,032.3	26.6	
	Latin America	159.3	4.1	
	OPEC	581.8	15.0	
	OPEC-Gulf	497.6	12.8	
	OECD	1,767.6	45.5	
	EU-28	460.9	11.9	

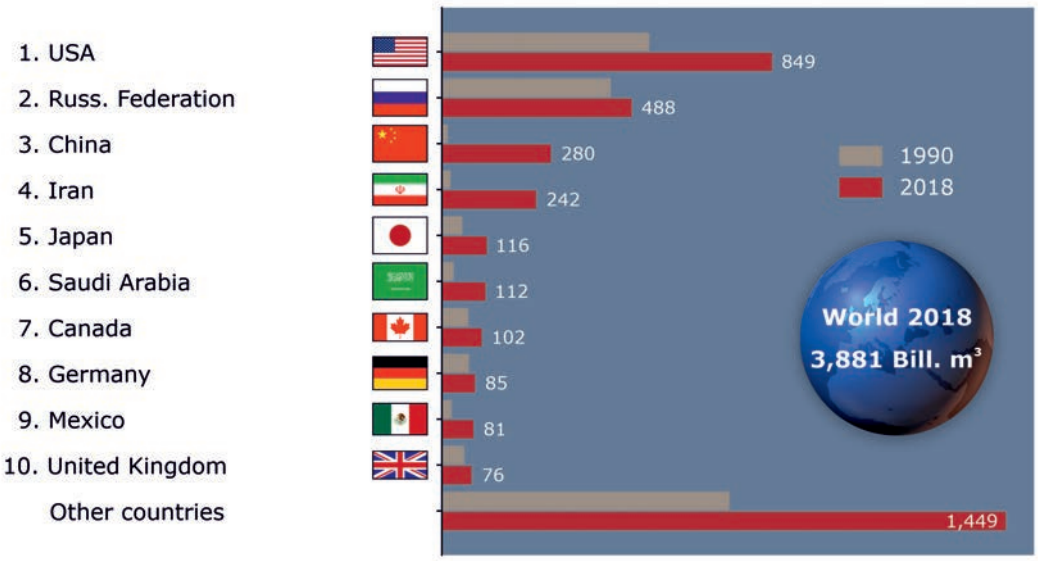

Figure A-16: Natural gas consumption – top 10 countries 1990 and 2018.

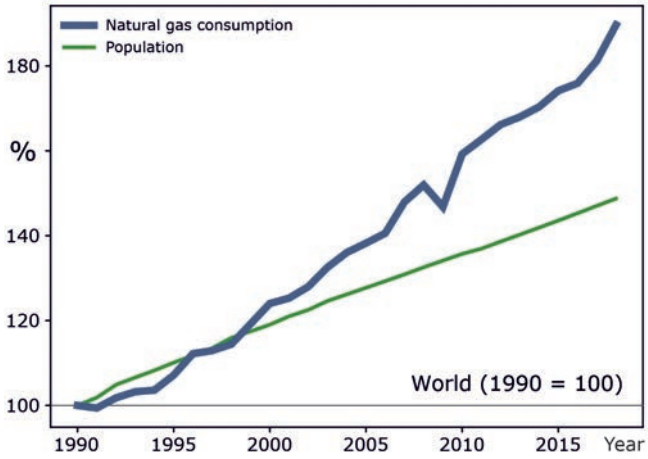

Figure A-17: Growth of global natural gas consumption and the global population from 1990 to 2018.

Table A-20: Natural gas exports 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[bcm]	Share [%] country	Share [%] cumulative
1	Russian Federation	251.3	19.4	19.4
2	Qatar	143.4	11.0	30.4
3	Norway	120.9	9.3	39.7
4	USA	102.2	7.9	47.6
5	Australia	90.7	7.0	54.6
6	Canada	80.3	6.2	60.8
7	Turkmenistan	55.9	4.3	65.1
8	Netherlands	52.6	4.0	69.1
9	Algeria	51.4	4.0	73.1
10	Germany	40.3	3.1	76.2
11	Indonesia	35.6	2.7	78.9
12	Malaysia	32.8	2.5	81.5
13	Nigeria	28.6	2.2	83.7
14	Belgium	23.8	1.8	85.5
15	Trinidad and Tobago	17.7	1.4	86.9
16	Bolivia	17.0	1.3	88.2
17	Kazakhstan	16.8	1.3	89.5
18	Oman	13.4	1.0	90.5
19	Iran	12.3	0.9	91.4
20	Myanmar	12.0	0.9	92.4
	other countries [26]	99.1	7.6	100.0
	World	1,298.2	100.0	
	Europe	267.9	20.6	
	CIS (+ GEO, UKR)	343.6	26.5	
	Africa	95.6	7.4	
	Middle East	176.3	13.6	
	Austral-Asia	192.0	14.8	
	North America	182.5	14.1	
	Latin America	40.4	3.1	
	OPEC	253.2	19.5	
	OPEC-Gulf	162.9	12.5	
	OECD	541.1	41.7	
	EU-28	146.3	11.3	

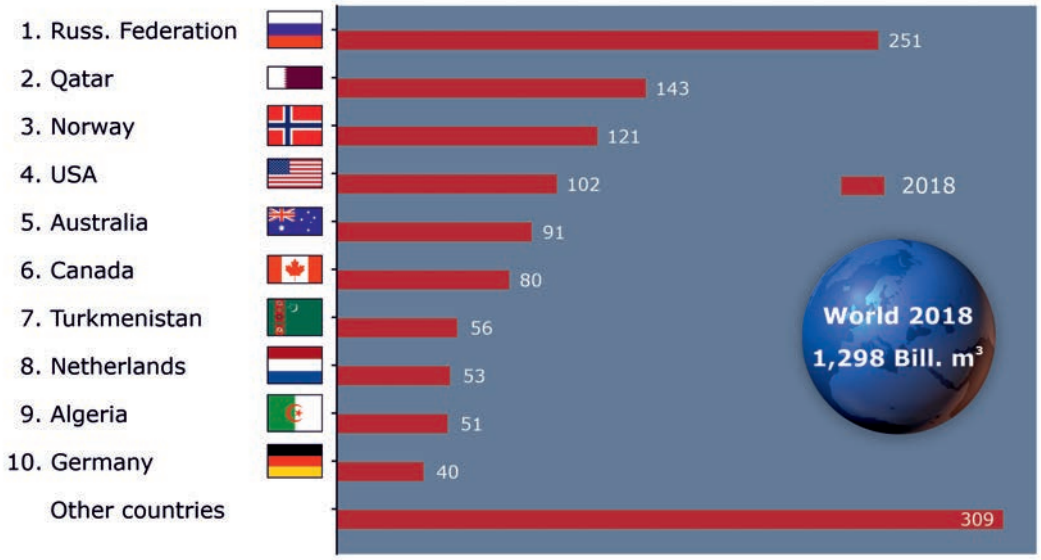

Figure A-18: Natural gas exports – top 10 countries 1990 and 2018.

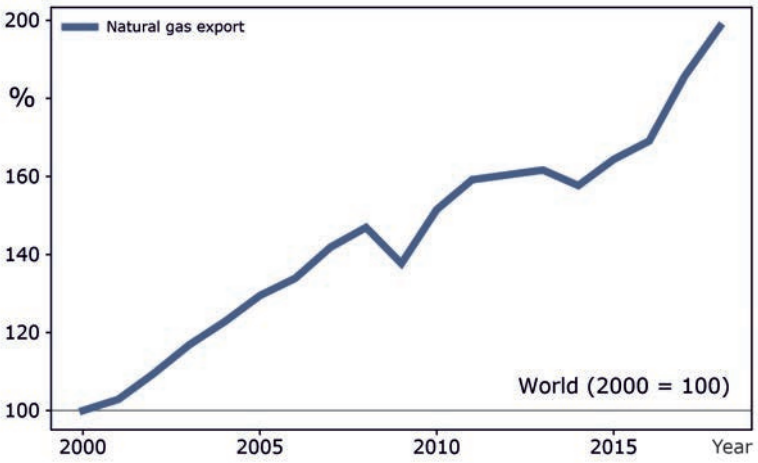

Figure A-19: Development of global natural gas exports from 2000 to 2018.

Table A-21: Natural gas imports 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[bcm]	Share [%] country	Share [%] cumulative
1	China	125.4	10.2	10.2
2	Germany	117.0	9.5	19.6
3	Japan	110.7	9.0	28.6
4	USA	81.8	6.6	35.2
5	Italy	67.9	5.5	40.7
6	Netherlands	59.0	4.8	45.5
7	Korea, Rep.	55.5	4.5	50.0
8	Mexico	51.7	4.2	54.2
9	Turkey	50.4	4.1	58.3
10	France	49.3	4.0	62.3
11	United Kingdom	47.2	3.8	66.1
12	Belgium	39.8	3.2	69.3
13	Spain	34.8	2.8	72.1
14	India	28.7	2.3	74.5
15	U. Arab Emirates	26.1	2.1	76.6
16	Taiwan	22.4	1.8	78.4
17	Canada	21.3	1.7	80.1
18	Belarus	20.6	1.7	81.8
19	Poland	15.8	1.3	83.1
20	Brazil	14.3	1.2	84.2
	other countries [50]	194.8	15.8	100.0
	World	1,234.5	100.0	
	Europe	548.9	44.5	
	CIS (+ GEO, UKR)	56.8	4.6	
	Africa	11.0	0.9	
	Middle East	43.8	3.5	
	Austral-Asia	387.3	31.4	
	North America	154.8	12.5	
	Latin America	31.9	2.6	
	OPEC	36.5	3.0	
	OPEC-Gulf	36.5	3.0	
	OECD	872.9	70.7	
	EU-28	492.6	39.9	

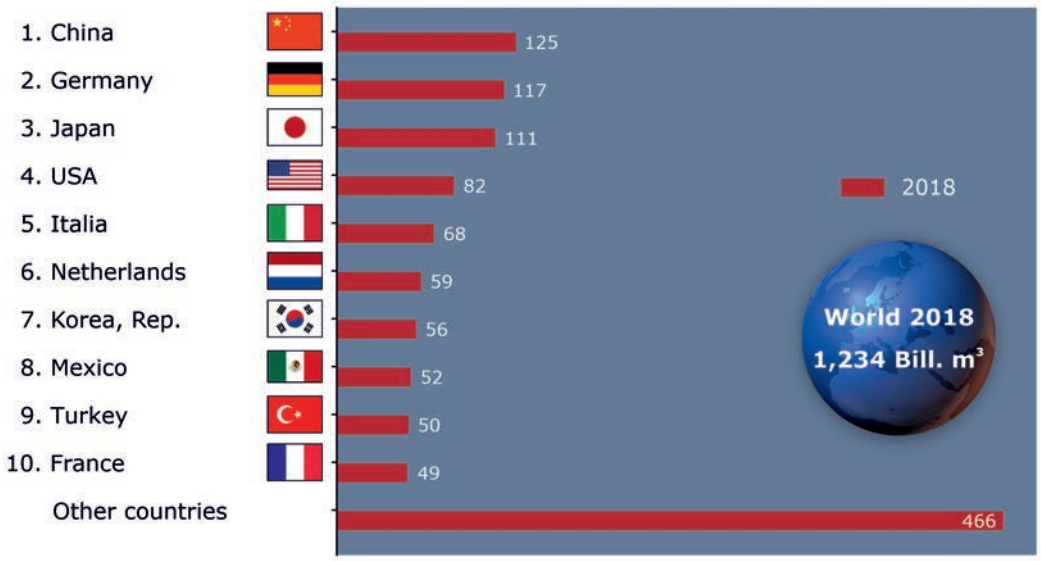

Figure A-20: Natural gas imports – top 10 countries 2018.

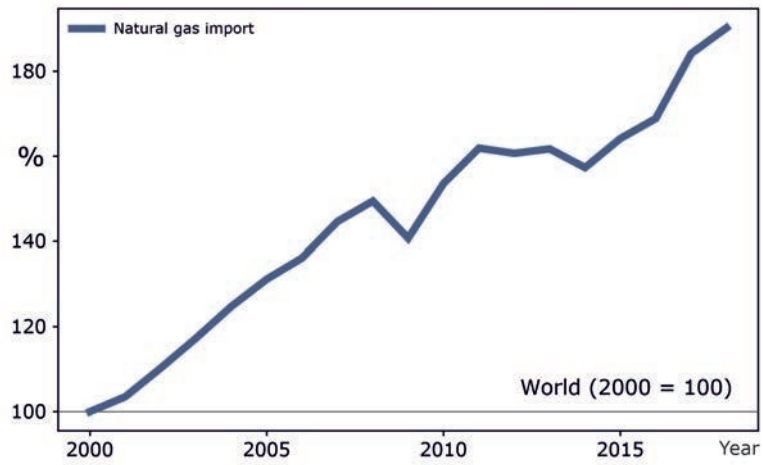

Figure A-21: Development of global natural gas imports from 2000 to 2018.

Table A-22: Hard coal 2018 [Mt]

	Country / Region	Production	Reserves	Resources	Remaining Potential
EUROPE	Belgium	–	–	4,100	4,100
	Bulgaria	–	192	3,920	4,112
	Croatia	–	–	4	4
	Czechia	4.1	413	15,257	15,670
	France	–	–	160	160
	Germany	2.8	–	82,965	82,965
	Hungary	–	276	5,075	5,351
	Ireland	–	14	26	40
	Italy	–	10	600	610
	Montenegro	–	142	195	337
	Netherlands	–	497	2,750	3,247
	Norway	0.1	2	84	86
	Poland	63.6	21,067	161,189	182,257
	Portugal	–	3	n. s.	3
	Romania	–	11	2,435	2,446
	Serbia	0.1	402	453	855
	Slovakia	–	–	19	19
	Slovenia	–	56	39	95
	Spain	2.2	868	3,363	4,231
	Sweden	–	1	4	5
	Turkey	1.1	550	786	1,337
	United Kingdom	2.6	26	186,700	186,726
CIS (+ GEO, UKR)	Armenia	–	163	154	317
	Georgia	–	201	700	901
	Kazakhstan	111.9	25,605	123,090	148,695
	Kyrgyzstan	0.3	971	27,528	28,499
	Russian Federation	352.6	71,719	1,117,389	1,189,108
	Tajikistan	1.9	375	3,700	4,075
	Turkmenistan	–	–	800	800
	Ukraine	33.3	32,039	49,006	81,045
	Uzbekistan	0.1	1,375	9,477	10,852
AFRICA	Algeria	–	59	164	223
	Botswana	2.5	1,660	56,300	57,960
	Congo, DR	–	88	900	988

continuation of table A-22
[Mt]

	Country / Region	Production	Reserves	Resources	Remaining Potential
AFRICA	Egypt	–	16	166	182
	Eswatini	0.2	144	4,500	4,644
	Madagascar	–	–	150	150
	Malawi	0.1	2	800	802
	Morocco	–	14	82	96
	Mozambique	15.2	1,792	30,528	32,321
	Namibia	–	–	350	350
	Niger	0.2	–	90	90
	Nigeria	0.4	287	1,857	2,144
	South Africa	253.3	9,893	203,667	213,560
	Tanzania	0.6	269	1,141	1,410
	Uganda	–	–	800	800
	Zambia	1.0	45	900	945
	Zimbabwe	3.3	502	25,000	25,502
	Iran	1.8	1,203	40,000	41,203
AUSTRAL-ASIA	Afghanistan	2.4	66	n. s.	66
	Australia	452.8	72,571	1,550,972	1,623,543
	Bangladesh	0.9	293	2,967	3,260
	Bhutan	0.2	n. s.	n. s.	n. s.
	China	3,530.0	133,467	5,321,722	5,455,189
	India	730.3	100,858	170,881	271,739
	Indonesia	497.8	28,163	72,819	100,982
	Japan	1.0	340	13,543	13,883
	Korea, DPR	20.0	600	10,000	10,600
	Korea, Rep.	1.2	326	1,360	1,686
	Laos	0.1	4	58	62
	Malaysia	2.7	148	840	988
	Mongolia	47.6	1,170	39,854	41,024
	Myanmar	0.7	3	248	252
	Nepal	< 0.05	1	7	8
	New Caledonia	–	2	n. s.	2
	New Zealand	2.9	825	2,350	3,175
	Pakistan	3.3	207	5,789	5,996
	Papua New Guinea	–	–	11	11

continuation of table A-22
[Mt]

	Country / Region	Production	Reserves	Resources	Remaining Potential
AUSTRAL-ASIA	Philippines	13.1	215	1,074	1,289
	Taiwan	–	1	101	102
	Viet Nam	42.0	3,116	3,519	6,635
N-AMERICA	Canada	46.9	4,346	183,260	187,606
	Greenland	–	183	200	383
	Mexico	6.8	1,160	3,000	4,160
	USA	634.2	219,534	6,459,327	6,678,861
LATIN AMERICA	Argentina	< 0.05	500	300	800
	Bolivia	–	1	n. s.	1
	Brazil	3.6	1,547	4,665	6,212
	Chile	2.3	1,181	4,135	5,316
	Colombia	84.3	4,554	9,928	14,482
	Costa Rica	–	–	17	17
	Peru	0.2	102	1,465	1,567
	Venezuela	0.2	731	5,981	6,712
	World	6,982.7	749,166	16,189,759	16,938,926
	Europe	76.6	24,531	470,125	494,656
	CIS (+ GEO, UKR)	500.1	132,446	1,331,845	1,464,291
	Africa	276.8	14,770	327,395	342,165
	Middle East	1.8	1,203	40,000	41,203
	Austral-Asia	5,349.0	342,377	7,198,116	7,540,494
	North America	687.9	225,223	6,645,787	6,871,010
	Latin America	90.6	8,616	26,491	35,107
	Antarctica[1]	–	–	150,000	150,000
	OPEC	2.3	2,279	48,002	50,281
	OPEC-Gulf	1.8	1,203	40,000	41,203
	OECD	1,224.6	324,251	8,681,265	9,005,515
	EU-28	75.2	23,435	468,606	492,041

