2015

ENERGY STUDY

Reserves, Resources and Availability of Energy Resources

19

BGR

ENERGY STUDY 2015

Reserves, Resources and Availability of Energy Resources

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Our energy future is not set in stone

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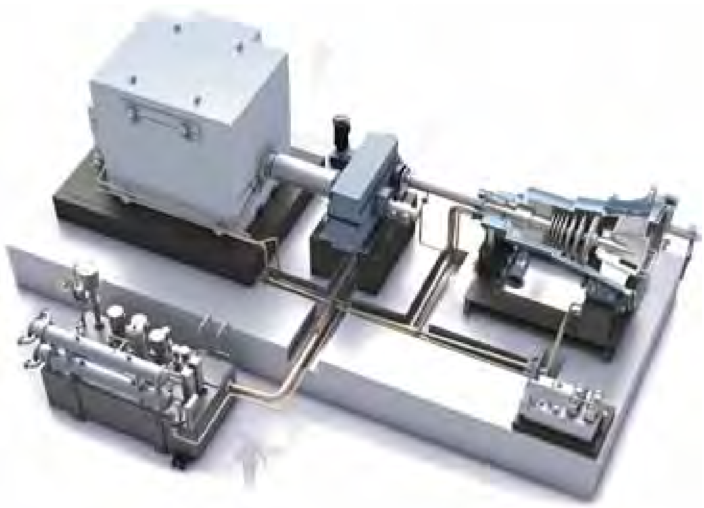
FOREWORD

The world's energy supplies undergo continuous change. Well into the 19th century, biomass was able to satisfy most of the world's energy requirements – although the amounts were very small compared with today's energy consumption levels. Biomass was followed by coal which, as a relatively cheap and easily extractable energy source, supplied the foundations for industrialisation, and therefore the platform for today's prosperity. Both biomass and coal dominated energy supplies in "their" respective ages. The principle of energy production changed at the beginning of the 20th century, and is still based today on a rising number of energy sources and different generation methods. This heterogeneity is increasingly enhanced by national energy strategies aimed at establishing a broader basis for the provison of energy supplies. Renewables are a part of global energy supplies, and there are already countries today whose energy requirements are largely covered by regenerative sources. However, from a global point of view, these are special cases attributable to various reasons, including special geological conditions, such as those which exist in Iceland. Despite intensive and ambitious efforts in part to raise the proportion of renewables, most of the countries around the world will still primarily have to rely on fossil fuels and nuclear energy to cover their energy requirements in the decades to come. Many industrial countries, and developing and emerging economies in particular, with foreseeable growing energy requirements, will not only depend on sun, wind and geothermal power in their future energy mixes, but also will continue to rely on crude oil, natural gas and coal. It is therefore of crucial importance for the long period of time involved in switching over to a low carbon energy system, that fossil fuels continue to be made available in the future to the degree to which they are actually required.



The Energy Study 2015 provides information in the form of data and facts on the availability and ongoing situation regarding the energy sources crude oil, natural gas, coal, uranium and deep geothermal energy. The study also includes renewables, to provide a comprehensive picture of global energy potential and the inventory situation of energy resources.

The "Energy resources in focus" section this year takes a closer look in particular at enhanced oil and gas recovery methods (EOR), the significance of geothermal energy for the East African energy sector, and the importance of natural gas and crude oil for developing and emerging economies.

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1 EXECUTIVE SUMMARY

Germany's energy needs, and those of the rest of the world, are currently primarily covered by fossil fuels. The dependence of energy supplies on fossil fuels will also continue for the foreseeable future. The rise in the world's population, and the increase in overall living standards, guarantee a growing demand for energy in the long term as well. A rise in the international competition for energy resources is therefore expected against this background. Despite the strong rise in renewables, Germany as well will become increasingly dependent on imports, because of the decline in domestic production and its withdrawal from nuclear energy. With a continuing share of around 80 %, crude oil, natural gas, bituminous coal and lignite still easily make the largest contribution to satisfying primary energy consumption in Germany.

This latest Energy Study from the Federal Institute for Geosciences and Natural Resources (BGR) contains comments and analyses on the situation regarding the energy resources crude oil, natural gas, coal, and nuclear fuels, as well as looking at deep geothermal energy sources, and also incorporating other renewables for the first time in this study. The study concentrates on estimating the geological inventory of energy resources by providing reliable assessments of reserves and resources (Fig. 1). The study also reviews the commodity markets with respect to the development of production, exports, imports, and the consumption of fossil energy resources. The study also looks at topical and socially relevant energy issues. The study is a consultation document on the natural resources situation for the Federal Ministry for Economic Affairs and Energy (BMWi), as well as for German industry as a whole. The database on which the study is founded is derived from the continuous assessment of information in technical journals, scientific publications, reports from industry, specialist organisations and political institutions, as well as internet sources, and surveys carried out for this specific purpose. Unless referred to specifically otherwise, all of the data referred to in this study is derived from BGR's energy resources database.

According to the information available today, there are still comprehensive amounts of fossil fuels available. A great deal of potential is revealed by the global comparison of reserves, resources and the already consumed energy resources for all regions around the world (Fig. 1). Whilst the potential hardly appears to have been touched in the Austral-Asian, CIS and North American regions, only a small proportion has been extracted so far even in regions such as Europe. This wealth in natural resources is primarily attributable to the huge coal deposits which are present on all continents, and unlike conventional crude oil and natural gas, are not restricted to localised regions. This means that although the Middle East is an important region for crude oil and natural gas, its overall potential is only relatively low.

The largest proportion of global non-renewable energy resources is defined as resources and accounts for 551,813 Exajoules (EJ), and thus exceeds reserves by a factor of 15. This applies to all energy resources with the exception of conventional crude oil – which further underlines the special role of this energy resource. The energy content of all reserves in total in 2014 was 37,934 EJ, and was therefore almost 0.77 % higher than last year's figure. The changes in resources and reserves were minimal overall. In terms of energy content, coal is the dominant energy resource – in terms of resources in particular, but also in terms of reserves. Crude oil on the other hand, continues to dominate consumption and production. Because of its larger non-conventional share compared to natural gas, crude oil also occupies second place behind coal in the reserves table. In the overall global energy mix, i.e. the amount of energy actually consumed, including renewables, fossil fuels play the most dominant role by far. From a geological point of view, the known inventories of energy resources are capable of covering even a long-term rise in the demand for natural gas, coal and nuclear fuels, and therefore guarantee a phased move into a low-carbon energy system on the basis of renewables. Crude oil is the only energy resource with an evident finiteness.

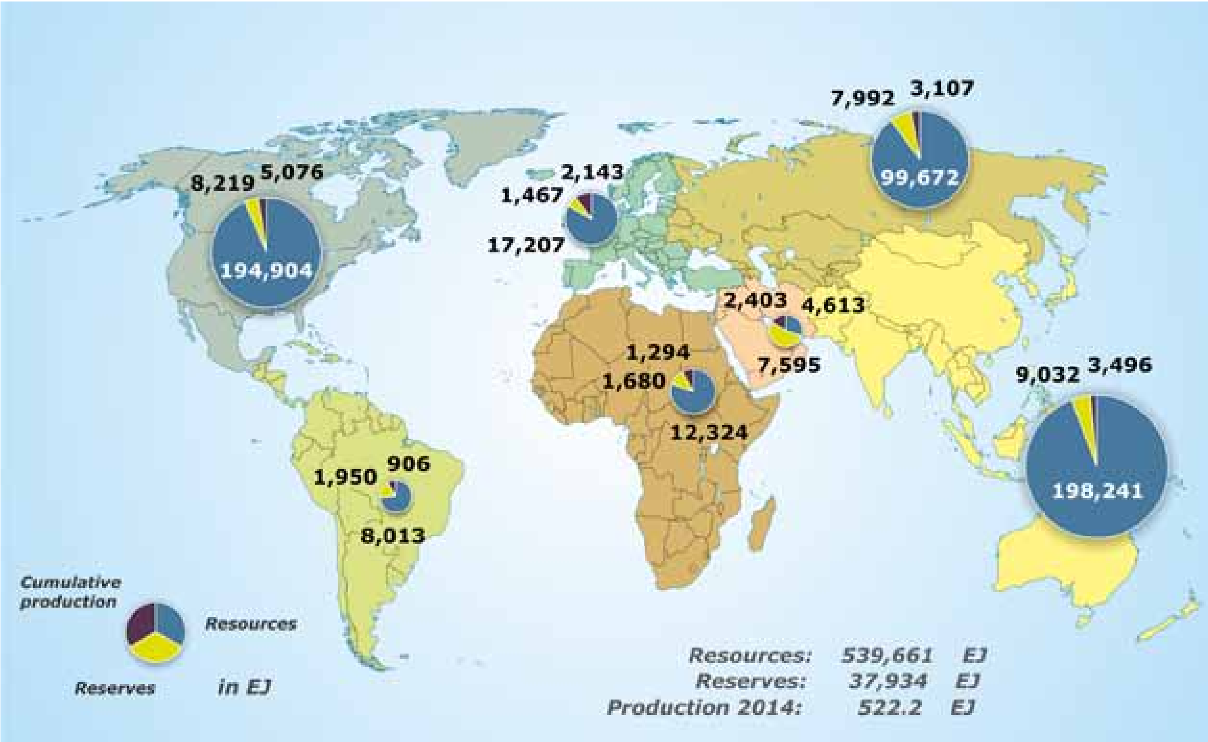

Figure 1: Total potential of fossil energy resources including uranium in 2014: regional distribution excluding coal resources in the Antarctic, and excluding resources of oil shale, aquifer gas, natural gas from gas hydrates, and thorium, because these cannot be classified regionally (estimated accumulative production of coal since 1950).

In the light of the foreseeable limited global potential of conventional crude oil, and a further rise in demand, there is an increasing interest in enhanced oil recovery methods (EOR). The EOR share of crude oil production will therefore rise in future, and could be around 5.5 % by 2040. However, it is probable that the current high level of crude oil supplies around the world, and the associated low oil price, will slow down the further expansion of EOR capacities.

There has been an above average rise in energy demand in East African countries for many years. Because of its reliable base load capacity, the development of the large but previously hardly exploited geothermal resources in the area for power generation, as well as a large number of direct thermal application possibilities, could play a key role in the economic development of this region.