[1] The exploration and production of raw materials in the Antarctic is prohibited by international law

n. s. not specified
– no production, reserves or resources

Table A-23: Hard coal resources 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	USA	6,459,327	39.9	39.9
2	China	5,321,722	32.9	72.8
3	Australia	1,550,972	9.6	82.3
4	Russian Federation[1]	1,117,389	6.9	89.3
5	South Africa	203,667	1.3	90.5
6	United Kingdom	186,700	1.2	91.7
7	Canada	183,260	1.1	92.8
8	India	170,881	1.1	93.8
9	Poland	161,189	1.0	94.8
10	Kazakhstan	123,090	0.8	95.6
11	Germany	82,965	0.5	96.1
12	Indonesia	72,819	0.4	96.6
13	Botswana	56,300	0.3	96.9
14	Ukraine[1]	49,006	0.3	97.2
15	Iran	40,000	0.2	97.5
16	Mongolia[1]	39,854	0.2	97.7
17	Mozambique	30,528	0.2	97.9
18	Kyrgyzstan	27,528	0.2	98.1
19	Zimbabwe	25,000	0.2	98.2
20	Czechia[1]	15,257	0.1	98.3
	other countries [59]	272,304	1.7	100.0
	World	16,189,759	100.0	
	Europe	470,125	2.9	
	CIS (+ GEO, UKR)	1,331,845	8.2	
	Africa	327,395	2.0	
	Middle East	40,000	0.2	
	Austral-Asia	7,198,116	44.5	
	North America	6,645,787	41.0	
	Latin America	26,491	0.2	
	Antarctica[2]	150,000	0.9	
	OPEC	48,002	0.3	
	OPEC-Gulf	40,000	0.2	
	OECD	8,681,265	53.6	
	EU-28	468,606	2.9	

[1] Hard coal resources contains only bituminous coal and anthracite according to national classification

[2] The exploration and production of raw materials in the Antarctic is prohibited by international law

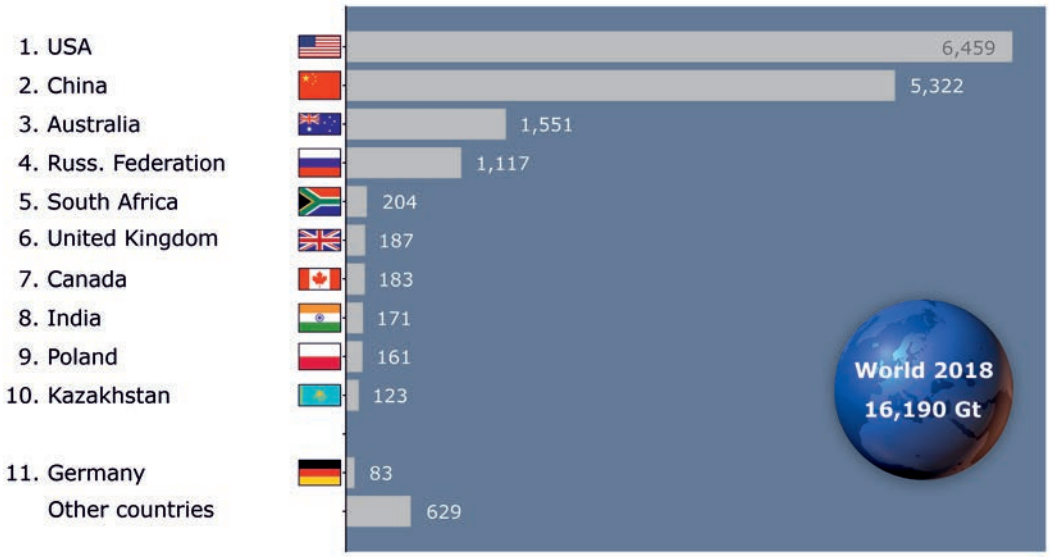

Figure A-22: Hard coal resources 2018.

Table A-24: Hard coal reserves 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	USA	219,534	29.3	29.3
2	China	133,467	17.8	47.1
3	India	100,858	13.5	60.6
4	Australia	72,571	9.7	70.3
5	Russian Federation[1]	71,719	9.6	79.8
6	Ukraine[1]	32,039	4.3	84.1
7	Indonesia	28,163	3.8	87.9
8	Kazakhstan	25,605	3.4	91.3
9	Poland	21,067	2.8	94.1
10	South Africa	9,893	1.3	95.4
11	Colombia	4,554	0.6	96.0
12	Canada	4,346	0.6	96.6
13	Viet Nam	3,116	0.4	97.0
14	Mozambique	1,792	0.2	97.3
15	Botswana	1,660	0.2	97.5
16	Brazil	1,547	0.2	97.7
17	Uzbekistan	1,375	0.2	97.9
18	Iran	1,203	0.2	98.0
19	Chile	1,181	0.2	98.2
20	Mongolia[1]	1,170	0.2	98.4
	other countries [50]	12,306	1.6	100.0
	World	749,166	100.0	
	Europe	**24,531**	**3.3**	
	CIS (+ GEO, UKR)	132,446	17.7	
	Africa	14,770	2.0	
	Middle East	1,203	0.2	
	Austral-Asia	342,377	45.7	
	North America	225,223	30.1	
	Latin America	8,616	1.2	
	OPEC	2,279	0.3	
	OPEC-Gulf	1,203	0.2	
	OECD	324,251	43.3	
	EU-28	23,435	3.1	

[1] Hard coal reserves contains only bituminous coal and anthracite according to national classification

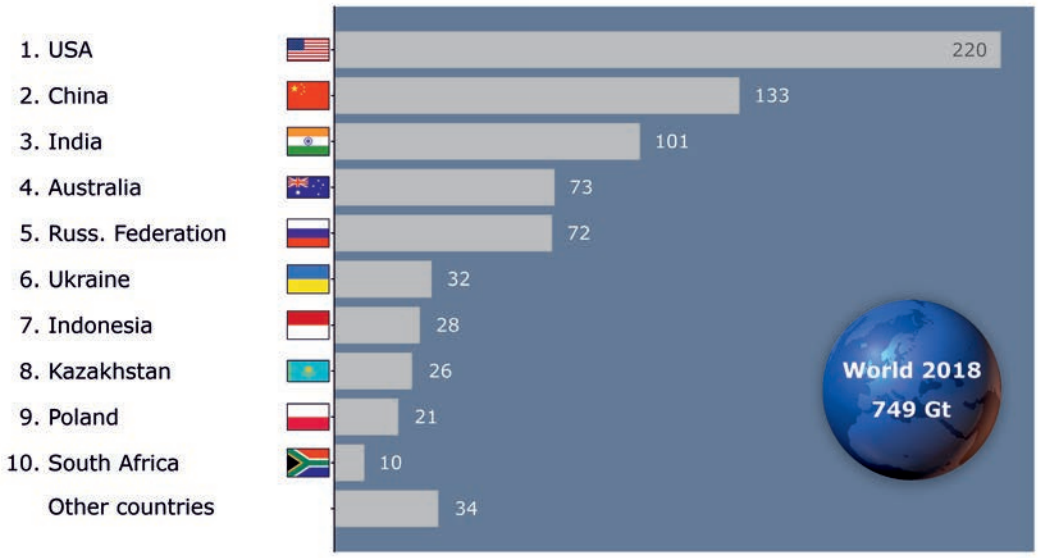

Figure A-23: Hard coal reserves 2018.

Table A-25: Hard coal production 2013 to 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2013	2014	2015	2016	2017	2018	Share [%]		Change	
		[Mt]						country	cum.	2017/2018	[%]
1	China	3,601.5	3,495.2	3,423.2	3,268.0	3,380.0	3,530.0	50.6	50.6	150.0	4.4
2	India	565.8	609.2	639.2	657.9	675.4	730.3	10.5	61.0	54.9	8.1
3	USA	823.4	835.1	749.4	596.1	641.3	634.2	9.1	70.1	-7.1	-1.1
4	Indonesia	430.0	410.8	401.6	396.2	401.2	497.8	7.1	77.2	96.5	24.1
5	Australia	411.3	441.5	440.0	443.4	435.9	452.8	6.5	83.7	16.9	3.9
6	Russian Federation[1]	279.0	287.0	300.1	312.0	333.9	352.6	5.0	88.8	18.7	5.6
7	South Africa	256.6	261.9	252.2	250.6	252.3	253.3	3.6	92.4	1.0	0.4
8	Kazakhstan	112.9	107.7	101.8	97.3	106.2	111.9	1.6	94.0	5.7	5.4
9	Colombia	86.0	88.9	86.6	91.1	91.1	84.3	1.2	95.2	-6.8	-7.4
10	Poland	77.1	73.3	72.7	70.8	66.0	63.6	0.9	96.1	-2.4	-3.6
11	Mongolia[1]	27.0	18.1	18.2	28.4	42.7	47.6	0.7	96.8	4.9	11.5
12	Canada	59.9	60.9	53.5	51.4	51.5	46.9	0.7	97.5	-4.6	-9.0
13	Viet Nam	41.0	41.1	41.7	38.7	38.4	42.0	0.6	98.1	3.6	9.5
14	Ukraine[1]	83.4	65.0	39.7	40.9	34.9	33.3	0.5	98.5	-1.6	-4.7
15	Korea, DPR[2]	31.6	34.0	34.0	34.0	20.0	20.0	0.3	98.8	0.0	0.0
16	Mozambique	5.9	6.3	6.6	6.2	11.8	15.2	0.2	99.0	3.5	29.4
17	Philippines	7.2	8.4	8.2	12.1	13.3	13.1	0.2	99.2	-0.2	-1.8
18	Mexico	13.1	13.5	7.5	8.2	7.5	6.8	0.1	99.3	-0.8	-10.0
19	Czechia[1]	8.6	8.3	7.6	6.1	4.9	4.1	0.1	99.4	-0.8	-15.6
20	Brazil	-	4.5	4.5	3.5	3.3	3.6	0.1	99.4	0.2	7.2
24	Germany	8.3	8.3	6.6	4.1	3.8	2.8	< 0.05	99.6	-1.1	-28.0
	other countries [32]	51.7	52.6	44.6	35.6	38.0	36.7	0.5	100.0	-1.3	-3.5
	World	6,981.1	6,931.8	6,739.5	6,452.4	6,653.5	6,982.7	100.0		329.2	4.9
	Europe	117.6	109.5	101.4	89.2	82.1	76.6	1.1		-5.5	-6.7
	CIS (+ GEO, UKR)	476.4	461.0	443.7	452.3	477.6	500.1	7.2		22.6	4.7
	Africa	268.0	277.2	266.5	262.8	271.6	276.8	4.0		5.2	1.9
	Middle East	0.9	1.4	1.5	1.5	1.5	1.8	< 0.05		0.3	16.7
	Austral-Asia	5,130.7	5,073.4	5,020.7	4,893.1	5,022.7	5,349.0	76.6		326.2	6.5
	North America	896.4	909.5	810.4	655.6	700.3	687.9	9.9		-12.5	-1.8
	Latin America	91.0	99.8	95.3	97.9	97.6	90.6	1.3		-7.0	-7.2
	OPEC	3.3	3.8	2.4	3.0	2.3	2.3	< 0.05		0.0	0.2
	OPEC-Gulf	0.9	1.4	1.5	1.5	1.5	1.8	< 0.05		0.3	16.7
	OECD	1,432.7	1,471.1	1,360.9	1,196.2	1,226.2	1,224.6	17.5		-1.6	-0.1
	EU-28	113.6	105.9	98.7	86.9	80.7	75.2	1.1		-5.5	-6.8

[1] Hard coal production contains only bituminous coal and anthracite according to national classification

[2] Data preliminary

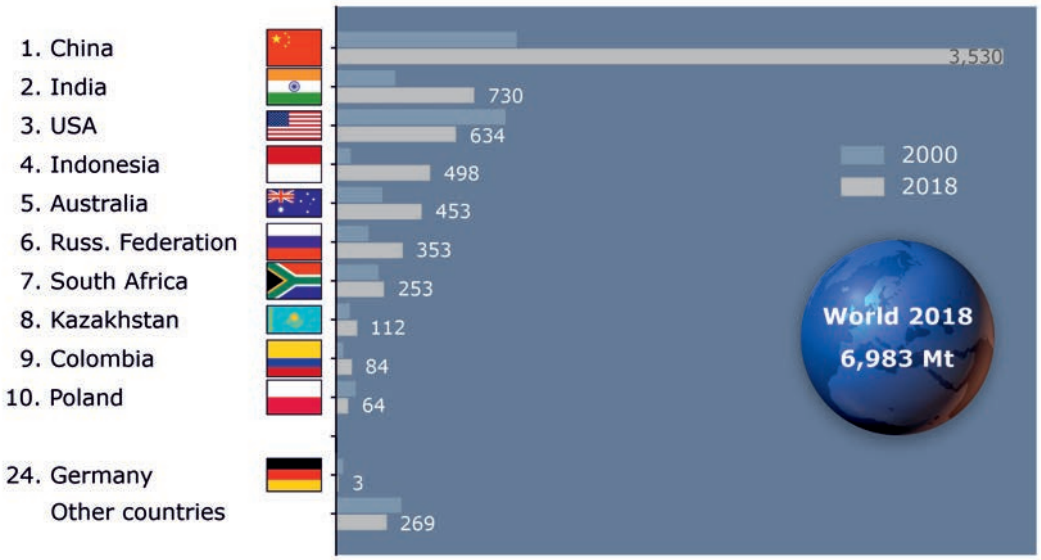

Figure A-24: Hard coal production – top 10 countries 2000 and 2018.

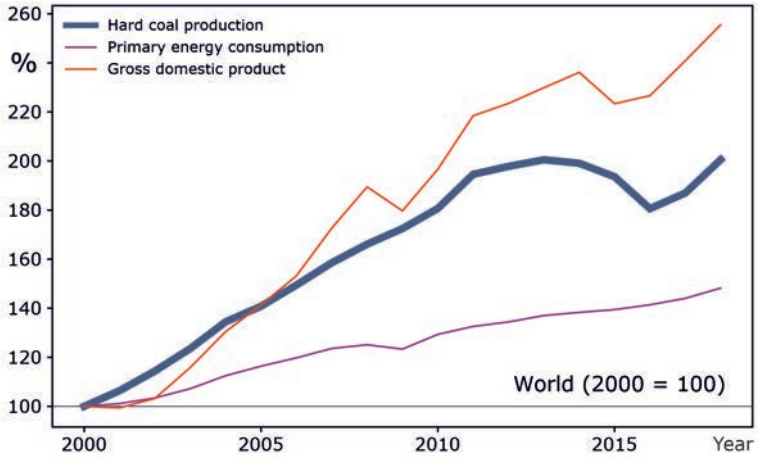

Figure A-25: Development of global hard coal production, of primary energy consumption and gross domestic product (GDP) from 2000 to 2018.

Table A-26: Hard coal consumption 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	China	3,806.3	54.4	54.4
2	India	964.1	13.8	68.2
3	USA	534.7	7.6	75.9
4	Japan	190.3	2.7	78.6
5	South Africa	175.3	2.5	81.1
6	Russian Federation[1]	175.2	2.5	83.6
7	Korea, Rep.	149.9	2.1	85.8
8	Kazakhstan	89.6	1.3	87.1
9	Poland	78.3	1.1	88.2
10	Indonesia	74.2	1.1	89.2
11	Taiwan	67.0	1.0	90.2
12	Australia	66.4	1.0	91.1
13	Viet Nam	62.4	0.9	92.0
14	Ukraine[1]	54.6	0.8	92.8
15	Germany	46.9	0.7	93.5
16	Turkey	39.5	0.6	94.1
17	Malaysia	36.4	0.5	94.6
18	Philippines	34.2	0.5	95.1
19	Brazil	24.6	0.4	95.4
20	Thailand	23.7	0.3	95.8
	other countries [91]	296.9	4.2	100.0
	World	6,990.5	100.0	
	Europe	275.7	3.9	
	CIS (+ GEO, UKR)	325.2	4.7	
	Africa	201.3	2.9	
	Middle East	13.3	0.2	
	Austral-Asia	5,553.9	79.4	
	North America	574.3	8.2	
	Latin America	46.8	0.7	
	OPEC	5.5	0.1	
	OPEC-Gulf	5.1	0.1	
	OECD	1,275.1	18.2	
	EU-28	233.0	3.3	

[1] Hard coal consumption contains only bituminous coal and anthracite according to national classification

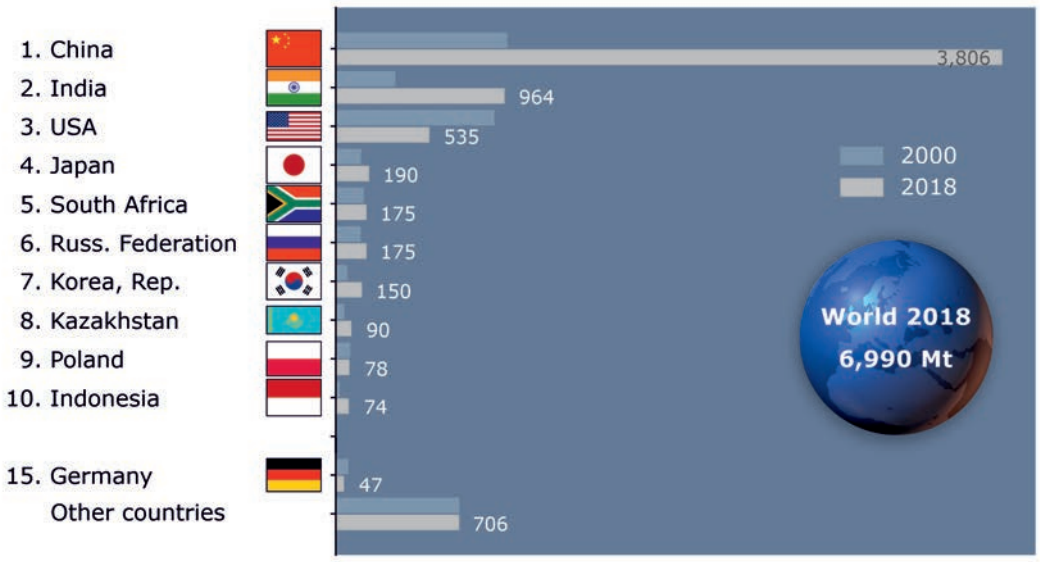

Figure A-26: Hard coal consumption – top 10 countries 2000 and 2018.