The production of crude oil and natural gas in developing and emerging economies is of considerable significance for the global market, as well as for the countries themselves. The socially and environmentally compatible production of hydrocarbons is a fundamental principle here for the sustainable economic development of these countries. Stable conditions in these countries are an important prerequisite for safeguarding the energy supplies of industrial countries in general, including Germany in particular, who import a considerable proportion of crude oil from these countries.

Key findings 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, and will continue to remain so for the foreseeable future.** Crude oil therefore still accounts for one third of global production as well as primary energy consumption.

- **From a geological point of view, the supplies of crude oil can be guaranteed in the next few years even with a moderate rise in crude oil consumption.** Despite a continuing rise in production levels, reserves in 2014 were again increased by a small amount.

- **The development in the price of oil is unpredictable.** The decline in oil prices starting in the middle of 2014 was relatively unexpected, and can be explained in retrospect by a global oversupply of crude oil, and especially due to shale oil in the USA, and the absence of any control on production levels by OPEC.

- **There is currently enough crude oil available.** However, in the medium to long term, the decline in investments by the oil industry caused by the lower oil price, could lead to shortages in future supplies, which could then cause significant rises in prices as a consequence.

- **Crude oil is the only non-renewable energy resource where growing demand in future decades can probably not be covered by supplies.** The early development of alternative energy systems is therefore necessary given the long time periods involved in transforming the energy sector. The exploitation of non-conventional crude oil deposits plays a significant part in the global availability of crude oil, but will not lead to a paradigm shift in the long term from a geological point of view.

- **Germany's crude oil supplies are currently highly diversified, with sources in 38 producing countries.** However, 60 % of imports are covered by Russia, Norway and the United Kingdom alone.

Natural gas

- **From a geological point of view, the world can be supplied with natural gas for many decades to come.** Natural gas is present in very large quantities world-wide. Around 80 % of global natural gas reserves are in OPEC and CIS countries, with over half in Russia, Iran and Qatar.

- **The global trade in natural gas declined in 2014.** However, the trade in liquefied natural gas (LNG) has increased at the expense of pipeline gas. The growing supplies of LNG can guarantee satisfactory levels of supplies in the years to come.

- **With its growing gas grid, Europe is connected to a large proportion of global natural gas reserves.** Despite the increases in LNG capacities, geopolitical risks are still a key factor affecting natural gas supplies.

- **Natural gas production in Germany and Europe continues to decline.** This increases dependence on imports, in particular from the Russian Federation, but also from the Middle East and Africa.

Coal

- **The reserves and resources of hard coal and lignite can satisfy even growing demands for many decades from a geological point of view.** With their share of around 55 % of the reserves, and around 89 % of the resources, coal has the largest potential of all non-renewable energy resources.

- **Coal will play a major role in future as well in the light of the expected rise in global primary energy consumption.** However, global production is only expected to grow slightly given the predicted economic development, the good overall supply situation for fossil energy resources, and the expansion of renewables.

- **The global market for hard coal continues to be affected by an oversupply, which has a significant effect on the global coal prices.**
  - No change in this situation is expected in the near future given the rise in production in many export coal mines, and the commissioning of modern, more efficient coal mines.
  - 2014 as well was marked by the further closures of mines associated with high production costs, primarily in the USA, Australia and China. Far reaching restructuring processes have been initiated in the remaining European coal industry (primarily hard coal).
  - Global coal prices have been mainly bolstered so far by the rise in volumes of coal imported into Asia (73 % of globally traded coal volumes).

- **The nominal steam coal prices declined by autumn 2015 to almost the same level of the last super commodity cycle in autumn 2003.** Rises in the price of steam coal and coking coal are also unlikely in the near future because of the continuing oversupply.

- **The imports of hard coal (bituminous coal) into Germany rose again in 2014 to the present level of around 54 Mt.** Together with imports of coking coal and briquettes, Germany currently imports 87 % of its demand for bituminous coal and coal products.

Nuclear fuels

- **The uranium market continues to be influenced by the relatively low spot market prices, which jeopardise the economic efficiency of various mines and exploration projects.** The falling uranium price trend, which began in 2011 as a consequence of the reactor accidents in Fukushima, has now continued for a third year in a row.

- **There was no rise in global uranium production for the first time since 2007.** Global uranium production declined by 6 % compared to the previous year. With its share of over 40 %, Kazakhstan is again the world's most important uranium producer.

- **There continues to be a growing interest world-wide in the use of nuclear fuels for power generation.** 70 nuclear reactors were under construction in 15 countries at the end of 2014. 26 of these alone in China. The demand for uranium will rise further in the long term, in Asia in particular.

- **No shortage in the supply of nuclear fuels is expected from a geological point of view.** There are very large global reserves, currently totalling 1.2 Mt (cost category < 80 USD/kg U) as well as around 13.4 Mt uranium resources.

- **The withdrawal from the use of nuclear energy for commercial power generation continues to be implemented in Germany.** Eight of Germany's 17 nuclear power plants have been switched off since the amendment to the Atomic Energy Act in 2011 (as at December 2014).

Deep geothermal energy

- **Deep geothermal energy is a successfully tried-and-tested form of energy production, which is attractive both in terms of climate problems as well as from a geopolitical point of view.** It is a low-emission innovative technology capable of providing base-load power, and has a relatively low footprint on the surface.

- **The global potential for geothermal energy is very high, but has only been exploited to a minor degree so far.** Geothermal energy accounted for around 0.3 % of global power generation in 2014. The global potential for geothermal energy down to a depth of 3 km is estimated at around 300 EJ/a for heat production, and 100 EJ/a for power generation.

- **With the exception of geothermally favourable regions, practical implementation and economic efficiency of geothermal projects still face difficulties.** There are considerable variations in investment costs, which are very difficult to estimate in advance. Typical return on investment periods exceed 25 years.

- **The situation regarding the use of geothermal energy varies considerably around the world.** The most favoured countries are those with high enthalpy deposits. Geothermal energy could become particularly important for developing countries, such as those in East Africa, where it could make a contribution to the generation of heat and power in regions with weak infrastructures.

- **The exploitation of geothermal energy has risen steadily in Germany from year to year.** Deep geothermal energy satisfied 0.3 % of primary energy consumption in Germany in 2014. The installed capacity in Germany has grown by a factor of nearly five in the last five years (2009 to 2014), and now stands close to 32 MW_e. Geothermal energy is subsidised in Germany by the Renewable Energy Act (EEG).

Renewables

- **Renewables are very important for global energy supplies.** Around 14 % of global primary energy consumption was covered by renewables in 2014, and primarily by “classic” renewable energy sources such as solid biomass and hydroelectricity. Despite the rapid global expansion in capacities, the importance of “modern” energy sources such as windpower and photovoltaics is still relatively small.

- **The globally installed capacity for power production is considerable.** Around 1,800 GW power generation capacities from renewables have been installed world-wide. This corresponds to around 28 % of the estimated total global capacity. China alone accounts for over three quarters of the installed capacity. Germany leads the world with an installed photovoltaic capacity for power generation of 38 GW.

- **There is a growing level of interest in the use of renewables around the world.** Around 164 countries have currently formulated specific goals for their further expansion. Around 60 % of the global increase in installed power generation capacities in 2014 was accounted for by investment in renewables.

- **The use of renewables for power generation continues to grow in Germany.** The proportion of renewables in the German power mix reached 26.2 % in 2014. Most of this is accounted for by windpower, biomass and photovoltaics.

2 ENERGY RESOURCES IN GERMANY

Even up until the middle of the 20th century, the energy base for the industrialisation of Germany was dominated by lignite and hard coal (Fig. 2). The use of crude oil as an efficient energy source began in the 1960s, and rapidly grew into the overriding energy resource by a large margin, and continues to dominate the energy mix even today. The demand for crude oil, and primary energy consumption (PEC), peaked in 1979 as a consequence of the global oil crises: with the shift away from crude oil for power generation, and the increased use of other energy sources such as natural gas and nuclear power. Since then, the demand for energy and mineral oil has remained at a relatively high level, although marked by a slowly declining trend overall. The proportions of the fossil fuels – mineral oil, natural gas and coal – have also declined from 95.5 % in 1979, to their minimum of 78.2 % of PEC in 2010 (AGEB 2015). Overall, the changes in the German energy mix since the second oil crisis have been gradual from a long-term point of view. Whilst there has been a general downward trend in the share of coal, and lignite in particular, amongst the fossil fuels, the importance of natural gas grew and reached a maximum in 2005. The proportion of coal, however, has stayed at the same level over the past 10 years.

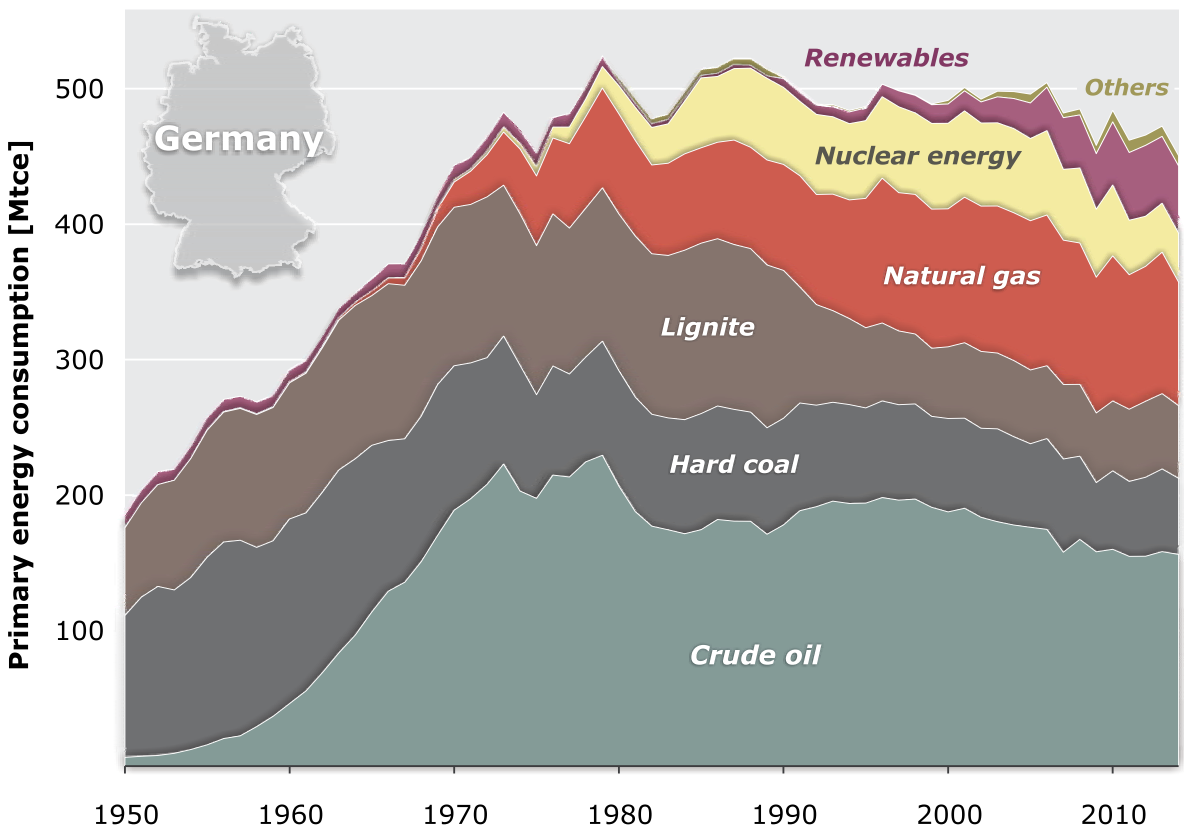

Figure 2: Historic development of the shares of each energy source in German primary energy consumption (AGEB 2015).

After a long period of expansion in the 1970s, nuclear power reached its largest share of PEC at the beginning of the new millennium. Since then, there has been a declining trend, as expected given the decision to withdraw from nuclear power generation. The most recent development is the increased proportion of renewables since the turn of the millennium. Unlike earlier times, when renewable power production was largely based on hydroelectric power, this has now been overtaken by wind power and biomass, as well as by photovoltaics in recent years.

2.1 Primary energy consumption and energy supplies

Compared to the previous year, primary energy consumption in Germany declined by 4.7 % in 2014 largely because of the much milder weather compared to 2013. 2014 was the warmest year on record since the beginning of regular temperature measurements in Germany in 1881. According to AGEB (2015) the decline in consumption is also attributable in part to a significant boost in energy productivity. Without the temperature effect, energy consumption would only have declined by around one per cent year-on-year (AGEB 2015). PEC overall in 2014 was 13,077 petajoules (PJ) and therefore at the same level as the early 1970s, as well as being at the lowest level since German reunification.

With respect to energy content, the strongest drop in the consumption of all fossil fuels was accounted for by natural gas, which dropped by 12.6 %, primarily due to the weather conditions, so that it had a proportion of 20.5 % of PEC in 2014. There was also a considerable decline in coal consumption, which dropped 7.9 %, but still occupies third place in the German energy mix behind mineral oil and natural gas. Against the background of an overall shrinkage in Germany's primary energy consumption, and therefore also power consumption, the decline in the consumption of coal is largely attributable to the increasing use of renewables for power generation, and therefore also to the "Energiewende" in Germany – the transition away from fossil fuels to renewables. Lignite dropped by 3.6 %, and mineral oil by 1.3 %. However, with mineral oil accounting for a 35 % share of total energy consumption, it is still the most important source of energy by far (AGEB 2015).

The use of renewables rose slightly by 0.5 % in 2014, and therefore now accounts for 11.1 % of consumption, putting it slightly behind coal (12.6 %) and lignite (12.0 %). This minor rise compared to previous years is primarily attributable to the decline in hydroelectric power (minus 10.9 %) and biogenic solid fuels (minus 9.1 %). In contrast, there was a significant rise in photovoltaics (plus 12.6 %), windpower (plus 8.2 %), and biogas. In absolute terms, the proportion of nuclear power remained almost constant, and therefore had a slightly higher share compared to the other energy sources, of 8.1 % in 2014 (AGEB 2015).

As a highly developed industrial country, Germany is one of the world's largest energy consumers, and has to import most of the energy resources it requires. Of all the natural resources imported in 2014 (mineral and energy resources) with a total value of Euro 123.1 billion, around two thirds were accounted for by the energy resources crude oil, natural gas and coal (Fig. 3). The relative proportions of energy resources were 60.5 % for crude oil, 33 % for natural gas, and 5.7 % for coal, and 0.8 % for nuclear fuels. In total, 230 million t of energy resources were imported with a total value of Euro 81.8 billion. Compared to the previous year, imports in 2014 declined by 7.1 %, and their value by 19.2 % (BGR 2015).

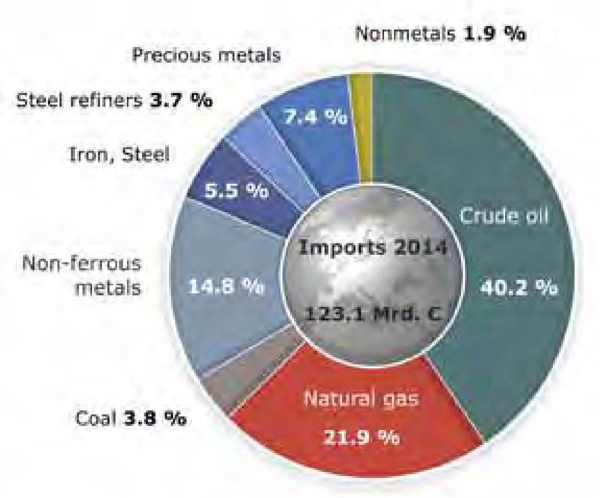

Figure 3: Proportions and value of German natural resource imports in 2014.

Domestic production accounted for only around 2 % of crude oil consumption and 12 % of natural gas consumption (Fig. 4) because the production volumes of the producing fields in Germany are declining as a result of natural depletion. The proportion of domestic hard coal will disappear completely when the subsidies for hard coal production run out as planned at the end of 2018. Lignite is the only non-renewable energy resource which is found in large economically extractable volumes in Germany. Germany satisfies all of its own needs for lignite, and is the largest consumer world-wide. The ten-year comparison reveals that there has been a decline in the shares of all fossil fuels, and in nuclear power in particular, with respect to PEC in Germany, whilst the share of renewables has increased. This reflects the long-term impact of the Energiewende, as well as the short-term effects of the relatively mild weather in 2014, which led to an over proportional decline in PEC. There will be a further decline in the level of domestic supplies because of the naturally declining production of domestic oil and gas fields, and the low level of conventional reserves, the lack of exploration for non-conventional domestic oil and gas reserves, and the scheduled end to subsidised coal mining, and withdrawal from nuclear power production. Therefore, despite the probable further decline in PEC in future, it is likely that Germany's dependence on imports of fossil energy resources will rise further.

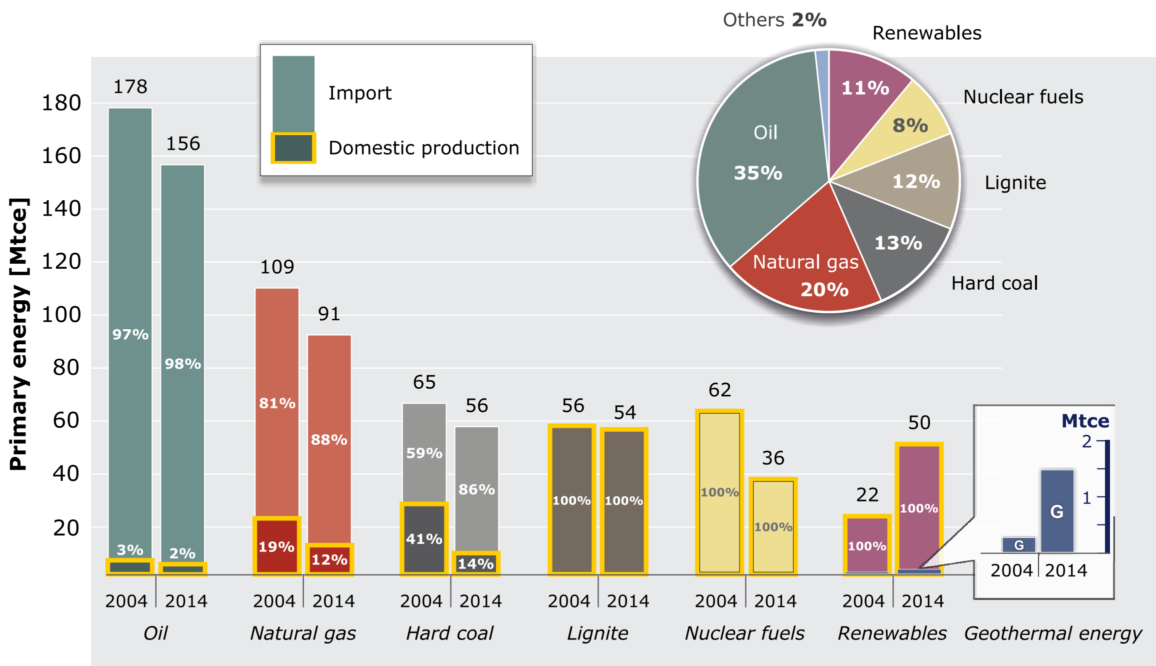

Figure 4: Germany's import dependency and domestic supply levels for specific primary energy resources in 2004 and 2014 (sources: AGEB 2015, LBEG 2015, BMU 2013).

2.2 Energy resources in detail

Crude oil

Proven and probable crude oil reserves in Germany were around 31.1 million t at the end of 2014, and therefore 1.2 % lower than the previous year. This decline is largely attributable to the annual production and revised estimates of the reserves in known fields (LBEG 2015). Most of Germany's crude oil reserves are in northern Germany, where Schleswig-Holstein (40.8 %) and Lower Saxony (31 %) account for over 70 % of German reserves. The reserves in Germany's largest oil field "Mittelplate/Dieksand", rose by 0.5 million t despite production of 1.3 million t. No new oil fields were discovered.