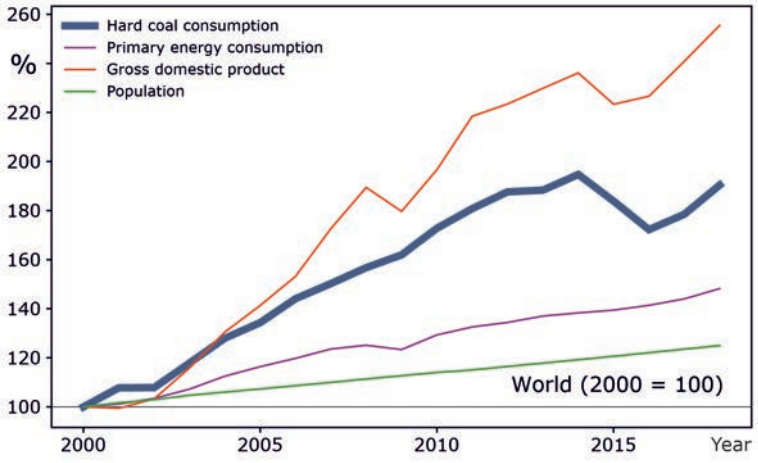

Figure A-27: Development of global hard coal consumption, primary energy consumption, gross domestic product (GDP) and global population from 2000 to 2018.

Table A-27: Hard coal exports 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	Indonesia	429.1	30.4	30.4
2	Australia	386.5	27.4	57.7
3	Russian Federation	199.5	14.1	71.9
4	USA	104.9	7.4	79.3
5	Colombia	81.9	5.8	85.1
6	South Africa	81.0	5.7	90.8
7	Mongolia	36.7	2.6	93.4
8	Canada	30.9	2.2	95.6
9	Kazakhstan	23.1	1.6	97.2
10	Mozambique	13.5	1.0	98.2
11	Philippines	5.2	0.4	98.6
12	Poland	5.0	0.4	98.9
13	China	4.9	0.3	99.3
14	Viet Nam	2.4	0.2	99.4
15	Czechia	1.9	0.1	99.6
16	India	1.4	0.1	99.7
17	New Zealand	1.3	0.1	99.8
18	United Kingdom	0.6	< 0.05	99.8
19	Peru	0.6	< 0.05	99.8
20	Chile	0.6	< 0.05	99.9
23	Germany	0.2	< 0.05	100.0
	other countries [6]	1.3	0.1	100.0
	World	1,412.6	100.0	
	Europe	8.1	0.6	
	CIS (+ GEO, UKR)	222.7	15.8	
	Africa	94.5	6.7	
	Middle East	0.2	< 0.05	
	Austral-Asia	867.9	61.4	
	North America	135.8	9.6	
	Latin America	83.3	5.9	
	OPEC	0.3	< 0.05	
	OPEC-Gulf	0.2	< 0.05	
	OECD	532.4	37.7	
	EU-28	8.0	0.6	

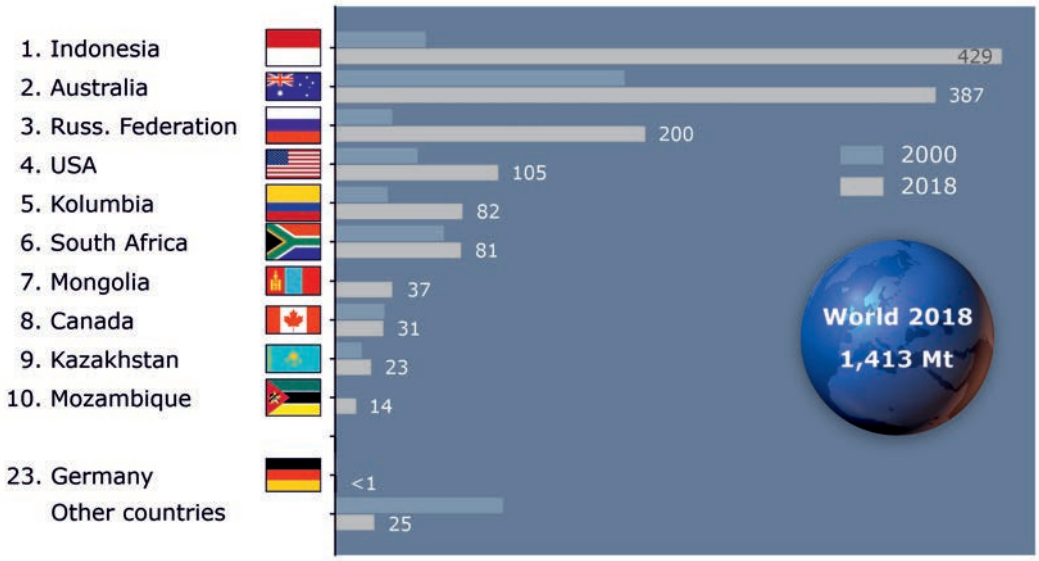

Figure A-28: Hard coal exports – top 10 countries 2000 and 2018.

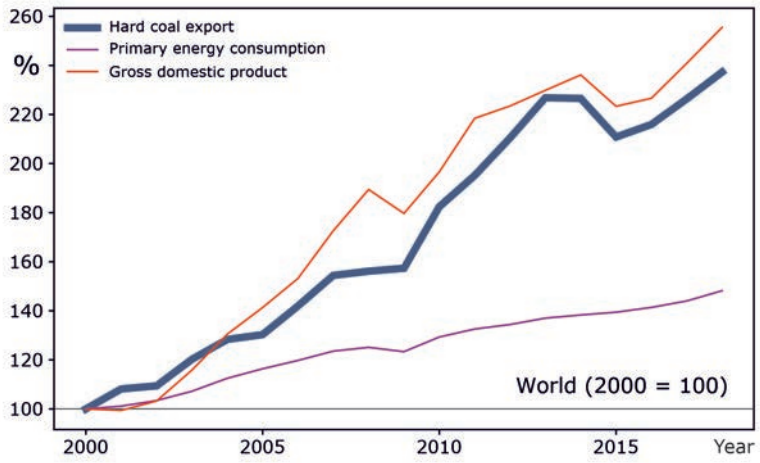

Figure A-29: Development of global hard coal exports, and primary energy consumption and gross domestic product (GDP) from 2000 to 2018.

Table A-28: Hard coal imports 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%]	
			country	cumulative
1	China	281.2	19.8	19.8
2	India	235.2	16.5	36.3
3	Japan	189.3	13.3	49.6
4	Korea, Rep.	148.7	10.5	60.1
5	Taiwan	66.5	4.7	64.8
6	Germany	44.4	3.1	67.9
7	Turkey	38.3	2.7	70.6
8	Malaysia	34.3	2.4	73.0
9	Philippines	26.3	1.8	74.9
10	Thailand	24.7	1.7	76.6
11	Viet Nam	22.7	1.6	78.2
12	Russian Federation	22.1	1.6	79.7
13	Ukraine	21.4	1.5	81.2
14	Brazil	21.0	1.5	82.7
15	Poland	19.7	1.4	84.1
16	Pakistan	15.9	1.1	85.2
17	Spain	15.1	1.1	86.3
18	Italy	14.1	1.0	87.3
19	France	13.5	0.9	88.2
20	Netherlands	13.1	0.9	89.1
	other countries [77]	154.3	10.9	100.0
	World	1,421.8	100.0	
	Europe	206.7	14.5	
	CIS (+ GEO, UKR)	47.7	3.4	
	Africa	20.7	1.5	
	Middle East	11.8	0.8	
	Austral-Asia	1,073.4	75.5	
	North America	22.3	1.6	
	Latin America	39.3	2.8	
	OPEC	3.5	0.2	
	OPEC-Gulf	3.5	0.2	
	OECD	582.4	41.0	
	EU-28	165.3	11.6	

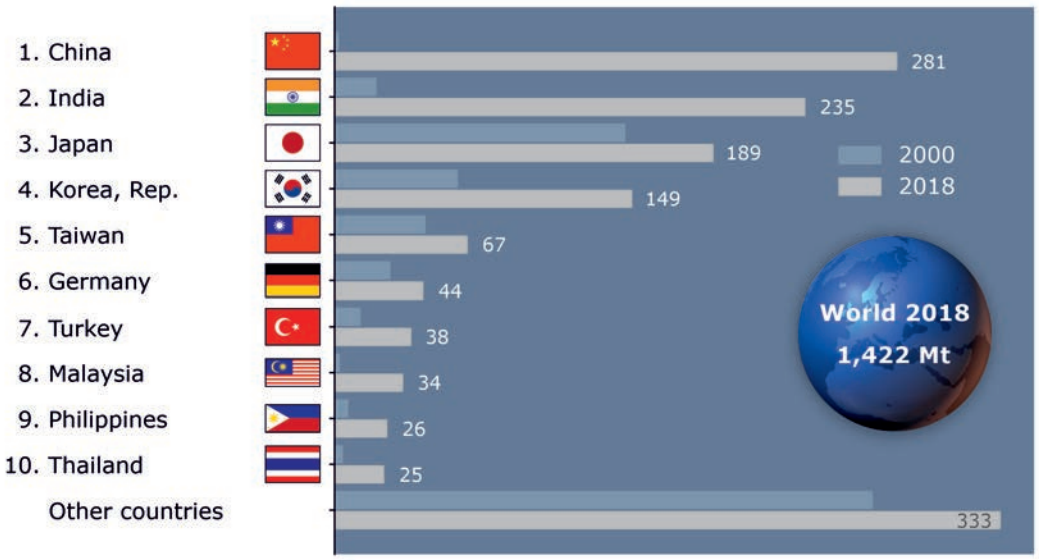

Figure A-30: Hard coal imports – Top 10 countries 2000 and 2018.

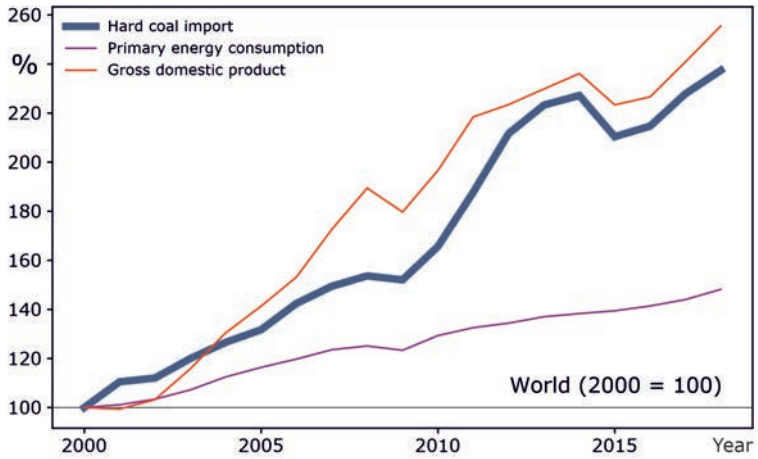

Figure A-31: Development of global hard coal imports, and primary energy consumption and gross domestic product (GDP) from 2000 to 2018.

Table A-29: Lignite 2018 [Mt]

	Country / Region	Production	Reserves	Resources	Remaining Potential
EUROPE	Albania	0.4	522	205	727
	Austria	–	–	333	333
	Bosnia & Herzegovina	14.0	2,264	3,010	5,274
	Bulgaria	30.3	2,174	2,400	4,574
	Croatia	–	n. s.	41	41
	Czechia	39.2	2,514	7,070	9,584
	France	–	n. s.	114	114
	Germany	166.3	35,900	36,500	72,400
	Greece	36.1	2,876	3,554	6,430
	Hungary	7.9	2,633	2,704	5,337
	Italy	–	7	22	29
	Kosovo	7.2	1,564	9,262	10,826
	Macedonia	5.0	332	300	632
	Montenegro	1.6	n. s.	n. s.	n. s.
	Poland	58.6	5,865	222,394	228,259
	Portugal	–	33	33	66
	Romania	23.6	280	9,640	9,920
	Serbia	37.5	7,112	13,074	20,186
	Slovakia	1.5	135	938	1,073
	Slovenia	3.2	315	341	656
	Spain	–	319	n. s.	319
	Turkey	85.0	10,975	5,284	16,259
	United Kingdom	–	–	1,000	1,000
CIS (+ GEO, UKR)	Belarus	–	–	1,500	1,500
	Georgia	0.1	–	–	–
	Kazakhstan	6.6	n. s.	n. s.	n. s.
	Kyrgyzstan	2.0	n. s.	n. s.	n. s.
	Russian Federation	80.0	90,447	541,353	631,800
	Tajikistan	0.1	n. s.	n. s.	n. s.
	Ukraine	0.2	2,336	5,381	7,717
	Uzbekistan	4.0	n. s.	n. s.	n. s.

continuation of table A-29
[Mt]

	Country / Region	Production	Reserves	Resources	Remaining Potential
AFRICA	Central African Rep.	–	3	n. s.	3
	Ethiopia	< 0.05	n. s.	n. s.	n. s.
	Madagascar	–	–	37	37
	Mali	–	–	3	3
	Morocco	–	–	40	40
	Niger	–	6	n. s.	6
	Nigeria	–	57	320	377
	Sierra Leone	–	–	2	2
AUSTRAL-ASIA	Australia	45.1	76,508	403,382	479,890
	Bangladesh	–	–	3	3
	China	150.0	8,128	324,068	332,196
	India	45.3	5,073	38,971	44,044
	Indonesia	60.0	11,728	27,998	39,726
	Japan	–	10	1,026	1,036
	Korea, DPR	6.0	n. s.	n. s.	n. s.
	Laos	15.9	499	22	521
	Malaysia	–	78	817	896
	Mongolia	7.0	1,350	119,426	120,776
	Myanmar	0.2	3	2	5
	New Zealand	0.3	6,750	4,600	11,350
	Pakistan	1.2	2,857	176,739	179,596
	Philippines	–	146	842	988
	Thailand	14.9	1,063	826	1,889
	Viet Nam	–	244	199,876	200,120
N-AMERICA	Canada	7.7	2,236	118,270	120,506
	Mexico	–	51	n. s.	51
	USA	51.7	30,003	1,368,102	1,398,105
LATIN AMERICA	Argentina	–	–	7,300	7,300
	Brazil	1.4	5,049	12,587	17,636
	Chile	–	n. s.	7	7
	Dominican Rep.	–	–	84	84
	Ecuador	–	24	n. s.	24
	Haiti	–	–	40	40
	Peru	–	–	100	100

continuation of table A-29
[Mt]

Country / Region	Production	Reserves	Resources	Remaining Potential
World	1,017.2	320,468	3,671,943	3,992,411
Europe	517.4	75,821	318,218	394,039
CIS (+ GEO, UKR)	93.0	92,783	548,234	641,016
Africa	< 0.05	66	402	468
Middle East	–	–	–	–
Austral-Asia	345.9	114,436	1,298,599	1,413,035
North America	59.5	32,290	1,486,372	1,518,662
Latin America	1.4	5,073	20,118	25,191
OPEC	–	81	320	401
OPEC-Gulf	–	–	–	–
OECD	502.7	177,131	2,175,673	2,352,804
EU-28	366.7	53,051	287,084	340,135

n. s. not specified
– no production, reserves or resources

Table A-30: Lignite resources 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	USA	1,368,102	37.3	37.3
2	Russian Federation[1]	541,353	14.7	52.0
3	Australia	403,382	11.0	63.0
4	China	324,068	8.8	71.8
5	Poland	222,394	6.1	77.9
6	Viet Nam	199,876	5.4	83.3
7	Pakistan	176,739	4.8	88.1
8	Mongolia[1]	119,426	3.3	91.4
9	Canada	118,270	3.2	94.6
10	India	38,971	1.1	95.7
11	Germany	36,500	1.0	96.7
12	Indonesia	27,998	0.8	97.4
13	Serbia	13,074	0.4	97.8
14	Brazil	12,587	0.3	98.1
15	Romania	9,640	0.3	98.4
16	Kosovo	9,262	0.3	98.6
17	Argentina	7,300	0.2	98.8
18	Czechia[1]	7,070	0.2	99.0
19	Ukraine	5,381	0.1	99.2
20	Turkey	5,284	0.1	99.3
	other countries [32]	25,265	0.7	100.0
	World	3,671,943	100.0	
	Europe	318,218	8.7	
	CIS (+ GEO, UKR)	548,234	14.9	
	Africa	402	< 0.05	
	Austral-Asia	1,298,599	35.4	
	North America	1,486,372	40.5	
	Latin America	20,118	0.5	
	OPEC	320	< 0.05	
	OECD	2,175,673	59.3	
	EU-28	287,084	7.8	

[1] Lignite resources contains subbituminous coal

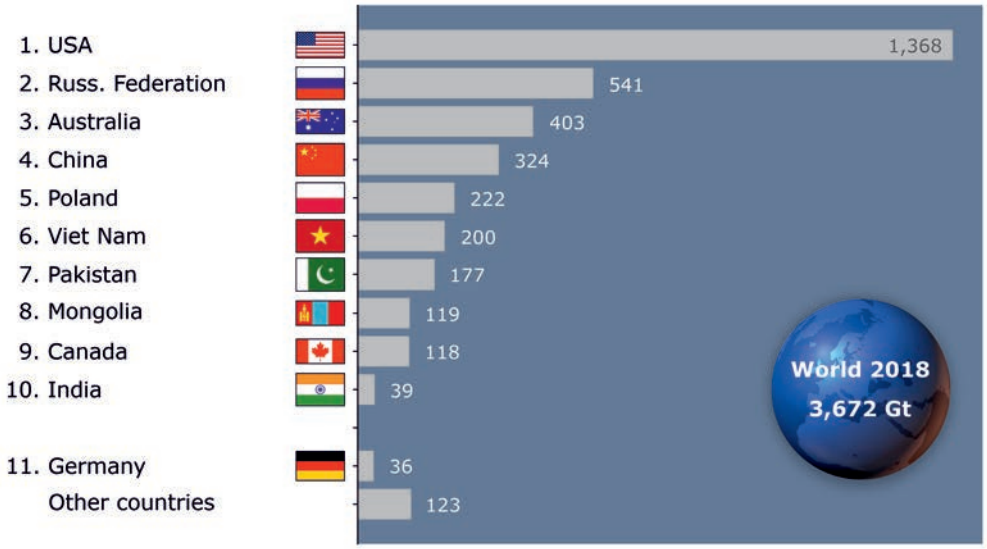

Figure A-32: Lignite resources – top 10 countries 2018.