The production of crude oil and condensate in Germany declined by more than 7.9 % compared to the previous year, and totalled 2.43 million t. The most important production areas are in northern Germany. The oil fields of Schleswig-Holstein and Lower Saxony accounted for almost 90 % of total German production in 2014. Production in the Mittelplate/Dieksand oil field, Germany's largest, declined slightly by 0.1 million t to 1.34 million t, and therefore continued to account for around 55 % of domestic crude oil production. The production in the Rühle field (Lower Saxony), Römerberg field (Rhineland-Palatinate) and Emlichheim field (Lower Saxony) dropped between 4 % and 11 % (LBEG 2015). The number of producing fields rose to 50 because of the restart of production operations in the Börger/Werlte field. Oil was produced from 1,066 production wells in 2014 (previous year: 1,077 production wells). The condensate produced during natural gas production totalled 17,426 t in 2014, corresponding to a 0.7 % share of German oil production. One third of this was produced in the A6/B4 natural gas field in the German North Sea. The Emlichheim, Georgsdorf and Rühle fields are produced using EOR methods such as steam and hot water flooding to increase the recovery rates (cf. Chapter 4.1). The production achieved in this way totalling 283,259 t declined considerably compared to the previous year (317,562 t), amounting to a drop of almost 11 %. From the beginning of the 20th century to the end of 2014, a total of 300 million t crude oil and condensate has been produced in Germany.

The most important oil production companies, and their production in 2014 in Germany based on their consortium shares, are as follows (WEG 2015):

▪ Wintershall Holding AG	942,175 t
▪ RWE DEA AG	691,989 t
▪ GDF Suez E&P Deutschland GmbH	393,963 t
▪ BEB Erdgas and Erdöl GmbH & Co. KG	241,528 t

The German oil and gas industry employed 10,044 people at the end of 2014, a decline of 41 employees compared to the previous year (WEG 2015).

Germany's crude oil imports in 2014 dropped by 1.4 % (around 1.2 million t) to 89.3 million t. This oil was mainly supplied by CIS countries, Europe and Africa (Fig. 5).The three most important supplying countries (of a total of 34) were Russia, Norway and the United Kingdom, which together accounted for over 61 %. The volumes of imports from some countries increased considerably in some cases compared to the previous year: Norway (plus 38.6 %, 4.2 million t), Azerbaijan (plus 11.9 %, 0.4 million t), Algeria (plus 39 %, 1 million t), Brazil (plus 150.5 %, 0.4 million t), Mexico (plus 118.7 %, 0.2 million t). Reductions in imports came mainly from several main supplying countries including Russia (minus 4.6 %, 1.5 million t) and Nigeria (minus 2.5 %, 0.2 million t), as well as Kazakhstan (minus 6.2 %, 0.4 million t). Because of the crisis in Libya, imports from there slumped by 52 %, and imports from Saudi Arabia were also down almost 43 % (AGEB 2015, BAFA 2015a). Table 13 (in the apendix) provides an overview of all of the countries exporting crude oil to Germany in 2014.

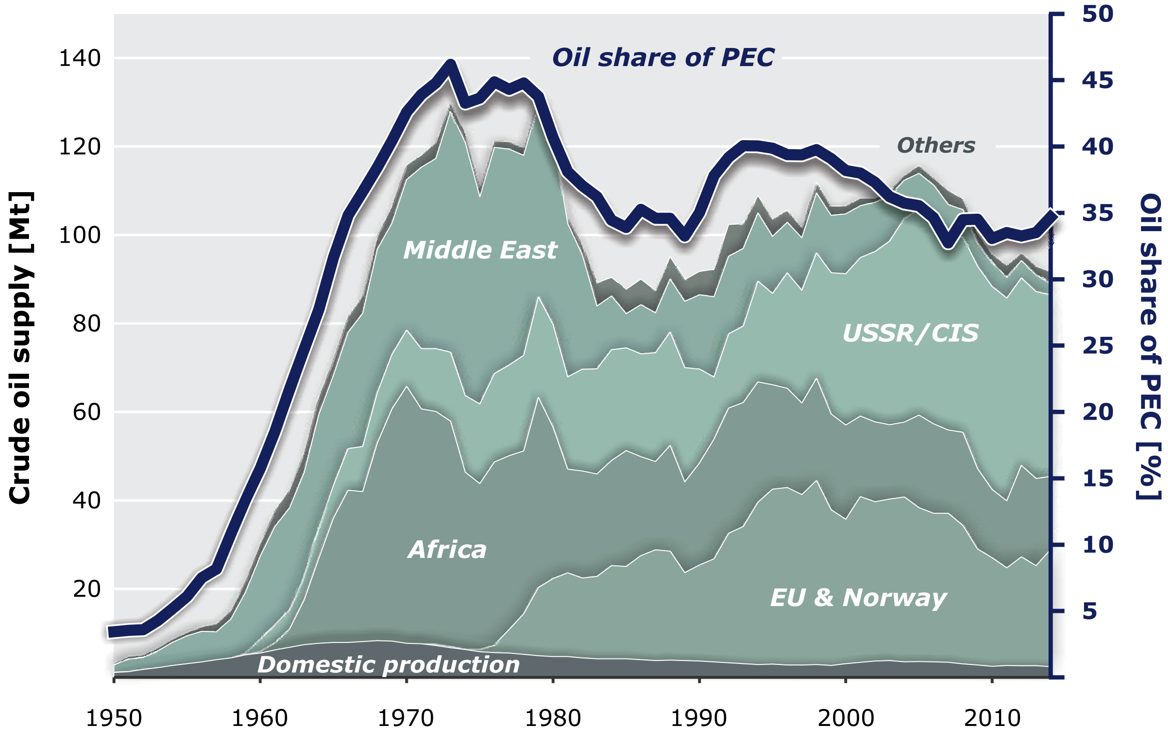

Figure 5: Germany's crude oil supplies from 1950 - 2014.

The re-export of crude oil into neighbouring countries reduced further in 2014, and is now down to only 30,131 t (2013: 34,029 t). The trade with mineral oil products – primarily with EU countries – stayed at a relatively constant level compared to the previous year: exports 21.2 million t (2013: 20.2 million t), imports 37 million t (2013: 37.7 million t), (BAFA 2015a).

German companies produced around 7 million t of crude oil overseas, corresponding to a slight rise of 3.2 % compared to the previous year (6.7 million t). Bayerngas, E.ON, RWE DEA, VNG and Wintershall were all able to boost their production, in some cases considerably. Suncor suffered a major decline in production amounts because of the unrest in Libya.

The most important German crude oil producing companies and their production in 2014 according to their consortium shares overseas were as follows (EEK 2015, WEG 2015, own estimates):

- Wintershall AG 3.3 million t
- RWE DEA AG/DEA 1.6 million t
- E.ON Ruhrgas AG/E.ON E&P GmbH 1.4 million t
- Bayerngas GmbH/Bayerngas Norge As 0.3 million t
- Suncor Energy Germany GmbH 0.2 million t
- VNG-Verbundnetz Gas AG 0.2 million t

Natural gas

Proven and probable natural gas reserves in Germany on 31.12.2014 totalled 88.5 billion m³ (V_n) crude gas (minus 14.6 %) or 82.6 billion m³ (V_n) pure gas (minus 14.4 %), and therefore again declined considerably in this reporting year. After deducting the production in 2014 from last year's reserves, it is clear that the re-evaluation of gas fields has led to an overall reduction in crude gas reserves of around 5 billion m³, and pure gas reserves of around 4.8 billion m³.

During the 2014 reporting year, natural gas production in Germany declined further by around 0.6 billion m³ (V_n) to 10.1 billion m³ (V_n) crude gas, or 9.1 billion m³ (V_n) pure gas. This corresponds to a decline of 5.8 % in crude gas and a decline of 6.1 % in pure gas compared to the previous year.

The continuous decline in production volumes, as well as natural gas reserves, is largely attributable to the increasing depletion and watering out of the gas fields. This situation is exacerbated by the absence of any significant discoveries in the recent years, so that the volumes of natural gas which are produced every year are not replaced by any additions made to the reserves.

Natural gas definitions in Germany

The figures for the production and reserves of natural gas are reported by the German production industry as "crude gas volumes" in reservoir engineering terms, as well as "pure gas volumes" in gas industry terms The crude gas volumes correspond to the gas extracted from the reservoirs with the natural calorific values, which can vary considerably from field to field in Germany. The pure gas figure refers to a standard calorific value of H_o = 9.7692 kWh/m³ (V_n), which is also known as the "Groningen calorific value" by the gas production industry, and is a fundamental parameter in the gas industry (LBEG 2015).

Of the 10.1 billion m³ of natural gas produced in Germany, only around 67 million m³ is accounted for by associated gas produced alongside crude oil, which is mainly produced in Lower Saxony (60 %) and Schleswig-Holstein (28 %).

In total, 494 production wells were in operation in 77 natural gas fields in 2014, of which over 90 % of the fields were located in Lower Saxony.

With respect to their consortium shares, 99 % of domestic pure gas production was produced by five companies in 2014 (WEG 2015):

▪ BEB Erdgas and Erdöl GmbH & Co. KG	3.474 billion m³
▪ Mobil Erdgas-Erdöl GmbH	2.778 billion m³
▪ DEA Deutsche Erdöl AG (formerly REW-DEA AG)	1.504 billion m³
▪ Wintershall Holding AG	0.622 billion m³
▪ GDF Suez E&P Deutschland GmbH	0.620 billion m³
TOTAL	8.998 billion m³

Around 40 % of domestic natural gas reserves contain varying amounts of hydrogen sulphide (H_2S). Around 0.71 million t of elemental sulphur is extracted during the processing of the hydrogen sulphide bearing natural gas – which mainly occurs in fields in the gas producing region between the Weser and the Ems rivers – and is treated in the gas processing facilities in Grossenkneten, and to a lesser extent also in Voigtei. This sulphur is mainly used by the chemical industry, and is even exported in part.

The large-scale production of natural gas in Germany did not start until the 1960s when the Buntsandstein (Lower Triassic) and Zechstein (Permian) reservoirs in Lower Saxony were developed. The production of natural gas was still at a level of around 22 billion m³ in 2003, but has continually declined since 2004, and was less than half of its peak in the reporting year.

The exploration for natural gas in shale rocks which requires the hydraulic stimulation of the shale to produce the gas is the subject of heated public discussions because of the possible consequences for people and the environment. It is not currently possible to foresee whether shale gas will ever be produced in Germany, and if it were, when production from such deposits would actually take place. The potentially extractable volumes of natural gas (resources) producible from shale gas deposits in Germany are estimated to be between 0.7 trillion m³ to 2.3 trillion m³ (BGR 2012). In addition, coal seams are estimated to have a potential of 0.45 trillion m³ of natural gas resources. Natural gas from tight sandstones (tight gas) has already been produced in relatively small volumes in Germany for several years. The resources of tight gas are estimated to be in the order of 90 billion m³.

The production of natural gas by German companies abroad (CIS/Russia, South America, Europe and North Africa) increased by around 4.6 % compared to 2013, and totalled around 24.4 billion m³ in 2014. At around 62 %, the lion's share of this production in 2014 was again produced by Wintershall AG, the largest internationally active German oil and gas producer. The company's operations are mainly focused in Europe, North Africa, South America, Russia, in the Caspian Sea region, as well as in the Middle East. Wintershall is also one of the largest natural gas producers in the Netherlands. E.ON E&P GmbH, previously known as E.ON Ruhrgas AG, produced the second largest proportion of natural gas abroad in 2014, and boosted its production by around 7.4 % compared to 2013. With a total of 5.923 billion m³, the largest share of E.ON's production in 2014 came from its stake in Yushno Russkoje, one of the world's largest natural gas fields. It also produced almost 1.9 billion m³ in the North Sea.

Despite the further decline in domestic natural gas production and as in the previous year, this still accounted for around 12 % of the natural gas consumed in Germany, due to the strong reduction in demand (Fig. 4). The total calculated volume of natural gas handled in the German market, consisting of domestic production and imports, amounts to 106.4 billion m³. Around 21.4 billion m³ of this was exported, and around 0.3 billion m³ was injected into German natural gas storages. In terms of their energy content, natural gas imports in 2014 totalled 3,604,567 terajoules (TJ) and were therefore down 3.7 % in total compared to the corresponding quantity the previous year (3,744,750 TJ). The three most important countries supplying gas to Germany were again Russia (1,391,163 TJ), Norway (1,194,227 TJ), and the Netherlands (867,522 TJ) (Fig. 6). Russia again had a share of almost 39 % of natural gas imports to Germany, followed by Norway with slightly more than 33 %, and the Netherlands with 24 %. The monetary value of the natural gas imported from Russia, the Netherlands, Norway, Denmark and the United Kingdom in 2014 was Euro 23.6 billion, compared to Euro 28.7 billion the previous year (BAFA 2015).

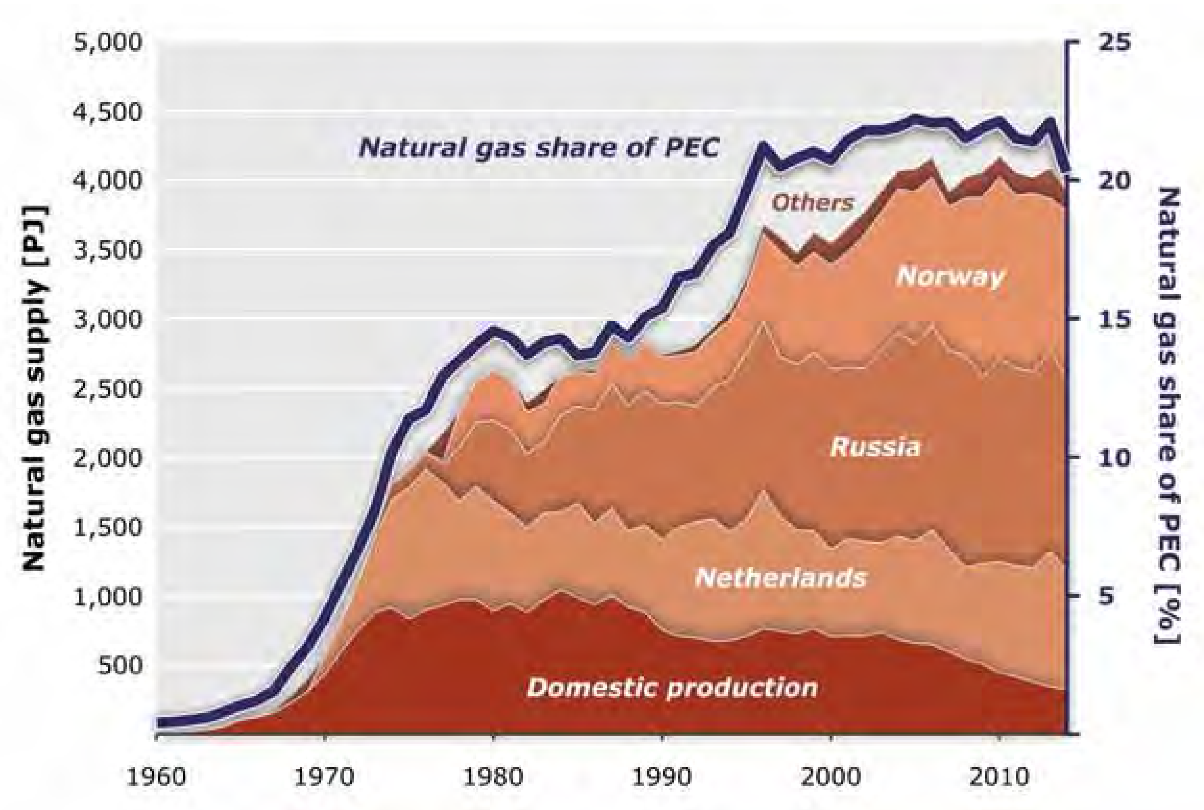

Figure 6: Natural gas supplies in Germany from 1960 - 2014.

Coal

In the middle of the previous century, domestic coal was the main springboard for the economic recovery in Germany. Coal production has been in decline ever since. The peak coal production figure in the period after 1945 was in 1956 at 152.5 million tons of saleable production (Fig. 7). This had declined to only 7.6 million tons of saleable production by 2014 (5 % of the peak in 1956). In past decades, domestic coal has been replaced by natural gas, as well as uranium, and particularly by coal imports (Fig. 8). Germany has total coal resources (total reserves and resources) of around 83 billion t, of which around 21 million t will probably be extracted up until the end of 2018.

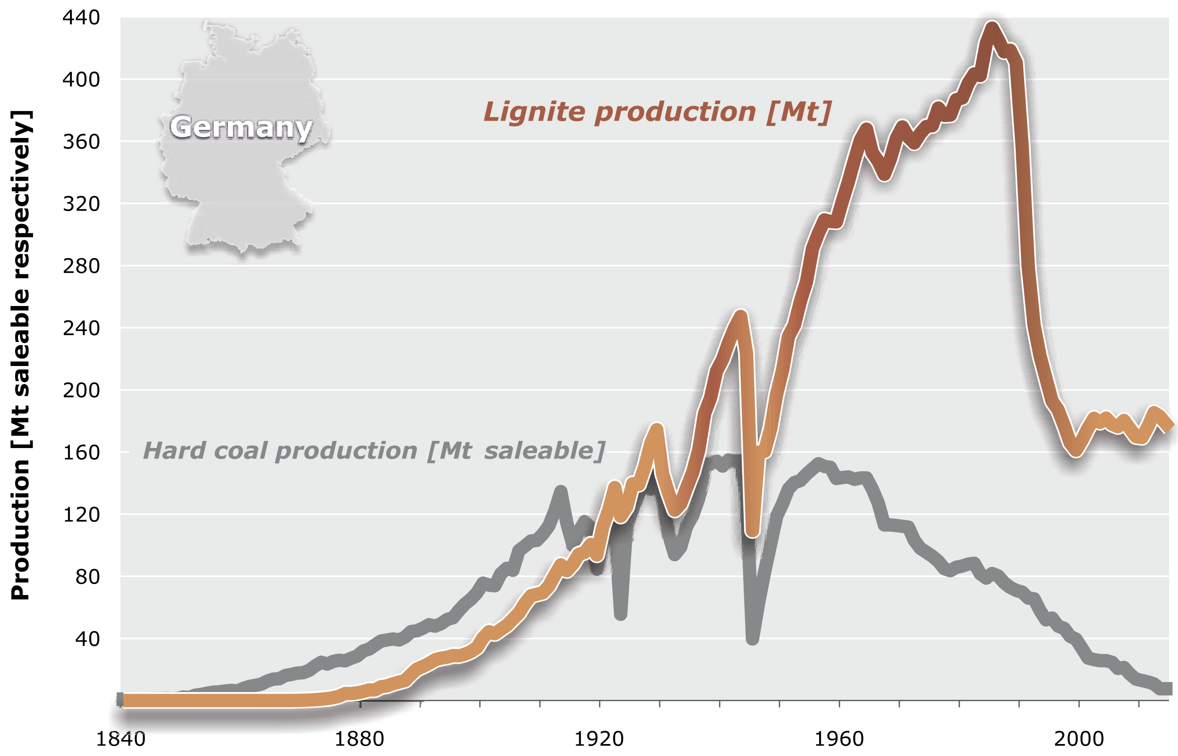

Figure 7: Change in German coal production from 1840 to 2014 (according to SDK 2015).

The two remaining hard coal mines in the Ruhr coalfield produced 74.5 % (5.7 million t of saleable production) of German hard coal production in 2014. One coal mine in the Ibbenbüren coalfield produced the remaining 25.5 % (2 million t of saleable production) of German hard coal production. Coal mining in the Saar coalfield was terminated at the end of June 2012. The nation-wide output per shift in 2014 rose by 13.1 % year-on-year to 7,491 kg of saleable production. The total sales of German coal declined slightly by 3.7 % in the reporting year, decreasing by 0.3 million t to 8.1 million t (GVSt 2015, SDK 2015).

German hard coal mines have not been internationally competitive for many years because of the unfavourable geological conditions in particular. It is therefore likely that coal will also not be able to be produced in the future in Germany at world market prices. According to estimates by the Verein der Kohlenimporteure e.V. (VdKi) (the Association of Coal Importers, the average German production costs in 2015 were around 180 €/tce. This is in contrast to the average annual prices for imported steam coal of 72.94 €/tce (VdKi 2015a). Nevertheless, domestic coal mining is publically subsidised with the aim of contributing to the safe supply of coal to power plants and steel works, as well as for job market policy reasons. Euro 1,648.6 million of public subsidies were set aside for coal mining in 2014 (BMWi 2015a).