Table A-31: Lignite reserves 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	Russian Federation[1]	90,447	28.2	28.2
2	Australia	76,508	23.9	52.1
3	Germany	35,900	11.2	63.3
4	USA	30,003	9.4	72.7
5	Indonesia	11,728	3.7	76.3
6	Turkey	10,975	3.4	79.7
7	China	8,128	2.5	82.3
8	Serbia	7,112	2.2	84.5
9	New Zealand	6,750	2.1	86.6
10	Poland	5,865	1.8	88.4
11	India	5,073	1.6	90.0
12	Brazil	5,049	1.6	91.6
13	Greece	2,876	0.9	92.5
14	Pakistan	2,857	0.9	93.4
15	Hungary	2,633	0.8	94.2
16	Czechia[1]	2,514	0.8	95.0
17	Ukraine	2,336	0.7	95.7
18	Bosnia & Herzegovina[1]	2,264	0.7	96.4
19	Canada	2,236	0.7	97.1
20	Bulgaria	2,174	0.7	97.8
	other countries [22]	7,041	2.2	100.0
	World	320,468	100.0	
	Europe	75,821	23.7	
	CIS (+ GEO, UKR)	92,783	29.0	
	Africa	66	< 0.05	
	Austral-Asia	114,436	35.7	
	North America	32,290	10.1	
	Latin America	5,073	1.6	
	OPEC	81	< 0.05	
	OECD	177,131	55.3	
	EU-28	53,051	16.6	

[1] Lignite reserves contains subbituminous coal

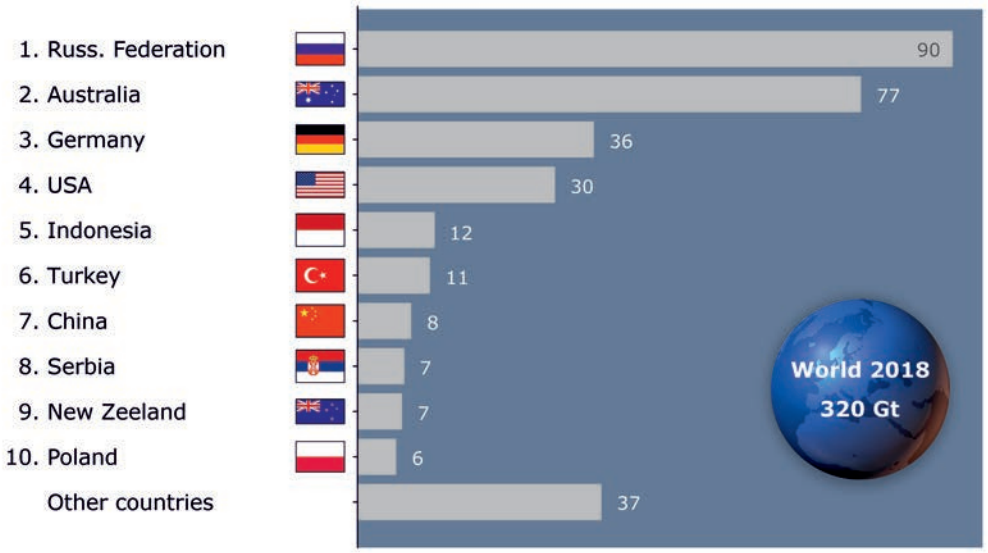

Figure A-33: Lignite reserves – top 10 countries 2018.

Table A-32: Lignite production 2013 to 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2013	2014	2015	2016	2017	2018	Share [%]		Change	
				[Mt]				country	cum.	2017/2018	[%]
1	Germany	183.0	178.2	178.1	171.5	171.3	166.3	16.3	16.3	-5.0	-2.9
2	China	147.0	145.0	140.0	140.0	145.0	150.0	14.7	31.1	5.0	3.4
3	Turkey	57.5	62.6	56.1	70.2	71.5	85.0	8.4	39.4	13.5	18.9
4	Russian Federation[1]	73.0	70.0	73.2	73.7	75.0	80.0	7.9	47.3	5.0	6.7
5	Indonesia[1]	65.0	60.0	60.0	60.0	60.0	60.0	5.9	53.2	0.0	0.0
6	Poland	65.8	63.9	63.1	60.2	61.2	58.6	5.8	59.0	-2.6	-4.2
7	USA	70.1	72.1	64.3	64.7	61.4	51.7	5.1	64.1	-9.6	-15.7
8	India	44.3	48.3	43.8	45.2	46.7	45.3	4.5	68.5	-1.3	-2.8
9	Australia	59.9	58.0	61.0	59.8	56.1	45.1	4.4	72.9	-11.0	-19.7
10	Czechia[1]	40.6	38.3	38.3	38.6	39.3	39.2	3.9	76.8	-0.1	-0.3
11	Serbia[1]	40.1	29.7	37.7	38.4	39.8	37.5	3.7	80.5	-2.3	-5.7
12	Greece	53.9	50.8	46.2	32.6	37.7	36.1	3.6	84.0	-1.6	-4.2
13	Bulgaria[2]	26.5	31.3	35.9	31.2	34.4	30.3	3.0	87.0	-4.1	-12.0
14	Romania[1]	24.7	23.6	25.5	23.0	25.7	23.6	2.3	89.3	-2.0	-7.9
15	Laos	0.4	< 0.05	4.5	13.1	13.4	15.9	1.6	90.9	2.5	18.3
16	Thailand	18.1	18.0	15.2	17.0	16.3	14.9	1.5	92.4	-1.4	-8.7
17	Bosnia & Herzegovina[1]	11.8	11.7	12.2	13.6	13.8	14.0	1.4	93.7	0.2	1.8
18	Hungary[1]	9.6	9.6	9.3	9.2	8.0	7.9	0.8	94.5	-0.1	-0.9
19	Canada	9.0	8.5	8.4	10.0	9.4	7.7	0.8	95.3	-1.6	-17.4
20	Kosovo	8.2	7.2	8.2	8.8	7.6	7.2	0.7	96.0	-0.4	-5.3
	other countries [18]	50.9	45.0	42.6	41.5	40.2	40.8	4.0	100.0	0.6	1.4
	World	1,059.3	1,031.7	1,023.4	1,022.6	1,033.6	1,017.2	100.0		-16.4	-1.6
	Europe	536.2	520.2	523.6	509.3	522.1	517.4	50.9		-4.7	-0.9
	CIS (+ GEO, UKR)	85.5	83.2	84.9	85.3	87.1	93.0	9.1		5.8	6.7
	Africa	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		0.0	0.0
	Austral-Asia	349.5	344.1	338.6	349.8	352.1	345.9	34.0		-6.3	-1.8
	North America	79.0	80.6	72.7	74.7	70.8	59.5	5.8		-11.3	-15.9
	Latin America	9.1	3.6	3.6[3]	3.5[3]	1.5[3]	1.4[3]	0.1		-0.1	-4.4
	OECD	556.3	547.8	530.2	522.4	521.2	502.7	49.4		-18.6	-3.6
	EU-28	410.2	400.9	401.4	371.7	382.7	366.7	36.1		-16.0	-4.2

[1] Lignite production contains subbituminous coal
[2] Lignite production contains subbituminous coal from 2014
[3] Lignite production in 2014 is not comparable with previous years due to changes in statistics

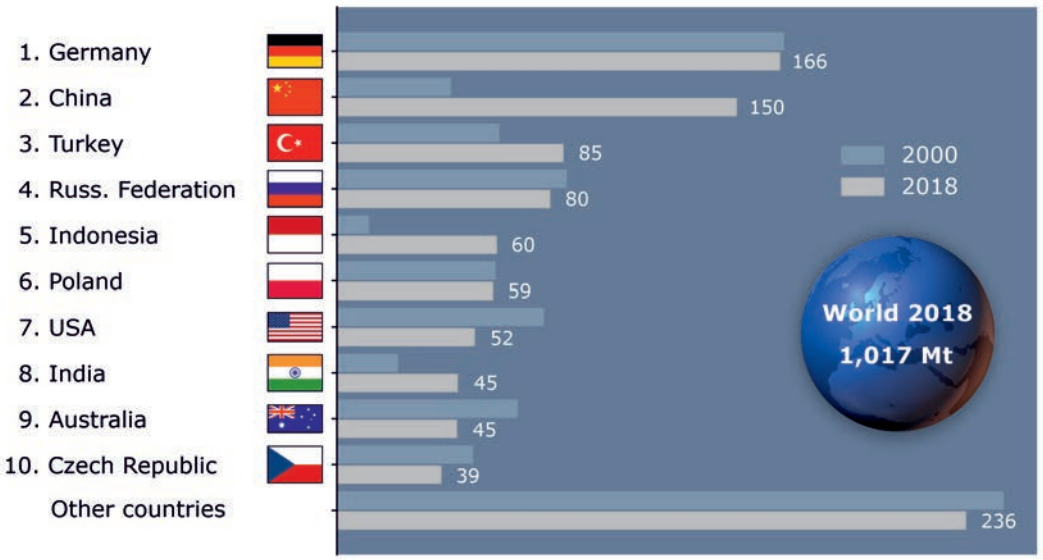

Figure A-34: Lignite production – top 10 countries 2000 and 2018.

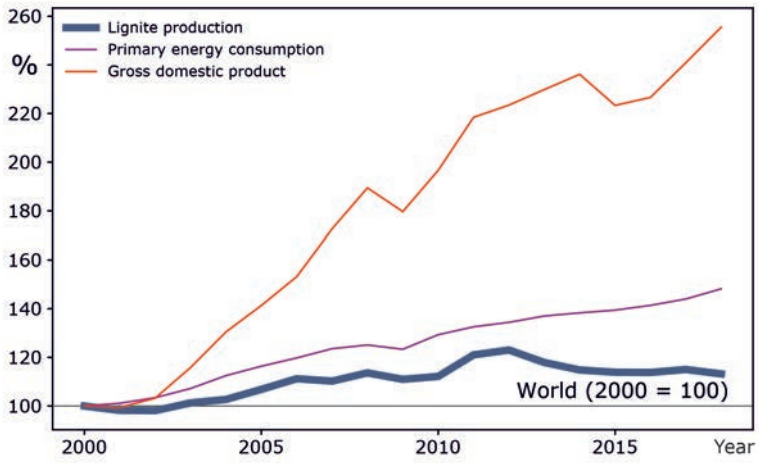

Figure A-35: Development of global lignite production, primary energy consumption, and gross domestic product from 2000 to 2018.

Table A-33: Lignite consumption 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[Mt]	Share [%] country	Share [%] cumulative
1	Germany	166.3	16.4	16.4
2	China	150.0	14.8	31.2
3	Turkey	85.0	8.4	39.5
4	Russian Federation[1]	80.0	7.9	47.4
5	Indonesia[1]	60.0	5.9	53.3
6	Poland	58.6	5.8	59.1
7	USA	51.7	5.1	64.2
8	India	45.3	4.5	68.6
9	Australia	45.1	4.4	73.1
10	Serbia[1]	37.5	3.7	76.8
11	Czechia	37.0	3.6	80.4
12	Greece	36.1	3.6	84.0
13	Bulgaria[1]	30.3	3.0	87.0
14	Romania[1]	24.2	2.4	89.3
15	Laos	15.9	1.6	90.9
16	Thailand	14.6	1.4	92.4
17	Bosnia & Herzegovina[1]	14.0	1.4	93.7
18	Hungary[1]	7.9	0.8	94.5
19	Canada	7.7	0.8	95.3
20	Kosovo[1]	7.2	0.7	96.0
	other countries [18]	40.8	4.0	100.0
	World	1,015.2	100.0	
	Europe	515.7	50.8	
	CIS (+ GEO, UKR)	93.0	9.2	
	Africa	< 0.05	< 0.05	
	Austral-Asia	345.6	34.0	
	North America	59.5	5.9	
	Latin America	1.4	0.1	
	OECD	500.5	49.3	
	EU-28	365.1	36.0	

[1] Lignite consumption contains subbituminous coal

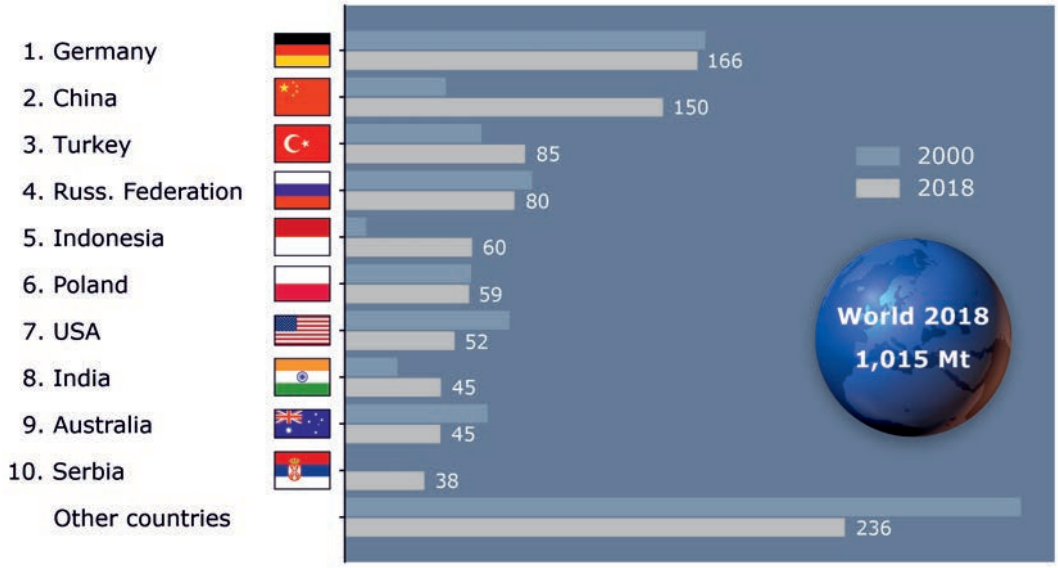

Figure A-36: Lignite consumption – top 10 countries 2000 and 2018.

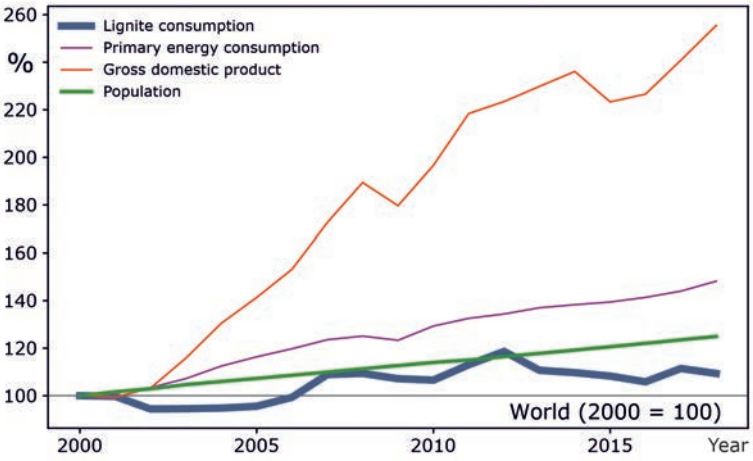

Figure A-37: Development of global lignite consumption, primary energy consumption, gross domestic product and global population from 2000 to 2018.