In February 2007, the German government, the state of Nordrhein-Westfalen and the Saarland reached an agreement to end the subsidised production of hard coal in Germany in a socially acceptable way by the end of 2018. One of the provisions of this agreement was that it should be reviewed by the German parliament in 2012. Recourse to this amendment clause was waived as a result of changes to the Coal Financing Act in spring 2011. The maximum subsidies – for which an act granting the subsidies has already been adopted – will decline to Euro 1,015 million in 2019 (BMWi 2015b). The workforce in the German coalfields has declined since 1958. The number of employees in 2014 declined by 16.8 % compared to 2013 and now totals 12,104 (at the end of 2014; SDK 2015).

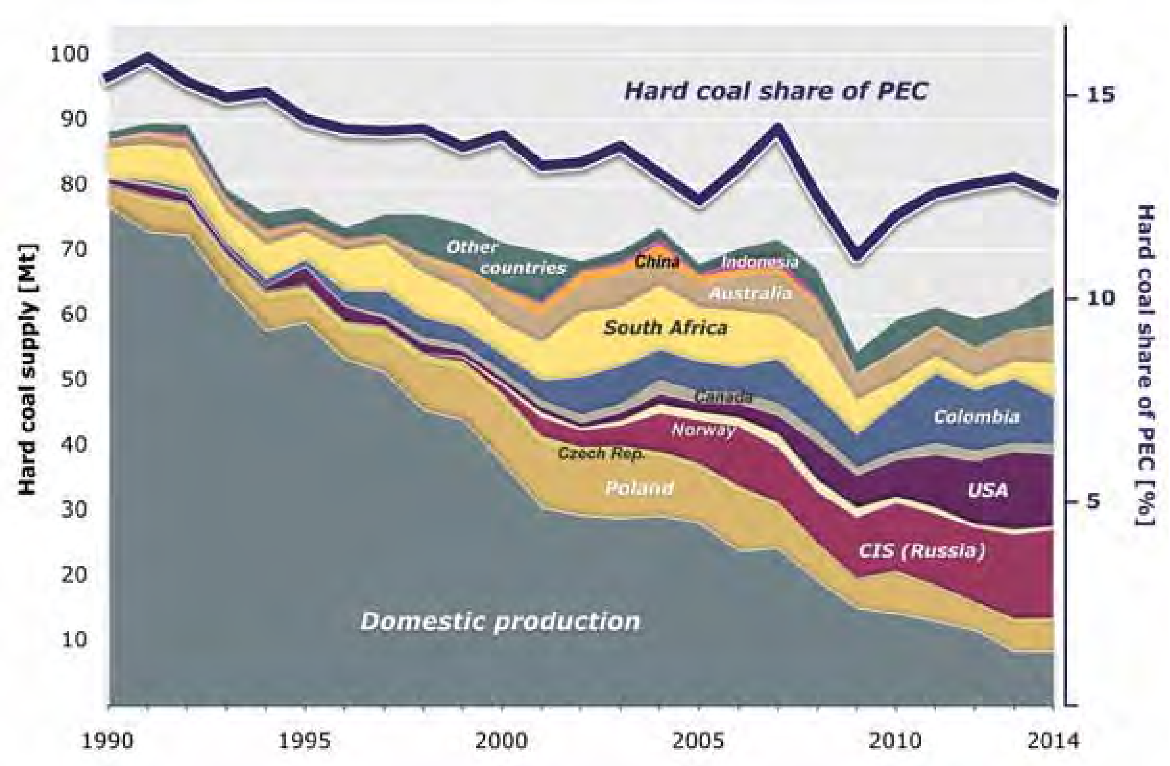

Figure 8: Germany's coal supplies from 1990 to 2014 (AGEB 2015, IEA 2015, SDK 2015, VdKi 2015a).

Compared to 2013, there was a significant drop in coal consumption in Germany in the reporting year. It declined by around 7.9 % to around 56.2 million tce. Because of the lower overall energy consumption, the share of coal in primary energy consumption declined only slightly to 12.6 %. Only 14 % of coal consumption in Germany in 2014 came from domestic production (AGEB 2015).

Imports of hard coal and hard coal products rose considerably by 6.3 % compared to 2013, and totalled 56.2 million t. Most of this amount was derived from Russia, the USA, Colombia, Australia, South Africa and Poland. With a total of around 13.7 million t (24.4 %), Russia was again the largest supplier in 2014, followed closely by the USA (19.7 %) and Colombia (13.1 %). The imports from Poland, the only remaining major coal exporting country in the EU-28, rose slightly to around 4.4 million t. Around 1.5 million t of this was accounted for by coking coal (VdKi 2015a). The import share of the total amount of coal traded in Germany was the same as the previous year at around 87 %. The trend towards growing dependency on imported coal will continue further in the coming years because of the closure of additional coal mines. Coal production from the Auguste Victoria mine will end at the end of 2015, whilst the Ibbenbüren and Prosper-Haniel mines will close at the end of 2018 (RAG Stiftung 2015, Van de Loo & Sitte 2015).

The prices (here: cross-border prices) for imported steam coal declined from around 77 €/tce at the beginning of 2014 to around 72 €/tce at the end of the year. During the summer of 2014, they even dropped as low as around 68 €/tce for a short period. The annual average price was therefore 72.94 €/tce (minus 8 % compared to 2013). Coking coal showed a similar development in prices. The price of coking coal declined by around 5 % year-on-year, and the annual average price was 193.66 €/t. There was an even more marked reduction in the prices of imported coking coal: the annual average price declined by around 17.7 % from 127.19 €/t the previous year to 104.67 €/t (BAFA 2015b, VdKi 2015b). Because of the continuing oversupply of coking coal as well as steam coal on the world coal market, the decline in prices also continued into 2015.

Lignite

Unlike hard coal, German lignite continues to hold its own without subsidies in the competition with imported fuels. The favourable geological conditions existing in the lignite deposits made it possible to produce the lignite by efficient open cast mining, so that large quantities can be sold to nearby power plants for power generation at acceptable market prices. Germany has been the world's largest producer of lignite since the beginning of industrial lignite production.

5.2 billion t of lignite reserves are accessible via developed or definitely planned open cast mines in Germany. There are additional reserves of 31 billion t. The resources total 40.5 billion t.

Lignite is produced in Germany in four lignite fields. Total German production in 2014 was 178.2 million t, and thus down slightly by 2.6 % compared to the previous year (Fig. 7). In the Rhenish lignite field, RWE Power AG operates three open cast mines – Garzweiler, Hambach and Inden – whose total production in 2014 reached 93.6 million t. The Garzweiler and Hambach open cast mines supply the Frimmersdorf, Goldenberg, Neurath and Niederaußem power plants with lignite by rail. The Weisweiler power plant is supplied by the Inden open cast mine. Production in the Lausitz lignite field totalled 61.8 million t during the reporting year, and came from the five open cast mines operated by Vattenfall Europe Mining AG – Jänschwalde, Cottbus-Nord, Welzow-Süd, Nochten and Reichwalde. Almost all of this lignite was sold to the modernised or new power plants operated by Vattenfall Europe Generation AG & Co. KG (formerly Vereinigte Energiewerke, VEAG). The most important power plants are Jänschwalde, Boxberg and Schwarze Pumpe. Production in the central German lignite field in 2014 totalled 20.9 million t and came primarily from the Profen and Vereinigtes Schleenhain open cast mines operated by Mitteldeutsche Braunkohlengesellschaft mbH (MIBRAG), which has been completely owned by the Czech holding EP Energy since 2012. Most of the lignite from these two open cast mines is used to generate power in the Schkopau and Lippendorf power plants. The lignite produced in the Amsdorf open cast mine by ROMONTA GmbH is primarily used for the production of montan waxes. The production equipment in the Amsdorf open cast mine was damaged by a landslide on 6 January 2014, and the open cast mining operations had to be shut down. ROMONTA GmbH was temporarily supplied with raw lignite from the Vereinigtes Schleenhain open cast mine operated by MIBRAG. This enabled ROMONTA to continue its raw montan wax production. Lignite production was restarted in the Amsdorf open cast mine in April 2015. In the Helmstedt lignite field, the Schöningen open cast mine supplies lignite to the Buschhaus power plant. In the second half of 2014, MIBRAG purchased the open cast mine and the power plant (Helmstedter Revier GmbH – HSR) from E.ON Kraftwerke GmbH (DEBRIV 2015, Maassen & Schiffer 2015, SDK 2015).

Total sales of lignite in the reporting year declined by 2.4 % to 167.7 million t. However, because of the overall drop in German primary energy consumption, the proportion of lignite in primary energy consumption rose slightly to 12.0 % (53.6 million tce). The sale of lignite briquettes, as well as the sales of the processing product lignite dust, declined compared to the previous year: briquette sales dropped by 12.4 % to 1.7 million t, and lignite dust sales sank by 0.7 % to 4.8 million t. There was a slight decline in the workforce during the reporting period: 15,931 people were employed in the lignite mining business across the country in 2014 (minus 2.9 % compared to the previous year) (AGEB 2015, SDK 2015).

The external trade balance in lignite and lignite products was positive in 2014, although at a relatively low level. Total imports declined to 88,000 t. At the same time, exports (briquettes, coke, dust and lignite) rose significantly by 64 % to 2.68 million t. The main importers are EU-28 countries (SDK 2015).

Nuclear power

One key aspect of the Energiewende is withdrawing from nuclear power. With the thirteenth amendment to the Atomic Energy Act on 6 August 2011, the German government adopted the resolution to end the use of nuclear power for commercial electricity generation. The provisions of the act set out that the last nuclear power plant in Germany must be switched off by 2022. The withdrawal from nuclear power production takes place in steps with precise shut-down dates. The nine nuclear power plants which are still in operation will be shut down according to the following timetable, and at the end of the year in each case: 2015: Grafenrheinfeld; 2017: Gundremmingen B; 2019: Philippsburg 2; 2021: Grohnde, Gundremmingen C and Brokdorf; 2022: Isar 2, Emsland and Neckarwestheim 2.