Table A-34: Uranium 2018 [kt]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
EUROPE	Bulgaria	–	–	–	25	25	25
	Czechia	< 0.05	112	–	342	454	342
	Finland	n. s.	< 0.5	–	1	1	1
	France	< 0.05	76	–	12	88	12
	Germany	< 0.05	220	–	7	227	7
	Greece	–	–	–	13	13	13
	Hungary	–	21	–	27	48	27
	Italy	–	–	5	11	16	16
	Portugal	–	4	5	11	19	16
	Romania	< 0.05	19	–	13	32	13
	Slovakia	n. s.	–	9	18	26	26
	Slovenia	n. s.	–	2	9	10	10
	Spain	–	5	23	11	39	34
	Sweden	n. s.	< 0.5	–	10	10	10
	Turkey	–	–	7	1	7	7
CIS (+ GEO, UKR)	Kazakhstan	21.7	339	304	1,131	1,774	1,435
	Russian Federation	2.9	171	25	1,367	1,563	1,392
	Ukraine	1.2	24	41	320	385	362
	Uzbekistan	2.4	60	37	127	223	164
AFRICA	Algeria	–	–	–	20	20	20
	Botswana	–	–	–	74	74	74
	Central African Rep.	–	–	–	32	32	32
	Chad	–	–	–	2	2	2
	Congo, DR	–	26	–	3	28	3
	Egypt	–	–	–	2	2	2
	Gabon	n. s.	25	–	6	31	6
	Malawi	< 0.05	4	–	14	19	14
	Mali	–	–	–	9	9	9
	Mauritania	–	–	–	24	24	24
	Namibia	5.5	137	–	598	736	598
	Niger	2.9	150	–	491	640	491
	Somalia	–	–	–	8	8	8
	South Africa	0.3	161	168	851	1,181	1,019
	Tanzania	–	–	38	20	58	58
	Zambia	–	< 0.5	–	57	57	57
	Zimbabwe	–	–	–	26	26	26

continuation of table A-34
[kt]

	Country / Region	Production	cum. Production	Reserves	Resources	EUR	Remaining Potential
MIDDLE EAST	Iran	0.1	< 0.5	–	19	19	19
	Jordan	–	–	–	93	93	93
AUSTRAL-ASIA	Australia	6.5	218	–	2,055	2,273	2,055
	China	1.9	46	102	196	344	298
	India	0.4	13	–	272	285	272
	Indonesia	–	–	2	36	38	38
	Japan	n. s.	< 0.5	–	7	7	7
	Mongolia	–	1	50	1,475	1,525	1,525
	Pakistan	< 0.05	2	–	–	2	–
	Viet Nam	–	–	–	85	85	85
NORTH AMERICA	Canada	7.0	531	275	1,421	2,227	1,696
	Greenland	–	–	–	198	198	198
	Mexico	n. s.	< 0.5	–	8	8	8
	USA	0.6	378	13	88	479	101
LATIN AMERICA	Argentina	–	3	5	119	127	124
	Brazil	< 0.05	4	156	421	581	577
	Chile	–	–	–	4	4	4
	Colombia	–	–	–	228	228	228
	Paraguay	–	–	–	4	4	4
	Peru	–	–	14	59	73	73
	World	53.5	2,749	1,280	12,477	16,506	13,757
	Europe	< 0.05	457	49	510	1,016	559
	CIS (+ GEO, UKR)	28.2	593	408	2,945	3,945	3,352
	Africa	8.8	504	206	2,236	2,946	2,442
	Middle East	0.1	< 0.5	–	112	112	112
	Austral-Asia	8.9	279	154	4,125	4,558	4,278
	North America	7.6	909	288	1,715	2,912	2,003
	Latin America	< 0.05	7	175	835	1,016	1,010
	OPEC	0.1	26	–	44	69	44
	OPEC-Gulf	0.1	< 0.5	–	19	19	19
	OECD	14.1	1,565	338	4,252	6,155	4,590
	EU-28	< 0.05	457	43	509	1,009	552

n. s. not specified
– no production, reserves or resources

Table A-35: Uranium resources 2018 (>20 kt U) [kt]

The most important countries (top 20) and distribution by regions and economic country groupings

Country / Region	Discovered		Total	Undiscovered		Total	Share [%]	
	RAR 80-260 USD/kg	inferred <260 USD/kg		prognosticated <260 USD/kg	speculative <260 USD/kg		country	cumu-lative
1	2	3	4 ≙ 2+3	5	6	7 ≙ 4+5+6	8	9
Australia	1,401	654	2,055	n. s.	n. s.	2,055	16.5	16.5
Mongolia	–	64	64	21	1,390	1,475	11.8	28.3
Canada	318	254	571	150	700	1,421	11.4	39.7
Russian Federation	236	397	632	144	591	1,367	11.0	50.6
Kazakhstan	130	470	600	231	300	1,131	9.1	59.7
South Africa	92	190	281	159	411	851	6.8	66.5
Namibia	369	173	541	57	n. s.	598	4.8	71.3
Niger	336	89	426	14	51	491	3.9	75.3
Brazil	–	121	121	300	n. s.	421	3.4	78.6
Czechia	51	68	119	223	–	342	2.7	81.4
Ukraine	96	81	178	23	120	320	2.6	83.9
India	149	8	157	115	n. s.	272	2.2	86.1
Colombia	–	n. s.	–	11	217	228	1.8	87.9
Greenland	67	81	148	n. s.	50	198	1.6	89.5
China	35	154	188	4	4	196	1.6	91.1
Uzbekistan	20	82	102	25	–	127	1.0	92.1
Argentina	6	20	26	14	80	119	1.0	93.1
Jordan	5	39	43	–	50	93	0.7	93.8
USA	88	n. s.	88	–	–	88	0.7	94.5
Viet Nam	1	3	4	81	n. s.	85	0.7	95.2
Botswana	14	60	74	n. s.	n. s.	74	0.6	95.8
Peru	–	19	19	20	20	59	0.5	96.3
Zambia	11	16	27	30	n. s.	57	0.5	96.7
Indonesia	4	2	6	30	n. s.	36	0.3	97.0
Central African Rep.	32	n. s.	32	n. s.	n. s.	32	0.3	97.3
Hungary	–	14	14	13	n. s.	27	0.2	97.5
Zimbabwe	1	n. s.	1	–	25	26	0.2	97.7
Bulgaria	–	–	–	25	n. s.	25	0.2	97.9
Mauritania	1	23	24	–	–	24	0.2	98.1
Germany	3	4	7	–	–	7	0.1	99.8
World	3,547	3,176	6,722	1,730	4,025	12,477	100.0	
Europe	77	131	208	286	16	510	4.1	

continuation of table A-35
[kt]

Country / Region	Discovered		Total	Undiscovered		Total	Share [%]	
	RAR 80-260 USD / kg	inferred < 260 USD / kg		prognosticated < 260 USD / kg	speculative < 260 USD / kg		country	cumu-lative
1	2	3	4 ≙ 2+3	5	6	7 ≙ 4+5+6	8	9
CIS (+ GEO, UKR)	483	1,029	1,512	422	1,011	2,945	23.6	
Africa	903	587	1,489	259	487	2,236	17.9	
Middle East	6	44	50	12	50	112	0.9	
Austral-Asia	1,595	885	2,480	251	1,394	4,125	33.1	
North America	474	338	812	153	750	1,715	13.7	
Latin America	9	162	171	347	316	835	6.7	
OPEC	25	6	32	12	–	44	0.4	
OPEC-Gulf	1	5	6	12	–	19	0.1	
OECD	1,956	1,121	3,076	413	763	4,252	34.1	
EU-28	77	131	207	286	16	509	4.1	

n. s. not specified
– no resources

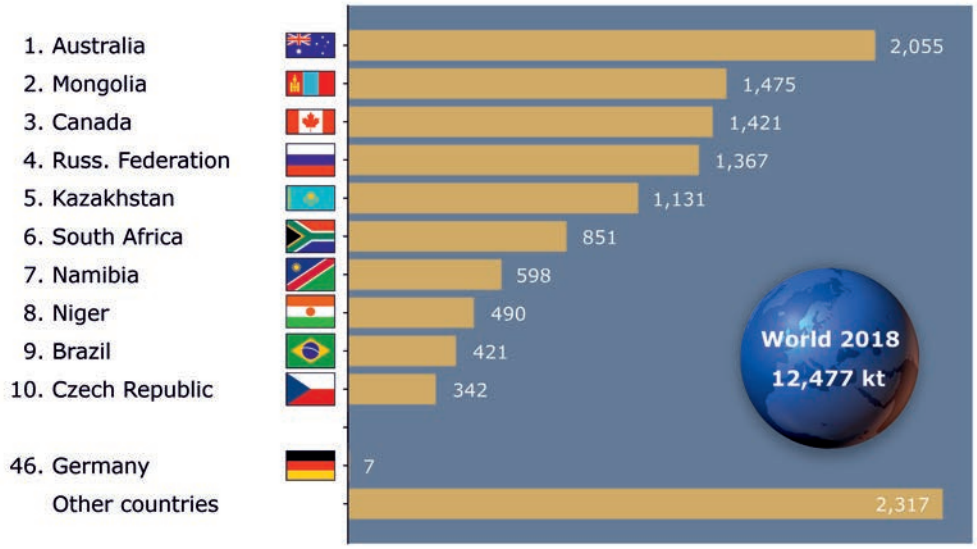

Figure A-38: Uranium resources – top 10 countries 2018 (> 20 kt U) [kt].

Table A-36: Uranium reserves 2018 (extractable < 80 USD / kg U)
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[kt]	Share [%]	
			country	cumulative
1	Kazakhstan	304	23.8	23.8
2	Canada	275	21.5	45.3
3	South Africa	168	13.1	58.4
4	Brazil	156	12.2	70.6
5	China	102	8.0	78.6
6	Mongolia	50	3.9	82.5
7	Ukraine	41	3.2	85.7
8	Tanzania	38	3.0	88.7
9	Uzbekistan	37	2.9	91.6
10	Russian Federation	25	1.9	93.5
11	Spain	23	1.8	95.3
12	Peru	14	1.1	96.4
13	USA	13	1.0	97.4
14	Slovakia	9	0.7	98.1
15	Turkey	7	0.5	98.6
16	Argentina	5	0.4	99.0
17	Italy	5	0.4	99.4
18	Portugal	5	0.4	99.7
19	Slovenia	2	0.1	99.9
20	Indonesia	2	0.1	100.0
	World	1,280	100.0	
	Europe	49	3.9	
	CIS (+ GEO, UKR)	408	31.8	
	Africa	206	16.1	
	Austral-Asia	154	12.0	
	North America	288	22.5	
	Latin America	175	13.7	
	OECD	338	26.4	
	EU-28	43	3.3	

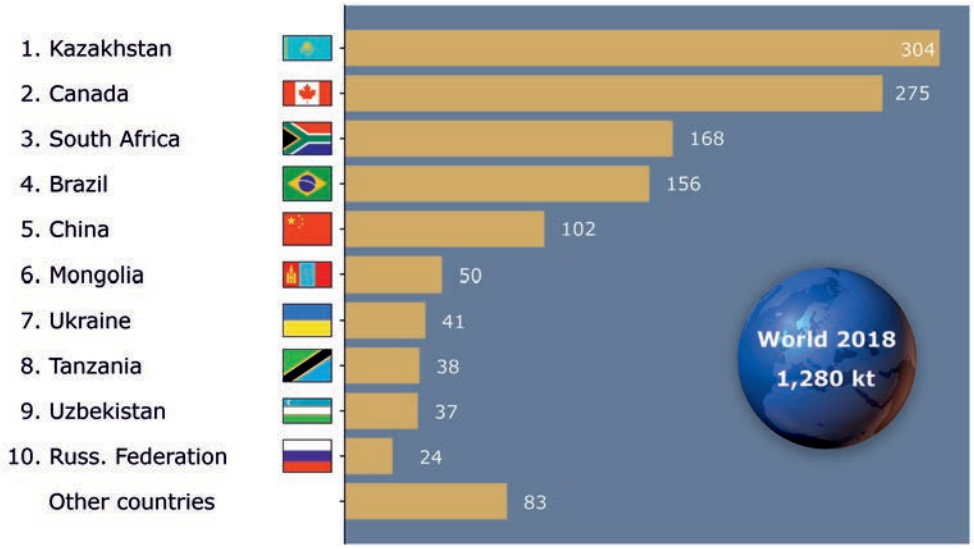

Figure A-39: Uranium reserves – top 10 countries 2018 (recoverable < 80 USD / kg U).

Table A-37: Uranium resources 2018 (extractable < 130 USD / kg U)
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[kt]	Share [%]	
			country	cumulative
1	Australia	1,269.8	32.9	32.9
2	Kazakhstan	415.2	10.7	43.6
3	Canada	409.7	10.6	54.2
4	Namibia	335.3	8.7	62.9
5	South Africa	237.6	6.1	69.0
6	Niger	237.4	6.1	75.2
7	Russian Federation	214.5	5.5	80.7
8	Brazil	155.9	4.0	84.7
9	China	136.7	3.5	88.3
10	Ukraine	81.2	2.1	90.4
11	Uzbekistan	57.6	1.5	91.9
12	Mongolia	49.8	1.3	93.2
13	USA	47.2	1.2	94.4
14	Tanzania	39.7	1.0	95.4
15	Central African Rep.	32.0	0.8	96.2
16	Spain	23.0	0.6	96.8
17	Peru	14.0	0.4	97.2
18	Botswana	13.7	0.4	97.6
19	Zambia	11.1	0.3	97.8
20	Argentina	11.0	0.3	98.1
	other countries [18]	72.6	1.9	100.0
	World	3,865.0	100.0	
	Europe	61.1	1.6	
	CIS (+ GEO, UKR)	768.5	19.9	
	Africa	921.7	23.8	
	Middle East	5.9	0.2	
	Austral-Asia	1,468.2	38.0	
	North America	458.7	11.9	
	Latin America	180.9	4.7	
	OPEC	5.9	0.2	
	OPEC-Gulf	1.1	< 0.05	
	OECD	1,793.2	46.4	
	EU-28	54.6	1.4	

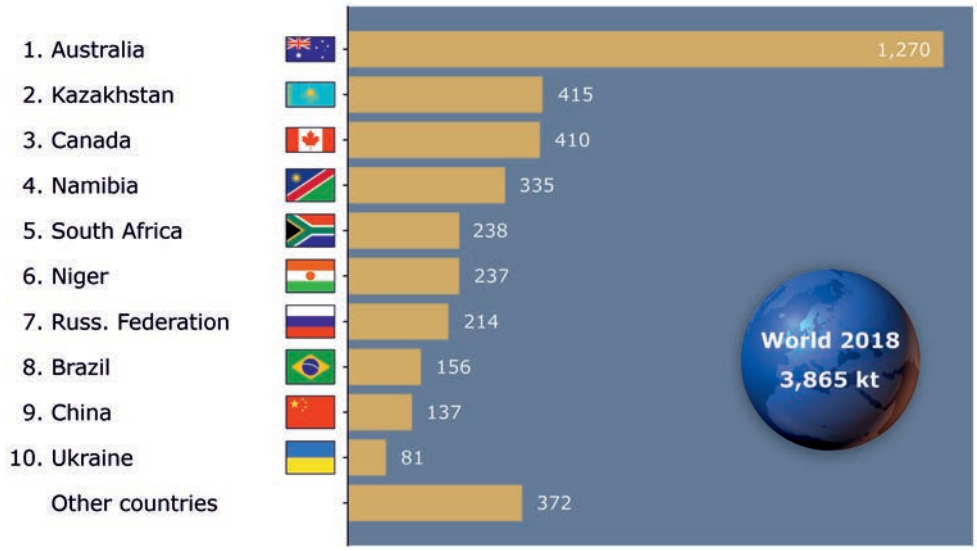

Figure A-40: Uranium resources – top 10 countries 2018 (recoverable < 130 USD / kg U).

Table A-38: Natural uranium production 2013 to 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2013	2014	2015	2016	2017	2018	Share [%]		Change	
				[kt]				country	cum.	2017/2018	[%]
1	Kazakhstan	22.6	23.1	23.8	24.6	23.4	21.7	40.6	40.6	-1.7	–7,2
2	Canada	9.3	9.1	13.3	14.0	13.1	7.0	13.1	53.7	-6.1	–46,6
3	Australia	6.4	5.0	5.7	6.3	5.9	6.5	12.2	65.8	0.6	10,8
4	Namibia	4.3	3.3	3.0	3.7	4.2	5.5	10.3	76.2	1.3	30,8
5	Niger	4.5	4.1	4.1	3.5	3.4	2.9	5.4	81.6	-0.5	–15,6
6	Russian Federation	3.1	3.0	3.1	3.0	2.9	2.9	5.4	87.0	0.0	–0,4
7	Uzbekistan	2.4	2.4	2.4	2.4	2.4	2.4	4.5	91.5	0.0	0,0
8	China	1.5	1.5	1.6	1.6	1.9	1.9	3.5	95.1	0.0	0,0
9	Ukraine	1.1	0.9	1.2	1.0	0.6	1.2	2.2	97.3	0.6	114,5
10	USA	1.8	1.9	1.3	1.1	0.9	0.6	1.1	98.3	-0.4	–38,1
11	India	0.4	0.4	0.4	0.4	0.4	0.4	0.8	99.1	0.0	0,5
12	South Africa	0.5	0.6	0.4	0.5	0.3	0.3	0.6	99.8	0.0	12,3
13	Iran	–	–	–	–	–	0.1	0.1	99.9		
14	Pakistan	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	100.0	0.0	0,0
15	Malawi	1.1	0.4	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	100.0	0.0	
	France	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	100.0	0.0	
	Germany[1]	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	100.0	0.0	–100,0
	Romania	0.1	0.1	0.1	0.1	< 0.05	< 0.05	< 0.05	100.0	0.0	
	Czechia	0.2	0.2	0.2	0.1	< 0.05	< 0.05	< 0.05	100.0	0.0	
	Brazil	0.2	0.2	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	100.0	0.0	
	World	59.6	56.2	60.5	62.4	59.6	53.5	100.0		–6.1	–10,2
	CIS (+ GEO, UKR)	29.2	29.4	30.4	31.0	29.3	28.2	52.7		–1.1	–3,7
	Africa	10.5	8.3	7.5	7.6	8.0	8.8	16.4		0.8	10,0
	Middle East	–	–	–	–	–	0.1	0.1			
	Austral-Asia	8.2	6.9	7.7	8.4	8.2	8.9	16.6		0.6	7,7
	North America	11.2	11.1	14.6	15.2	14.1	7.6	14.2		–6.5	–46,1
	OPEC	–	–	–	–	–	0.1	0.1			
	OPEC-Gulf	–	–	–	–	–	0.1	0.1			
	OECD	17.8	16.3	20.4	21.7	20.0	14.1	26.4		–5.9	–29,4

[1] only in the form of uranium concentrate as part of the remediation of production sites

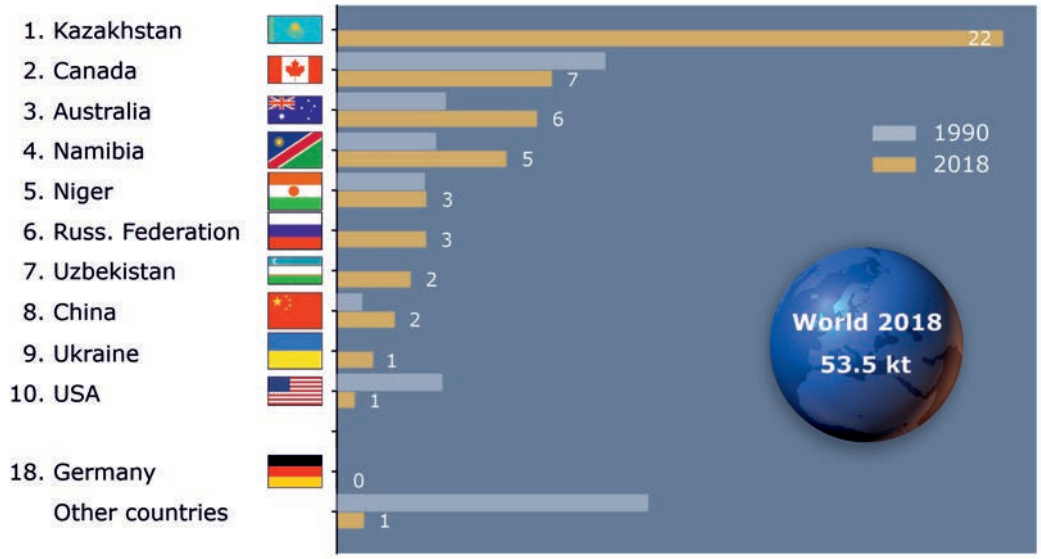

Figure A-41: Natural uranium production – top 10 countries 1990 and 2018.

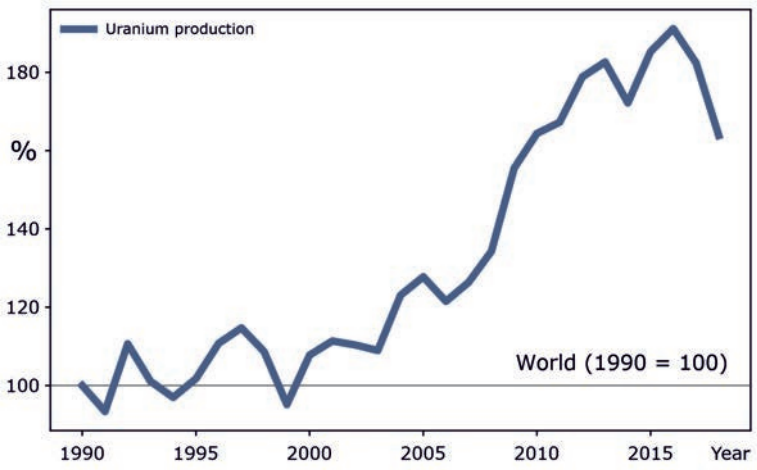

Figure A-42: Development of global uranium production from 1990 to 2018.

Table A-39: Uranium consumption 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[kt]	Share [%]	
			country	cumulative
1	USA	19.16	28.5	28.5
2	France	8.74	13.0	41.5
3	China	8.71	13.0	54.5
4	Russian Federation	5.62	8.4	62.8
5	Korea, Rep.	4.59	6.8	69.6
6	India	2.33	3.5	73.1
7	Ukraine	1.89	2.8	75.9
8	United Kingdom	1.80	2.7	78.6
9	Canada	1.62	2.4	81.0
10	Germany	1.38	2.1	83.0
11	Japan	1.34	2.0	85.0
12	Sweden	1.24	1.8	86.9
13	Spain	1.22	1.8	88.7
14	Finland	1.07	1.6	90.3
15	Belgium	0.90	1.3	91.6
16	Taiwan	0.74	1.1	92.7
17	Czechia	0.69	1.0	93.7
18	Slovakia	0.59	0.9	94.6
19	Switzerland	0.50	0.7	95.3
20	U. Arab Emirates	0.49	0.7	96.1
	other countries [12]	2.65	3.9	100.0
	World	67.24	100.0	
	Europe	19.21	28.6	
	CIS (+ GEO, UKR)	7.58	11.3	
	Africa	0.29	0.4	
	Middle East	0.65	1.0	
	Austral-Asia	17.93	26.7	
	North America	21.02	31.3	
	Latin America	0.56	0.8	
	OPEC	0.65	1.0	
	OPEC-Gulf	0.65	1.0	
	OECD	45.63	67.9	
	EU-28	18.71	27.8	

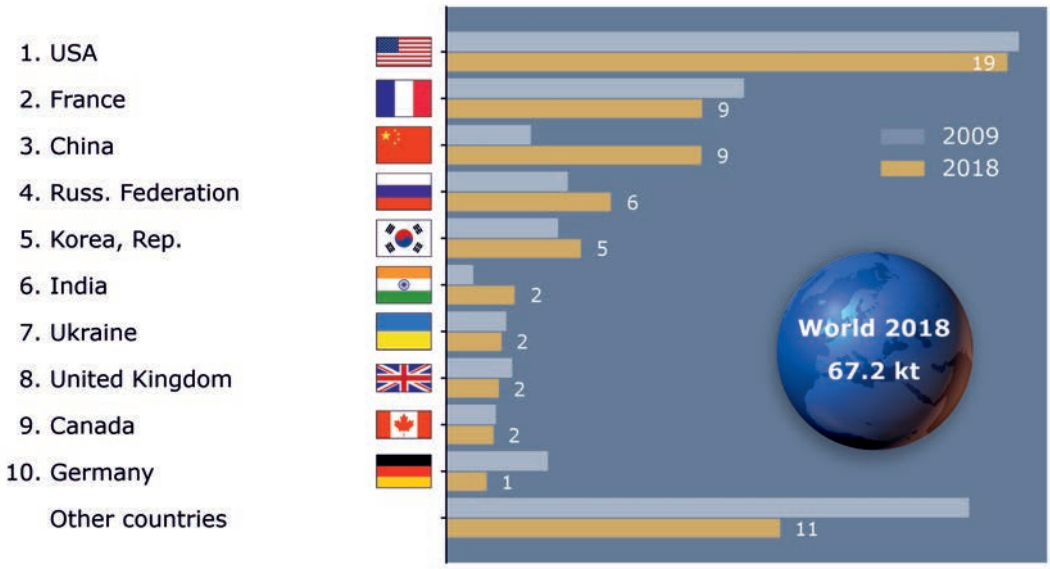

Figure A-43: Uranium consumption – top 10 countries 2009 and 2018.

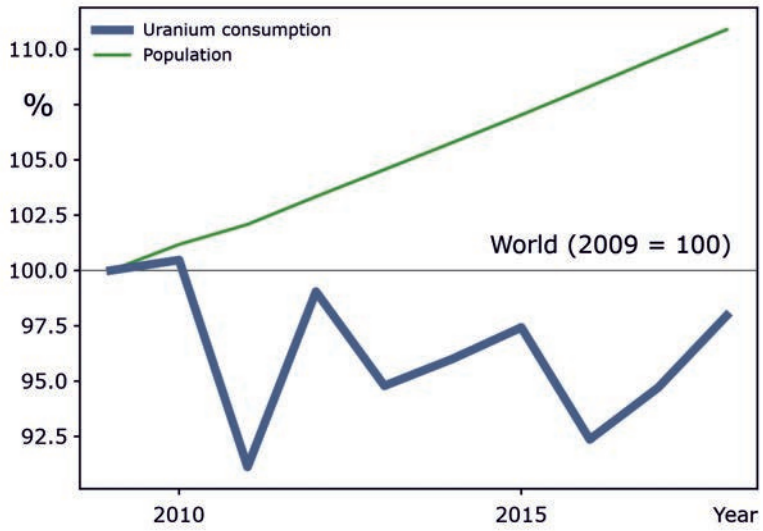

Figure A-44: Development of global uranium consumption and global population from 2009 to 2018.

Table A-40: Geothermal energy 2018[1]

	Country/Region	El. Power [MW_e]	El. Energy Consumption [GWh_e]	Therm. Power without heat pumps [MW_{th}]	Therm. Energy Consumption without heat pumps [GWh_{th}]
EUROPE	Austria	1	3	76	225
	Belgium	–	–	17	15
	Croatia	17	4	42	45
	Czechia	–	–	7	21
	Denmark	–	–	33	99
	Finland	–	–	1,560 (2016)	5,000 (2016)
	France	17	102	586	1,652
	Germany	37	159	374	1,377
	Greece	–	–	232 (2017)	–
	Hungary	3	–	223	636
	Iceland	753	5,170	2,172	7,422 (2016)
	Italy	916	6,064	149	237
	Lithuania	–	-	18	34
	Macedonia	–	–	43	106
	Netherlands	–	–	142	–
	Norway	–	–	1,300 (2016)	2,295 (2016)
	Poland	–	–	75	250
	Portugal	29	204	2	15
	Romania	< 0.5	< 0.5	158	300
	Serbia	–	–	48	154
	Slovakia	–	–	22	41
	Slovenia	–	-	47	124
	Spain	–	–	3	2
	Sweden	–	–	44	–
	Switzerland	–	–	12	36
	Turkey	1,283	6,763	1,453	4,600
	United Kingdom	–	2	3	15
CIS (+ GEO, UKR)	Russian Federation	74 (2017)	–	–	–
	Tajikistan	–	–	3 (2016)	15 (2016)
	Ukraine	–	–	1 (2017; m)	–
AFRICA	Ethiopia	7 (2017)	< 0.5 (2016)	2 (2016)	12 (2016)
	Kenya	663 (2017)	3,178 (2016)	22 (2016)	51 (2016)
	Madagascar	–	–	3 (2016)	21 (2016)
	Morocco	–	–	5 (2016)	–
	South Africa	–	–	2 (2016)	10 (2016)
	Tunisia	–	–	44 (2016)	–

continuation of table A-40

	Country/Region	El. Power [MW_e]	El. Energy Consumption [GWh_e]	Therm. Power without heat pumps [MW_{th}]	Therm. Energy Consumption without heat pumps [GWh_{th}]
MIDDLE EAST	Iran	–	–	153 (2016)	428 (2016)
	Israel	–	–	82 (2016)	609 (2016)
	Jordan	–	–	153 (2016)	428 (2016)
	Saudi Arabia	–	–	44 (2016)	–
	Yemen	–	–	1 (2016)	–
AUSTRAL-ASIA	Australia	< 0.5	–	18 (2016)	–
	China	26 (2017)	145 (2016)	17,870 (2016)	48,435 (2016)
	India	–	–	986 (2016)	1,195 (2016)
	Indonesia	1,946 (2017)	10,038 (2016)	2 (2016)	12 (2016)
	Japan	486 (2017)	2,489 (2017)	2,094 (2017)	7,250 (2017)
	Korea, Rep.	–	–	44 (2017)	165 (2017)
	Mongolia	–	–	20 (2016)	95 (2016)
	Nepal	–	–	3 (2016)	23 (2016)
	New Zealand	996 (2017)	7,453 (2017)	487 (2016)	2,395 (2016)
	Pakistan	–	–	0 (2016)	–
	Papua New Guinea	56 (2017)	–	–	–
	Philippines	1,944 (2017)	10,308 (2016)	3 (2016)	11 (2016)
	Thailand	< 0.5 (2017)	–	129 (2016)	–
	Viet Nam	–	–	31 (2016)	–
NORTH AMERICA	Canada	–	–	1,467 (2016)	3,227 (2016)
	Mexico	951 (2017)	5,937 (2017)	149 (2017)	1,159 (2017)
	USA	2,541 (2017)	16,060 (2017)	17,416 (2016)	21,075 (2016)
LATIN AMERIKA	Argentina	–	–	164 (2016)	278 (2016)
	Brazil	–	–	360 (2016)	1,840 (2016)
	Chile	48 (2017)	–	20 (2016)	–
	Costa Rica	207 (2017)	1,538 (2016)	1 (2016)	6 (2016)
	El Salvador	204 (2017)	1,558 (2016)	3 (2016)	16 (2016)
	Guatemala	49 (2017)	247 (2016)	2 (2016)	16 (2016)
	Honduras	35 (2017)	–	–	–
	Nicaragua	155 (2017)	662 (2016)	–	–

[1] Reliable actual data for countries outside of europe covering the year 2018 is not available as of ye

[2] Data partly from 2017 and older

– no Data available

Data based on
EGEC, LIAG-GeotIS (für Deutschland), IRENA Renewable Statistics 2019

Table A-41: Geothermal energy – electricity installed power from 2013 to 2018[1]

Rank	Country / Region	2013	2014	2015	2016	2017	2018	Share [%]		Change	
				[MW_e]				country	cum.	2017/2018	[%]
1	Turkey	368	397	624	775	1,131	1,283	42.0	42.0	152	13.4
2	Italy	916	916	915	916	916	916	30.0	72.0	–1	–0.1
3	Iceland	665	665	661	665	708	753	24.6	96.6	45	6.4
4	Germany	27	27	31	38	36	37	1.2	97.8	1	3.1
5	Portugal	29	29	23	29	33	29	0.9	98.8	–4	–12.1
6	France	17	16	18	17	17	17	0.5	99.3	0	–1.8
7	Croatia	–	–	–	–	–	17	0.5	99.8		
8	Hungary	–	–	–	–	3	3	0.1	100.0	0	10.0
9	Austria	2	1	1	–	1	1	< 0.05	100.0	0	20.0
10	Romania	–	< 0.5	< 0.5	–	< 0.5	< 0.5	< 0.05	100.0	0	0.0

[1] only regarding Europe

Data based on
BP Statistical Review 2018, IRENA Renewable Statistics 2019

Table A-42: Geothermal energy – resources 2018

Region	Theoretical Potential up to 5 km depth [EJ] total	Technical Potential [EJ/year]		
		power	heat	total
Europe	2,342,000	37.1	3.5	40.6
CIS (+ GEO, UKR)	6,607,000	104.0	9.9	113.9
Africa	6,083,000	95.0	9.1	104.1
Middle East	1,355,000	21.0	2.0	23.0
Austral-Asia	10,544,000	164.3	15.2	179.5
North America	8,025,000	127.0	11.8	138.8
Latin America	6,886,000	109.0	9.9	118.9
World	41,842,000	657.4	61.4	718.8

Comment: BGR currently considers the use of the term „technical potential" to make little sense because the technology for the extraction of deep geothermal energy, and for petrothermal geothermal energy in particular, has not yet been adequately developed

Table A-43: Consumption of renewable energy 2018 [Mtoe]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	Hydropower	Renewable energy (without hydropower)
1	China	415.6	272.1	143.5
2	USA	169.1	65.3	103.8
3	Brazil	111.4	87.7	23.6
4	Canada	97.9	87.6	10.3
5	India	59.1	31.6	27.5
6	Germany	51.2	3.8	47.3
7	Japan	43.7	18.3	25.4
8	Russian Federation	43.3	43.0	0.3
9	Norway	32.3	31.3	0.9
10	Italy	25.3	10.4	14.9
11	United Kingdom	25.1	1.2	23.9
12	France	25.1	14.5	10.6
13	Spain	24.0	8.0	16.0
14	Turkey	22.0	13.5	8.5
15	Sweden	20.6	14.0	6.6
16	Viet Nam	18.4	18.3	0.1
17	Venezuela	16.3	16.3	< 0.05
18	Colombia	13.3	12.8	0.5
19	Mexico	12.2	7.3	4.8
20	Austria	11.3	8.5	2.8
	other countries [60]	273.0	183.1	89.9
	World	1,510.0	948.8	561.3
	Europe	317.5	145.3	172.2
	CIS (+ GEO, UKR)	56.0	55.4	0.6
	Africa	37.3	30.1	7.2
	Middle East	5.1	3.4	1.7
	Austral-Asia	614.2	388.9	225.4
	North America	279.1	160.3	118.8
	Latin America	200.8	165.5	35.4
	OPEC	24.8	24.2	0.7
	OPEC-Gulf	3.6	3.1	0.4
	OECD	651.7	321.3	330.4
	EU-28	237.7	78.0	159.6

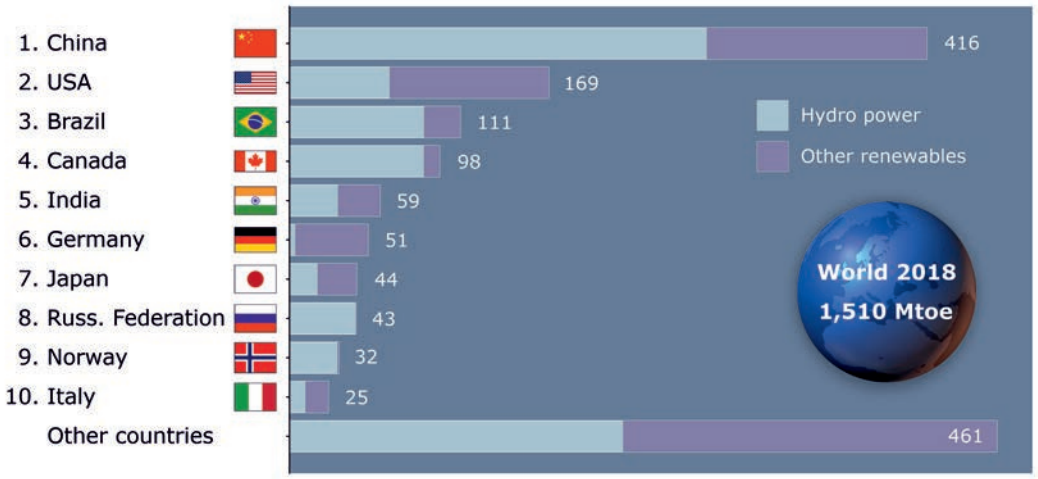

Figure A-45: Power consumption from renewables − top 10 countries hydroelectric power and other renewables 2018.