The contribution made by nuclear power remained almost constant at 1,059 PJ, or 36.2 million tce, with an 8.1 % share of primary energy consumption (2013: 7.8 %). As in the previous year, with a 15.8 % contribution to public power supplies, nuclear power remained in fourth place behind renewables (26.2 %), lignite (25.4 %), and coal (17.8 %). With a total output of 614.0 TWh in 2014, 3 % less power was produced in Germany than in 2013 (633.2 TWh). The proportion of nuclear power in the overall gross power generation mix declined slightly again by 0.2 % to 97.1 TWh compared to 2013 (97.3 TWh). The net power generation was 91.8 TWh (2013: 94.2 TWh). 17 nuclear power plants with a gross output of 21,517 MW_e were running before eight nuclear power plants were shut down in 2011. Only 9 nuclear power plants with 12,702 MW_e (gross) were connected up to the grid at the end of 2014. The temporal and productive operational availabilities were 90.56 % (2013: 91.1 %) and 89.11 % (2013: 90.7 %) respectively.

The demand for natural uranium in fuel was calculated as 2,000 t. This was covered by imports and from stockpiles. The volumes of natural uranium required for the production of nuclear fuels is still almost exclusively acquired on the basis of long-term contracts with producers in the United Kingdom, USA, France and Canada.

No mining for the production of natural uranium has been carried out in Germany since 1990, since the closure of the Sowjetisch-Deutsche Aktiengesellschaft (SDAG WISMUT). However, due to the flood water treatment being carried out as part of the remediation work in Königstein, 33 t of natural uranium was separated out in 2014 (2013: 27 t).

The decommissioning and remediation of the former SDAG WISMUT production sites entered their 24th year of operations in 2014. The work is undertaken on behalf of the Federal Ministry for Economic Affairs and Technology 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 mines, water treatment, dismantling and demolition of contaminated facilities and buildings, remediation of mining dumps and tailing ponds, environmental monitoring) are now more than 90 % complete. Of the Euro 7.1 billion set aside for this major project, around 83 % (Euro 5.9 billion) has already been spent by the end of 2014. One of the remaining major issues is treating the contaminated water from the flooded underground mines, and the remediation of the industrial settling facilities. 19 million m^3 of contaminated water was treated in 2014, and discharged into the rivers. After completion of the drifting of a 2,900 m long drainage gallery in Freital – the "WISMUT Stolln" – this was connected to the flooded underground mines by drill-holes in September 2014. Since then, the water has flown out naturally via the connecting gallery to the Elbe River. Work on the demolition of the shafts and the associated buildings at the Königstein site began in August 2014, and was already completed in 2015. The main focus of work in future will involve adjusting the current water treatment facilities to the lower volumes of water and changing hydrochemical conditions, as well as the further dismantling of the infrastructure which is no longer required, and the remediation of the land surfaces. At Wismut GmbH's Crossen site, the remediation work will also now continue with the adaptation of the local water treatment system in the next few years.

Deep geothermal energy

Three regions in Germany offer the best geological conditions for hydrothermal geothermal energy: the North German Basin, the Upper Rhine Graben, and the Molasse Basin in the Alpine foreland. Because of the more favourable geological conditions, heat and power are produced in southern Germany (South German Molasse Basin and Upper Rhine Graben), whilst geothermal heat production dominates in the North German Basin in northern Germany.

In this study, the main focus is on deep geothermal energy for both power generation, as well as heat production. In this context, there are pure heat plants as well as co-generation heat-and-power plants. Thanks to the coupling of heat and power generation, the latter plants achieve optimum energy yields. In addition to the specific aspects applying to the energy requirements in each case, the type of use is also determined naturally by the different temperature conditions and the presence or the nature of a heat transport medium.

At 0.32 %, the overall proportion of geothermal energy of total primary energy consumption (PEC) in Germany continues to be very low. Only 0.06 % of PEC is provided by deep geothermal energy. Seven power plants were operating in the electricity sector in 2014, generating 80 GWh_e of power, up 46 % year-on-year. There were 26 district heating systems with an installed capacity of 286 MW, which produced almost 940 GWh_{th} of heat. This was mainly divided up into three different uses: district heating, building heating, thermal baths/balneology. According to GtV Bundesverband Geothermie e.V. (Federal Geothermal Energy Association) there are currently 34 projects in the planning phase, including five petrothermal (EGS) plants (GtV as at April 2015).

The amount of electricity generated geothermally in Germany has grown continually from 0.4 GWh to 80 GWh in the period from 2004 up to the end of 2014. The installed capacity has risen in the last ten years from 0.2 MW to 32 MW. Over the same period, the proportion of deep geothermal energy for heat generation rose from 505 GWh to 940 GWh (GeotIS), with a parallel rise in the installed capacity from 93 MW (2004) to 286 MW in 2014 (Fig. 9 and Fig. 10[1]). It is likely that this trend will continue over the medium term. WEBER et al. (2015) predict a growth in installed capacities to 50 MW_e and 300 MW_{th} in 2015. However, a sudden increase is still not expected. Despite some successful ongoing projects, the use of geothermal energy in Germany for geothermal power production is still in the research and development stage. Currently, and in the near future as well, the most important region for geothermal energy for heat production is the Alpine foreland because the sedimentary Molasse Basin features particularly favourable properties with respect to the fluid permeabilities required for geothermal utilisation.

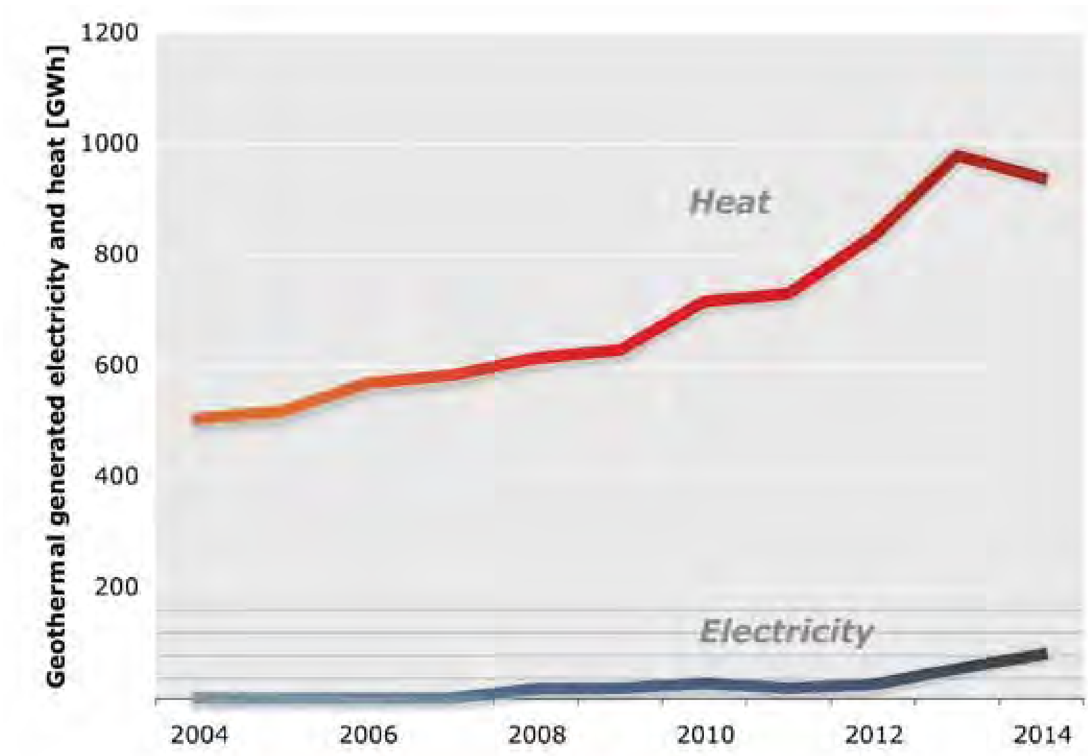

Figure 9: Amount of power and heat (GWh) produced in Germany every year by deep geothermal energy projects between 2004 and 2014 (data: GeotIS, accessed 21.10.2015).

1 The difference in the data when compared to the global tables 48 and 50, is attributable to the use of more up-to-date data in www.geotis.de

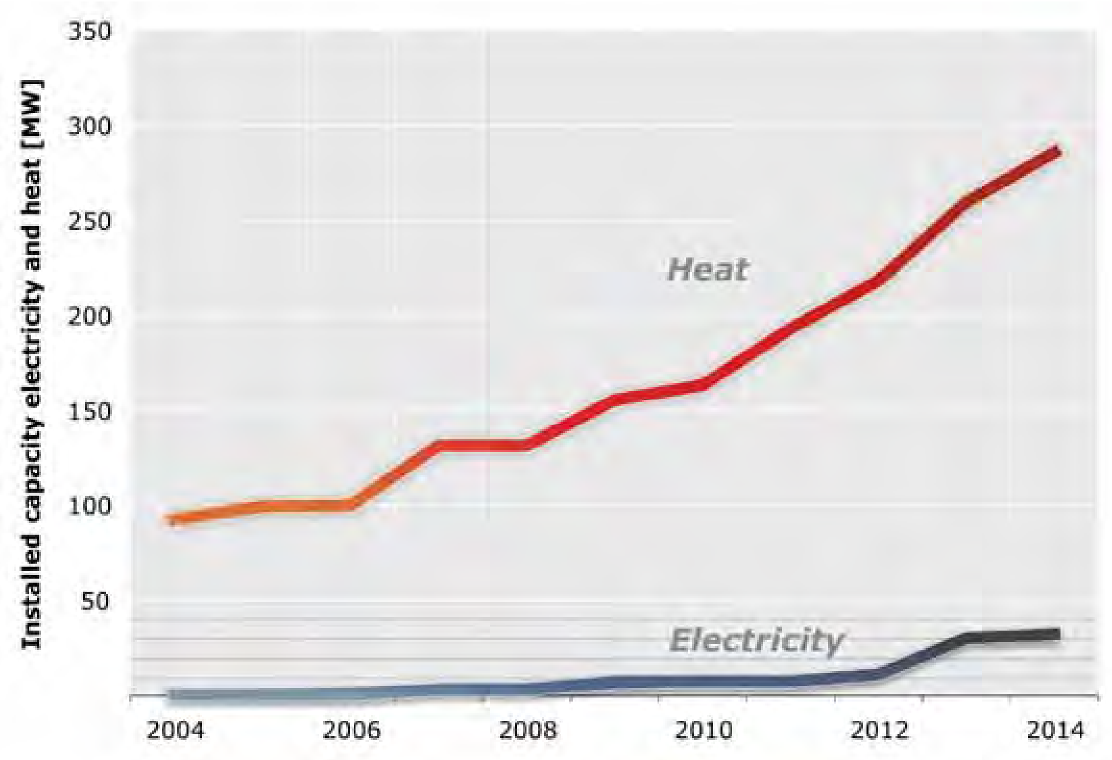

Figure 10: Installed capacities for heat and power generation (MW) from deep geothermal energy projects in Germany from 2004 to 2014 (data: GeotIS, accessed 21.10.2015).