Table A-44: Renewable energy – installed electrical capacity 2018
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	[MW]	Share [%]	
			country	cumulative
1	China	695,865	29.6	29.6
2	USA	245,245	10.4	40.0
3	Brazil	135,674	5.8	45.8
4	Germany	120,014	5.1	50.9
5	India	117,919	5.0	55.9
6	Canada	99,035	4.2	60.1
7	Japan	90,154	3.8	64.0
8	Italy	53,290	2.3	66.2
9	Russian Federation	52,224	2.2	68.5
10	France	50,504	2.1	70.6
11	Spain	48,278	2.1	72.7
12	United Kingdom	43,460	1.8	74.5
13	Turkey	42,215	1.8	76.3
14	Norway	34,333	1.5	77.8
15	Sweden	29,067	1.2	79.0
16	Australia	23,749	1.0	80.0
17	Mexico	22,128	0.9	81.0
18	Austria	20,026	0.9	81.8
19	Viet Nam	18,523	0.8	82.6
20	Switzerland	17,134	0.7	83.3
	other countries [196]	391,700	16.7	100.0
	World	2,350,535	100.0	
	Europe	570,550	24.3	
	CIS (+ GEO, UKR)	79,954	3.4	
	Africa	45,883	2.0	
	Middle East	20,026	0.9	
	Austral-Asia	1,041,155	44.3	
	North America	366,500	15.6	
	Latin America	226,039	9.6	
	OPEC	42,421	1.8	
	OPEC-Gulf	15,807	0.7	
	OECD	1,055,606	44.9	
	EU-28	465,565	19.8	

Figure A-46: Renewable energy – installed electrical capacity – top 10 countries 2000 and 2018.

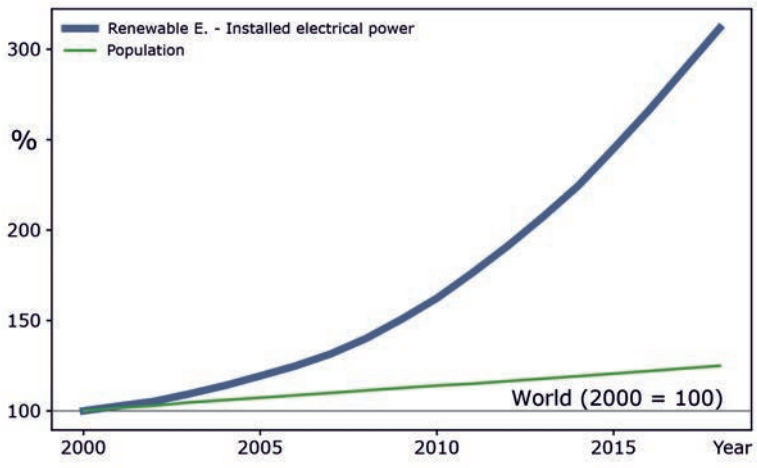

Figure A-47: Development of global renewables − installed electrical capacity and global population from 2000 to 2018.

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Bundesamt für Wirtschaft und Ausfuhrkontrolle – BAFA

Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit – BMUB

Bundesministerium für Wirtschaft und Energie – BMWi

Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung – BMZ

Bundesnetzagentur – BNetzA

Bundesverband Geothermie – GtV

Bundesverband Wärmepumpe e. V. – BWP

Bureau of Energy, Ministry of Economic Affairs (Taiwan)

Bureau of Resources and Energy Economics – BREE (Australia)

Cameco Corporation (Canada)

Canadian Association of Petroleum Producers – CAPP (Canada)

CARBUNION (Spain)

China Coal Information Institute

Coal India Limited – CIL

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CORES (Spain)

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Department for Business, Energy and Industrial Strategy – BEIS (United Kingdom)

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Mineral Resources and Petroleum Authority of Mongolia – MRPAM

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Ministerie van Economische Zaken (Netherlands)

Ministerio de Energia y Minas (Guatemala)

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Ministry of Business, Innovation and Employment – MBIE (New Zealand)

Ministry of Coal (India)

Ministry of Ecology, Sustainable Development and Energy (France)

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U.S. Geological Survey – USGS

Verein der Kohlenimporteure e.V. – VDKi

Wirtschaftskammer Österreich – WKO (Austria)

Wismut GmbH

World Coal Association

World Energy Council – WEC

World Geothermal Congress – WGC

World Nuclear Association – WNA

Glossary / List of abbreviations

AGEB	Arbeitsgemeinschaft Energiebilanzen e. V. (Energy Balance Group), headquarters in Berlin
AGEE-Stat	Arbeitsgruppe Erneuerbare Energien-Statistik (Working Group on Renewables Statistics), headquarters in Berlin
Aquifer	an underground layer of rock which is permeable enough to allow the movement of fluids
Aquifergas	natural gas dissolved in groundwater
API	American Petroleum Institute; umbrella organisation of the oil, gas and petroleum industry in the USA
°API	unit for the density of liquid hydrocarbons: the lower the degree, the heavier the oil
ARA	abbreviation for Amsterdam, Rotterdam, Antwerp
b, bbl	barrel; standard American unit for oil and oil products; *cf. Units*
Binary	a binary circuit, with a lower boiling point than water, is heated up via a heat exchanger. This vapourises and drives a turbine
Biofuels	liquid and gaseous fuels produced from biomass: e.g. bioethanol, biodiesel and biomethane
Biodiesel	its a fuel that has similar burning qualities to mineral diesel fuel. It is made from oleaginous plants (e.g. rapeseed, soy) by transesterification the oil and adding methanol or ethanol. But it can also be obtained from algae or cellulose-containing (→ biomass), such as plant waste (cornstalk, wheat straw)
Biomass	is the biodegradable part of products, waste and residues from agriculture of biological origin (including animal and vegetable substances), forestry and related industries including fishing industry and aquaculture. The biodegradable part of waste from industry and households also belongs to biomass
BMUB	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety), located in Berlin
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry of Economic Affairs and Energy), located in Berlin
boe	barrel(s) oil equivalent; energy unit corresponding to the amount of energy released when combusting on barrel of oil

BP	British Petroleum; internationally active energy corporation, headquarters in London
Brent	the most important crude oil type in Europe. Forms the reference price for the European market
BTL	biomass to liquid; synthetic fuel made from biomass
BTU	British thermal unit(s); english energy unit
BWP	Bundesverband Wärmepumpe e. V., headquaters in Berlin
CBM	coal-bed methane; gas contained in coal, including methane
cif	cost, insurance, freight; a typical transport clause incorporated in maritime transport transactions, corresponding to the `free on board` clause where the seller also bears the cost of delivery, insurance and freight to a defined port
Condensate	liquid constituents of natural gas which are gaseous in the reservoir, and can be separated out after production. Also known as natural gas liquids (NGL) (density >45°API or < 0.80 g/cm³)
Crude oil	natural occurring mixture of liquid hydrocarbons. The liquid hydrocarbons such as natural gas liquids (NGL) and condensates co-produced from a natural gas well are also categorised as oil production. *Conventional crude oil:* Generally used to describe oil that can be produced by relatively simple methods and inexpensively thanks to its low viscosity and a density of less than 1g per cm³ (heavy oil, light oil, condensate). *Non-conventional crude oil:* Hydrocarbons that cannot be produced used “classic” methods, but which require more complicated technology to produce them from the ground. In the reservoir itself, this oil is either incapable of flowing or can only flow marginally because of its high viscosity and/or density (extra heavy oil, bitumen), or because of the very low permeability of the reservoir rock (crude oil in tight rocks, tight oil, shale oil). In the case of oil shale, the oil is still in the form of kerogen in an early maturation stage.
Crude oil gas	gas dissolved in the oil in the reservoir which is released when the oil is produced.
CTL	coal to liquid; synthetic fuel made from coal
Cumulative production	total production since the start of production operations
Dena	German Energy Agency; located in Berlin
Deposit	part of the earth’s crust with a natural concentration of economically extractable mineral and/or energy commodities
DOE	Department of Energy (USA)

Downstream	activities in the production chain after the oil or gas has been produced from the production well: such as processing, transport, handling, sales
EEG 2017	Reenewable Energy Sources Act in Germany
EGC	European Geothermal Congress
EGS	enhanced geothermal systems: geothermal systems artificially enlarged by fracking and without any naturally convecting fluids
EIA	U.S. Energy Information Administration
EIB	European Investment Bank
EITI	Extractive Industries Transparency Initiative
Energy consumption	energetic and material use of energy resources. If there is no statistical data, consumption is simply determined from the sum of production and imports minus exports. Changes in inventory of energy resources such as stockpiles or in storage facilities are included, if there is sufficient data available
EOR	enhanced oil recovery: processes used to improve the natural recovery rate of an oilfield
ESA	Euratom Supply Agency – European Commission
EUR	Estimated ultimate recovery Estimated total amount of an energy commodity that can be extracted from a deposit
Field growth	increase/growth in original reserves during the production of a crude oil or natural gas field as a result of improvements in production technology, and a better understanding of the reservoir and production processes (cf. Reserves growth)
Gas hydrate	solid (snow-like) molecular compound consisting of gas and water which is stable under high pressures and low temperatures
Geothermal energy	Geothermal heat comprises the original heat of the earth and the heat generated by the decay of radioactive isotopes beneath the surface of the earth. A general distinction is made between shallow geothermal energy down to a depth of 400 m, and deep geothermal energy below depths of 400 m. Both of these zones are used for heating purposes (direct utilisation). Only deep geothermal energy is suitable for generating electrical power because of the higher temperatures in deeper underground rock formations and the associated adequate temperature difference compared to air temperatures. A distinction is made between deep geothermal energy systems associated with hydrothermal and petrothermal sources depending on whether geothermal heat is used primarily in the form of the heat of circulating thermal water (hydrothermal), or heat in the hot deep rock (petrothermal). Geothermal energy is considered to be a baseload-capable, needs-centric, low emission, innovative technology which is geopolitically attractive, and can make a contribution to solving climate problems. It is classified as a renewable energy resource.

	Hydrothermal geothermal energy The energy which harnesses the heat energy stored in natural deep thermal-water-filled horizons (hydrothermal).
GeotIS	Geothermal Information System, Leibnitz Institut für Angewandte Geophysik, Hannover
GDC	Geothermal Development Company
GDP	Gross Domestic Product
Giant, Super-Giant, Mega-Giant	categories of crude oil and natural gas fields depending on the size of their reserves: Giant: > 68 million t oil or > 85 billion m^3 natural gas, Super-Giant: > 680 million t oil or > 850 billion m^3 natural gas, Mega-Giant: > 6,800 million t oil or > 8,500 billion m^3 natural gas
Global production	sum of known individual country values. Countries for which no values are available or whose production or production data are confidential are not included. Than global production is probably higher
GRMF	Geothermal Risk Mitigation Facility
GTL	gas to liquid; using different methods to produce synthetic fuels from natural gas. Methods include Fischer-Tropsch synthesis
GW_e	Gigawatt electricity
GW_{th}	Gigawatt thermal
GWh	Gigawatt hours
Hard coal	anthracite, bituminous coal, hard lignite with an energy content >16,500 kJ/kg (ash-free)
HEU	highly enriched uranium (> 90 % U-235), mainly used for military purposes
High-enthalpy reservoir	geothermal reservoir with a large thermal anomaly. The high temperature differences support a high degree of efficiency when generating electricity. Reservoirs of this kind are usually found in the vicinity of active plate margins
Hydropower	(also hydro energy) is the use of kinetic or potential energy of water by using hydropower plants
IAEA	International Atomic Energy Agency; UN agency; headquarters in Vienna. cf. Economic country groupings
IEA	International Energy Agency OECD organisation; headquarters in Paris
IMF	International Monetary Fund

Initial reserves	cumulative production plus remaining reserves
in-place	total natural resource contained in a deposit/field (volume figure)
in-situ	located within the deposit: also refers to a reaction or a process occurring at the point of origin; also a synonym for in-place
Installed capacity	the nominal capacity or maximum capacity of a power plant. The associated SI unit is the Watt
IOC	International oil companies, including the super majors: Chevron Corp., ExxonMobil Corp., BP plc, Royal Dutch Shell plc, Total, etc..
IR	inferred resources; resources of uranium comprising those proven resources which do not satisfy the reserves criteria. Corresponds to the now obsolete class EAR I (estimated additional resources)
IRENA	International Renewable Energy Agency
J	joule; *cf. Units*
kWh	kilowatt hours
LBEG	Landesamt für Bergbau, Energie und Geologie, located in Hannover (State Office of Mining, Energy and Geology)
LEU	low enriched uranium
LIAG	Leibniz-Institut für Angewandte Geopysik (Leibniz Institute for Applied Geophysics), located in Hannover
Lignite	raw coal with an energy content (ash free) < 16,500 kJ/kg
LNG	liquefied natural gas. Natural gas liquefied at -162 °C for transport (1 t LNG contains approx. 1,400 Nm^3 natural gas, 1 m^3 LNG weighs approx. 0.42 t)
Marine energy	(or ocean power) refers to the energy carried by large ocean currents, such as the Gulf Stream, the tidal flow or the flow of individual waves. Special power plants are used for each of these flow types.
MENA	country Group (Algeria, Bahrain, Djibouti, Egypt, Iran (Islamic Rep.), Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Palestinian territories, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates, Yemen)
Methane	simplest hydrocarbon (CH_4)
MFAT	New Zealand Ministry of Foreign Affairs and Trade
Mine gas	gases which are released during the mining of coal. Primarily methane, carbon dioxide, carbon monoxide, nitric oxides, and in some cases hydrogen
Mineral oil	oil and petroleum products produced in refineries

MW_e	Megawatt of electricity
Natural gas	gas occurring naturally underground or flowing out at the surface. Combustible gases with variable chemical compositions. *Wet natural gas* contains methane as well as longer chain hydrocarbon constituents *Dry natural gas* only contains gaseous components and mainly consists of methane *Sour natural gas* contains varying amounts of hydrogen sulphide (H_2S) in the ppm range *Conventional natural gas*: free natural gas or crude oil gas in structural or stratigraphic traps *Natural gas from non-conventional deposits (in short: non-conventional natural gas):* Due to the nature and properties of the reservoir, the gas does not usually flow in adequate quantities into the production well without undertaking additional technical measures, either because it is not present in the rock in a free gas phase, or because the reservoir is not sufficiently permeable. These non-conventional deposits of natural gas include shale gas, tight gas, coal bed methane (CBM), aquifer gas and gas from gas hydrates
NCG	non-condensable gases
NDB	North German Basin
NEA	Nuclear Energy Agency; part of OECD, headquarters in Paris
NGL	natural gas liquids (→ *condensate*)
NGPL	natural gas plant liquids: constituents of produced natural gas which are liquefied separately in the processing plant, (→ condensate)
OECD	Organisation for Economic Co-operation and Development, headquarters in Paris; cf. Economic country groupings
Oil recovery rate	percentage of recoverable oil from a deposit
OPEC	Organization of Petroleum Exporting Countries, headquarters in Vienna; cf. Economic country groupings
OPEC basket price	average price of the different qualities of crude oil produced by OPEC members
ORG	Oberrheingraben
Peak Oil	time when maximum crude oil production level is reached
PEC	primary energy consumption; describes the total amount of energy required to supply an economy
Permeability	measure of the hydraulic transmissivity of a rock; unit: Darcy [D]; symbol: k; cf.: Units

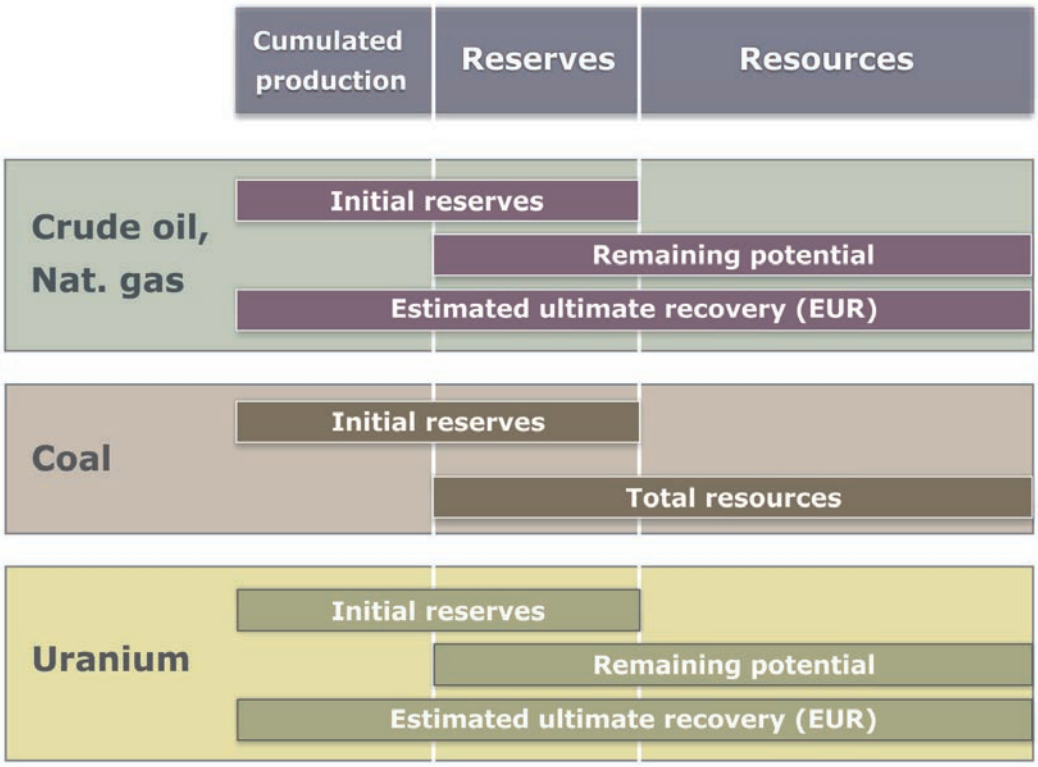
Photovoltaics	describes the electrical use of (→ solar energy). Light is converted directly into electricity by using solar cells.
Porosity	pore space in a rock: unit: [%]
Potential	total potential: cumulative production plus reserves plus resources
Primary energy	primary energy is the energy directly present in the energy resources, for instance hard coal, lignite, crude oil, natural gas, water, wind, nuclear fuel, solar radiation. Primary energy is converted to end energy in power plants or refineries for instance. Some primary energy is used for non-energetic purposes (for instance, crude oil for the plastics industry).
Pure gas	standardized natural gas with a calorific value of 9.7692 kWh / Nm^3 in Germany
Raw gas	untreated natural gas recovered during production
REEGLE	Renewable Energy and Energy Efficiency Partnership
REmap 2030	Renewable Energy Roadmap
REN21	Renewable Energy Policy Network for the 21st Century
Renewable energy	these encompass a very wide range of energy resources. Because they are virtually inexhaustible, or renew themselves relatively quickly, they differ from fossil energy resources which only regenerate over periods of millions of years. They include biomass, geothermal energy, marine energy, solar power, hydropower and windpower.
Reserves	proven volumes of energy resources economically exploitable at today's prices and using today's technology *Original reserves: cumulative production plus remaining reserves*
Reserve growth	(→ field growth)
Resources	proven amounts of energy resources which cannot currently be exploited for technical and/or economic reasons, as well as unproven but geologically possible energy resources which may be exploitable in future
Shale gas	natural gas from fine-grained rocks (shales)
Single Flash	hydrothermal fluid >182 °C which condenses in a tank at low pressure and subsequently powers a turbine
Solar energy	is radiant energy from the sun that is harnessed using a range of technologies such as (→ photovoltaics) converting radiation directly into electricity, or via absorption to generate heat (→ solar thermal)
Solar thermal	thermal use of (→ solar energy).
SPE	Society of Petroleum Engineers

Synfuel	synthetic fuel; liquid fuels can be synthesised by various technical processes. Important technologies are coal and gas liquefaction, as well as the production of fuels from biomass (→ biofuels)
tce	tons coal equivalent, corresponds to approx. 29.308 x 109 Joules; cf.: Conversion factors
Tight Gas	natural gas from tight sandstones and limestones
toe	ton(s) oil equivalent: an energy unit corresponding to the energy released when burning one tonne of crude oil. cf.: Conversion factors
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNFC	United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources
UNFCCC	United Nations Framework Convention on Climate Change
Upstream	all activities in the production chain which take place before hydrocarbons leave the production well: exploration, development and exploitation/production
Uranium	a natural constituent of rocks in the earth's crust. Natural uranium [Unat] (standard uranium) is the uranium which occurs naturally with an isotope composition of U-238 (99.2739 %), U-235 (0.7205 %) and U-234 (0.0056 %). Uranium has to be present in a deposit in concentrated form to enable it to be extracted economically. The following deposit (dps) types are currently of economic importance: discordancy-related vein dps, dps in sandstones, hydrothermal vein dps, dps in quartz conglomerates, Proterozoic conglomerates, breccia complex dps, intragranitic and metasomatic dps. Uranium from non-conventional deposits (in short: non-conventional uranium): uranium resources in which the uranium is exclusively subordinate, and is extracted as a by-product. These deposits include uranium in phosphates, non-metals, carbonates, black shales, and lignites. Uranium is also dissolved in seawater in concentrations of around 3 ppb (3 µg/l) and is theoretically extractable.
USAID	United States Agency for International Development
USD	US-Dollar; currency of the United States of America
USGS	United States Geological Survey
VDKi	Verein der Kohlenimporteure e.V. (Coal Importer Association); headquarters in Berlin

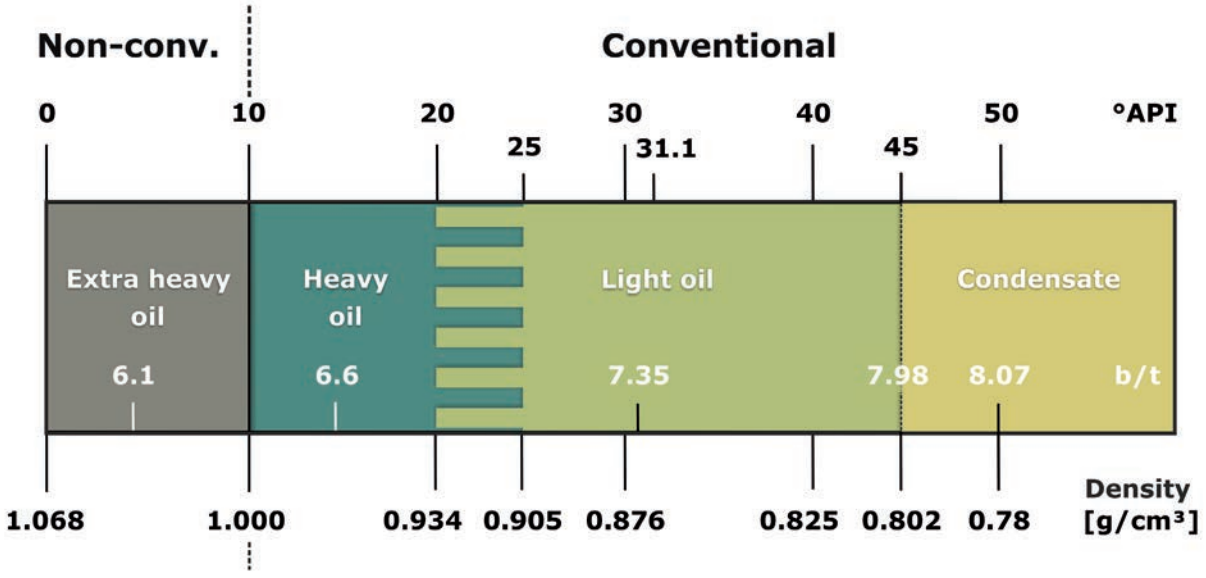
WEC	World Energy Council, headquarters in London; organises the World Energy Congress
WGC	World Geothermal Congress: takes place every five years. Discussions on geothermal issues take place between global representatives from science, engineering, business, and society. In the run-up to the congress, comprehensive data is collected at a national level on the current situation regarding shallow and deep geothermal energy. This data is presented at the congress.
Wind energy	(or wind power) is the use of wind through wind turbines to turn electric generators. In addition, the use of wind for traditionally mechanical use, like sailing, is common
WNA	World Nuclear Association, headquarters in London
WPC	World Petroleum Council; headquarters in London; organises the World Petroleum Congress
WTI	West Texas Intermediate: reference price for the American market

Definitions

Distinction between reserves and resources



Classification of crude oil according to its density

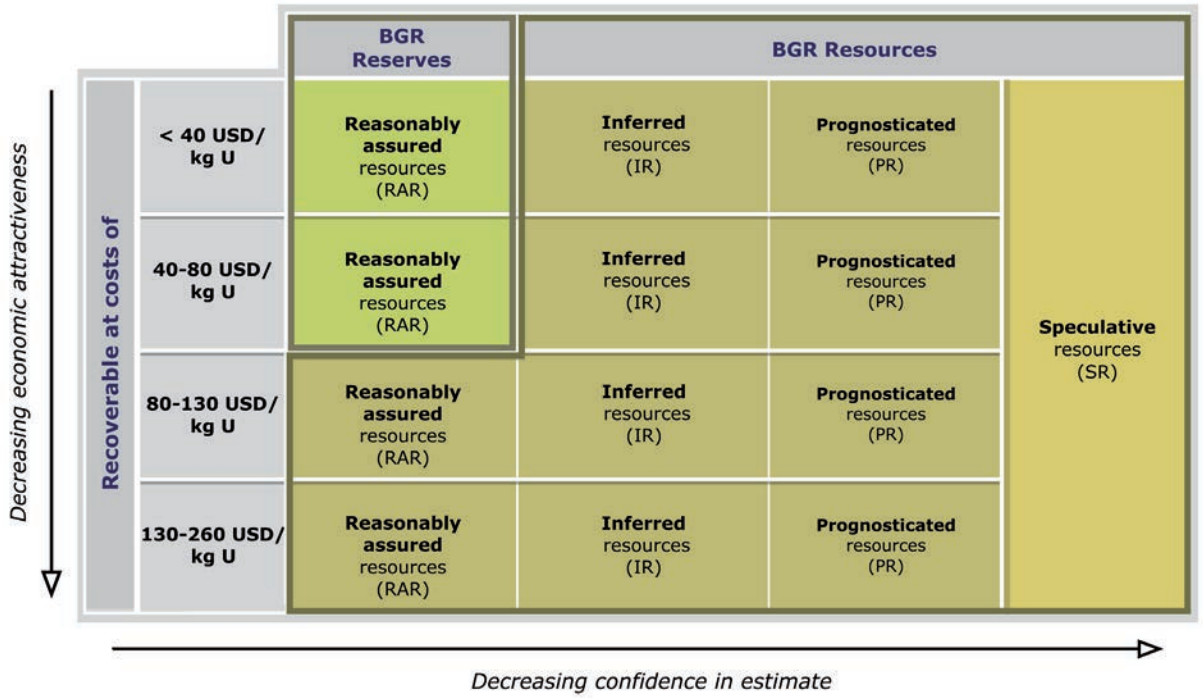


Uranium reserves classification according to cost categories

Unlike the other fuels, uranium reserves are classified according to production costs. According to the definition of reserves, the limit for the extraction costs is currently < 80 USD/kg U. However, the production costs in many countries are already much higher than this level. The following diagram illustrates the relationship between the various resource categories. The horizontal axis describes the amount of geological information available, and the certainty of there being a certain volume of resources. The vertical axis shows the economic cost of extracting the resource in US dollars. The system should be considered as dynamic. Changes in resource classifications can be the consequence of new information on the one hand (e.g. about size and position) of uranium deposits, but could also be due on the other hand to increasing technical and economic criteria and extraction costs. This means that the resources category as well as the class of extraction costs could be redefined for parts of the resources. The most reliable details are in the RAR cost category < 80 USD kg U, which according to BGR's current definition are classified as reserves (green). All resources with higher extraction costs are classified as resources (brown) from the point of view of BGR.

Diagram showing uranium reserves classification according to cost categories

(modified after IAEA and OECD 2014)



Country groups of the BGR energy study

Europe

Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Faroe Islands, Finland, France, Germany, Gibraltar, Greece, Guernsey, Hungary, Isle of Man, Ireland, Iceland, Italy, Jersey, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia (former Yugoslav Republic), Malta, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, Vatican City State.

CIS inc. Georgia

Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova (Republic), Russian Federation, Tajikistan, Turkmenistan, Ukraine, Uzbekistan .

Africa

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Central African Republic, Chad, Comoros, Congo (Democratic Republic), Congo (Republic), Côte d'Ivoire, Djibouti, Egypt, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kap Verde,Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mayotte, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Saint Helena, Ascension and Tristan da Cunha, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Sudan, Swaziland, Tanzania (United Republic), Togo, Tunisia, Uganda, Western Sahara, Zambia, Zimbabwe.

Middle East

Bahrain, Iran (Islamic Republic), Iraq, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syrian Arab Republic, United Arab Emirates, Yemen.

Austral-Asia

„Austral"-Part:

Australia, Cook Islands, Fiji, French-Polynesia (Territory), Guam, Kiribati, Marshall Islands, Micronesia (Federated States), Nauru, New Caledonia, New Zealand, Northern Mariana, Norfolk Island, Palau, Pacific Islands (USA), Pitcairn, Ryukyu Islands, Salomon Islands, Samoa, Timor-Leste, Tokelau, Tonga, Tuvalu, Vanuatu, Wallis and Futuna, West-Timor (Indonesia).

„Asia"-Part:

Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, Cambodia, China, Hong Kong, India, Indonesia, Japan, Korea (Democratic People's Republic), Korea (Republic), Laos (People's Democratic Republic), Macao, Malaysia, Maledives, Mongolia, Myanmar, Nepal, Pakistan, Papua New Guinea, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Viet Nam.

North America

Canada, Greenland, Mexico, United States

Latin America (Middle- and South America without Mexico)

Anguilla, Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Bermudas, Bolivia (Plurinational State), Brazil, Cayman Islands, Chile, Colombia, Costa Rica, Cuba, Dominica,

Dominican Republic, Ecuador, El Salvador, Falkland Islands (Islas Malvinas), Grenada, Guadeloupe, Guatemala, Guyana, Haiti, Honduras, Jamaica, Martinique, Montserrat, Nicaragua, Kaimaninseln, Kolumbien, Kuba, Martinique, Montserrat, Nicaragua, Panama, Paraguay, Peru, Puerto Rico, St. Kitts und Nevis, St. Lucia, St. Pierre und Miquelon, St. Vincent und die Grenadinen, Suriname, Trinidad und Tobago, Turks- und Caicosinseln, Uruguay, Venezuela (Bolivarische Republik).

Ecconomic country goupings status: 2018

BRICS-nations

Brazil, **R**ussian Federation, **I**ndia, **C**hina, **S**outh Africa

European Union

EU-15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, United Kingdom.
EU-25	European Union (from 01.05.2004): EU-15 plus new Member: Cyprus, Czechia, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia.
EU-27	European Union (from 01.01.2007): EU-25 plus new Member: Bulgaria and Romania.
EU-28	European Union (from 01.07.2013): EU-27 plus new Member: Croatia.

IAEA (International Atomic Energy Agency; 169 countries)

Afghanistan (Islamic Republic), Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bolivia (Plurinational State), Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Congo (Democratic Republic), Congo (Republic), Costa Rica, Côte d'Ivoire, Croatia, Cuba, Cyprus, Czechia, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, Guyana, Haiti, Honduras, Hungary, Iceland, India, Indonesia, Iran (Islamic Republic), Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Korea (Republic), Kuwait, Lao (People's Democratic Republic), Latvia, Lebanon, Lesotho, Liberia, Libya, Liechtenstein, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Macedonia (former Yugoslav Republic), Mexico, Moldova (Republic), Monaco, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Rwanda, Russian Federation, Saindt Vincent nd the Grenadines, San Marino, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania (United Republic), Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Turkmenistan, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, Vanuatu, Vatican City State, Venezuela (Bolivarian Republic), Viet Nam, Yemen, Zambia, Zimbabwe.

NAFTA (North American Free Trade Agreement)

Canada, Mexico, United States.

OECD (Organization for Economic Co-operation and Development; 35 countries)

Australia, Austria, Belgium, Canada, Chile, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea (Republic), Lativa, Luxembourg, Mexico, New Zealand, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.

OPEC (Organization of the Petroleum Exporting Countries; 14 countries)

Algeria, Angola, Ecuador, Equatorial Guinea, Indonesia, Iran (Islamic Republic), Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates, Venezuela (Bolivarian Republic).

OPEC-Gulf

Iran (Islamic Republic), Iraq, Kuwait, Qatar, Saudi Arabia, United Arab Emirates.

Units

b, bbl	barrel	1 bbl = 158.984 liter
cf	cubic feet	1 cf = 0.02832 m^3
J J	Joule	1 J = 0.2388 cal = 1 Ws
kJ	Kilojoule	1 kJ = 10^3 J
MJ	Megajoule	1 MJ = 10^6 J
GJ	Gigajoule	1 GJ = 10^9 J = 278 kWh = 0.0341 t tce
TJ	Terajoule	1 TJ = 10^{12} J = 278 x 10^3 kWh = 34.1 t tce
PJ	Petajoule	1 PJ = 10^{15} J = 278 x 10^6 kWh = 34.1 x 10^3 t tce
EJ	Exajoule	1 EJ = 10^{18} J = 278 x 10^9 kWh = 34.1 x 10^6 t tce
m^3	cubic meter	
Nm^3	standard cubic meter	Volume of Gas 1 m^3 at 0° C and 1.01325 bar [also m^3(Vn) abbreviated]
Mio. m^3	million cubic meter	1 Mio. m^3 = 10^6 m^3
Mrd. m^3	Milliarden cubic meter	1 Mrd. m^3 = 10^9 m^3
Bill. m^3	Billionen cubic meter	1 Bill. m^3 = 10^{12} m^3
lb	pound	1 lb = 453.59237 g
t	ton	1 t = 10^3 kg
t / a	metric ton(s) per year	
toe	tons of oil equivalent	

kt	Kiloton	1 kt = 10^3 t
Mt	Megaton	1 Mt = 10^6 t
Gt	Gigaton	1 Gt = 10^9 t
Tt	Teraton	1 Tt = 10^{12} t
W	Watt	1 W = 1 J/s = 1 kg m^2 /s^3
MW_e	Megawatt electric	1 MW = 10^6 W
MW_{th}	Megawatt thermal	1 MW = 10^6 W
Wh	Watt hour	1Wh = 3.6 kWs = 3.6 kJ
GWh_e	Gigawatt hour elektric	3,6 10^9 kJ
GWh_{th}	Gigawatt hour thermal	3,6 10^9 kJ
k	Kilo	10^3
M	Mega	10^6
G	Giga	10^9
T	Tera	10^{12}
P	Peta	10^{15}

Conversion factors

1 t crude oil	1 toe = 7.35 bbl = 1.428 tce = 1,101 m³ natural gas = 41.8 x 10^9 J
1 t heavy oil	1 toe = 6.19 bbl = 1.428 tce = 1,101 m³ natural gas = 41.8 x 10^9 J
1 t NGL/condensat	1 toe = 10.4 bbl = 1.428 tce = 1,101 m³ natural gas = 41.8 x 10^9 J
1 t LNG	1,380 m³ natural gas = 1.06 toe = 1.52 tce = 44.4 x 10^9 J
1,000 Nm³ nat. gas	35,315 cf = 0.9082 toe = 1.297 tce = 0.735 t LNG = 38 x 10^9 J
1 tce	0.70 toe = 770.7 m³ natural gas = 29.3 x 10^9 J
1 EJ (10^{18} J)	34.1 Mtce = 23.9 Mtoe = 26.3 G. m³ natural gas = 278 billion TWh
1 t uranium (nat.)	14,000–23,000 tce; value varies depending on degree of capacity utilisation
1 kg uranium (nat.)	2.6 lb U_3O_8

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