Despite the successful expansion of geothermal energy in Germany to date, there have also been set-backs. The cogeneration heat-and-power plant in Landau for instance had to be shut down in March 2014 because of surface uplift around the site. The surface uplift was attributed to the leakage of deep water into clay horizons located at a depth of 500 metres in the vicinity of the injection well. Ground movements of this kind, as well as induced seismicity or groundwater pollution as a result of geothermal activities, have been discussed in connection with the use of geothermal energy, and as potential risks, have a negative impact on public trust in this technology. Together with the debate concerning hydraulic stimulation, this could make the further expansion of deep geothermal energy exploitation more difficult, particularly enhanced geothermal systems (EGS) in Germany. Petrothermal reservoirs of this kind can only be exploited after first being hydraulically stimulated.

For 2020, the German government's national action plan for renewables targetted an installed capacity of 298 MW, with 1,654 GWh for power production, initially on the basis of hydrothermal plants, and later with the addition of hot-dry-rock plants (EGS). As part of the German government's energy research programme, 51 geothermal energy projects were funded in 2014 (BMWi 2015b). The total investment in these projects exceeds Euro 81 million for the whole planned duration (start of the projects between 2008 and 2014, end of the projects from 2014 to 2018). Of this, Euro 8.2 million was invested in projects starting up in 2014. The subsidies go to universities, scientific institutes, authorities and industry doing research on every phase involved, from planning to operation, as well as overriding issues.

Deep geothermal energy has the capacity to provide baseload electricity, can provide power on demand, and is classified as a renewable energy source because it is considered virtually inexhaustible to all extents and purposes. Geothermal energy is made up of the original heat from when the earth was formed, and the heat generated in the interior of the earth by the decay of the naturally occurring radioactive isotopes. The amount of heat which originates in the crust per year and radiates into space is much higher than global energy demand. Solar radiation only gives rise to temperature increases in the uppermost tens of metres in the earth's crust depending on the location, and is only relevant for shallow geothermal energy projects.

A differentiation is generally made between shallow geothermal energy down to approximately 400 m depth (in some cases only down to 150 m) and deep geothermal energy from 400 m downwards (and from 1,000 m downwards in the more strict sense). Both zones are used for producing heat, but only deeper zones can be used geothermally for the production of electrical power because of the higher temperatures required. Although shallow geothermal energy currently represents the largest portion of geothermal energy utilisation, accounting for almost two thirds of the capacity, this study looks exclusively at deep geothermal energy because its energy exclusively comes from the interior of the earth.

There are two different reservoir types for the utilisation of deep geothermal energy: stored heat energy in natural deep thermal water-bearing horizons (hydrothermal), and heat energy stored in solid rocks (petrothermal). In practical terms, this means that petrothermal reservoirs can only be harnessed after undertaking stimulation measures.

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3 ENERGY RESOURCES WORLD-WIDE

The reliable and uninterrupted supply of energy is an essential prerequisite for the proper functioning of today's modern societies. The demand for energy world-wide has been growing almost continuously for decades as a result (Fig. 11). And energy demand will continue to grow in the long term as well, as a consequence of the growth in the global population, and the rise in overall living standards.

Despite continuing shifts in the global energy mix, only a limited number of energy sources are involved in supplying today's energy requirements. And when looked at in the scale of coming decades, hardly any significant changes are expected – with the exception of a growing proportion of renewables – which means that the dominance of non-renewable energy sources, including nuclear power, will continue in the long term as well.

Following a review of the global reserves situation, this report will then look at the resources, reserves, production, consumption and important developments of each of the energy sources.

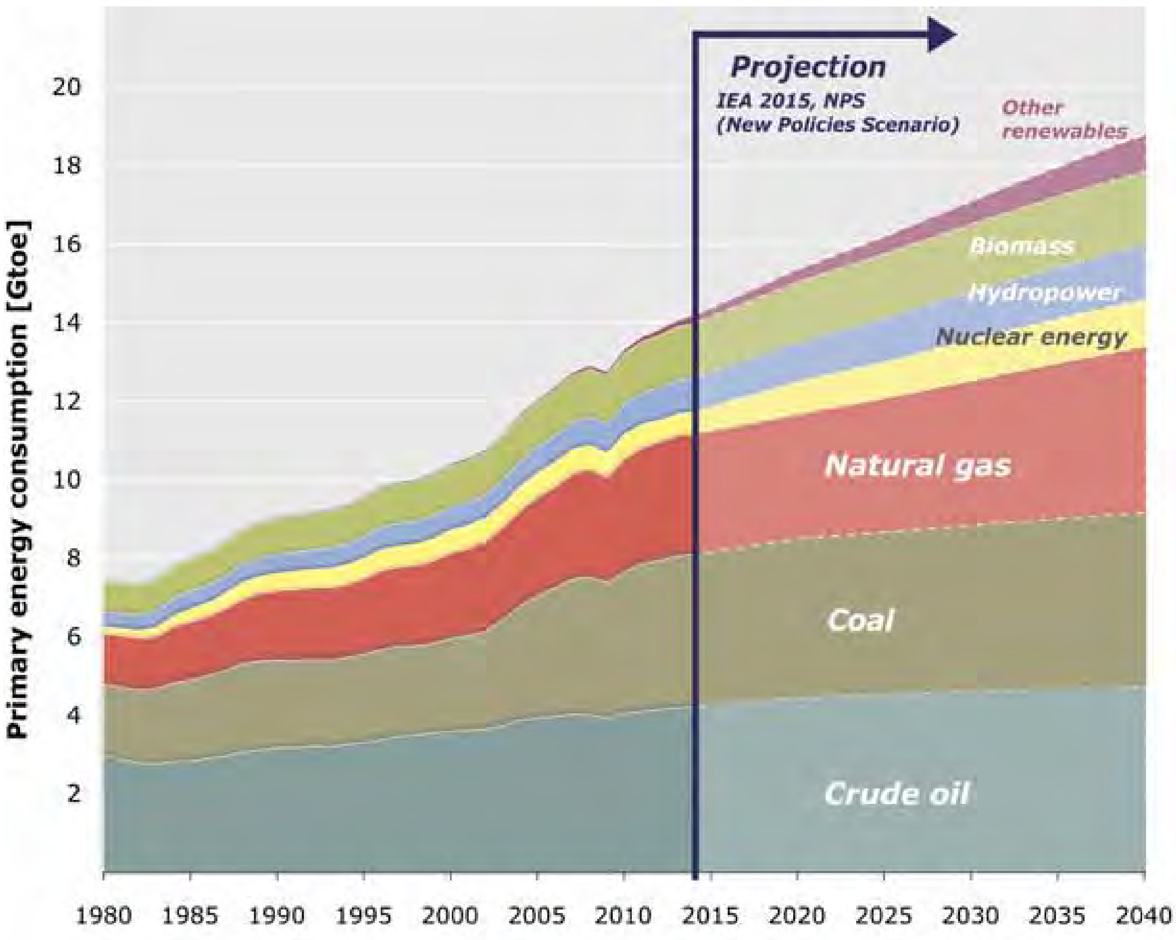

Figure 11: Development in global primary energy consumption per energy source, and a possible scenario for future developments (New Policies Scenario, IEA 2015).

3.1 Global inventory situation

Table 1 shows all of the known global potential for fossil energy resources including nuclear fuels. The figures shown in the table are from the total of the country data which are listed separately in Tables 16 to 50 in the Appendix. The table also incorporates information on the resources of oil shale, aquifer gas, natural gas from gas hydrates, and thorium, because their amounts cannot be broken down on a country by country basis. Despite the continuing presence of gaps in the data, they still show the potential of non-conventional energy resources as far as possible. These include the resources and reserves of extra heavy oil, crude oil from tight rocks (tight oil) and bitumen (oil sands), as well as tight gas, shale gas and coal bed methane. This study pursues a conservative approach overall and places a high priority on the potential economic extractability of energy resources as a vital criterion. Accordingly, so-called in-place amounts – enormous volumes, but from today's point of view, not even producible in the long term – are not listed as a matter of course in the inventories, or are only done so together with additional explanations. The resources of aquifer gas and natural gas from gas hydrates therefore appear relatively low in this table.

The largest proportion of the non-renewable global energy resources, accounting for 551,813 EJ, is defined as resources, and exceeds the reserves by a factor of 15. This applies to all energy resources with the exception of conventional crude oil. In total, the resources grew by only a minimal degree of 0.3 % compared to the previous year (BGR 2014). The main increases in resources are associated with shale oil (plus 15 %) and shale gas (plus 4 %), because a number of countries have produced estimates for the first time (cf. Chapter 3.2 and 3.3). All of the other changes were below 3 %. In the comparison of all energy resources, coal (hard coal and lignite) continues to dominate with a share of around 89 % (Fig. 12). This is followed well down in second place by natural gas resources accounting for 5.9 %, which is dominated by the share of non-conventional deposits. The other energy sources, including crude oil (3.3 %), only play a subordinate role with respect to the energy content of the resources. There are therefore only very minor changes compared to the previous year.

The energy content of the reserves in 2014 totalled 37,934 EJ, and has therefore risen by a very minor amount (plus 0.77 %) compared to the previous year. The only significant change was in shale gas reserves (plus 37 %) because of the updating of the database (now as at 2013) in the USA. All of the other changes were below 2 %. In terms of energy content, coal, which accounts for 54.4 % of the reserves, continues to be the dominant energy resource. Crude oil (conventional and non-conventional) accounts for 24.1 % of the total reserves, natural gas 19.8 %, and uranium 1.6 %. This means that the relative proportions of all energy sources have only changed minimally compared to the previous year. The volume of crude oil produced during the year was completely compensated for by transferring resources to reserves, whilst the produced volumes of natural gas were almost completely compensated for by the same process. The comparatively high proportion of crude oil in the reserves is attributable to the intense exploration and production activities invested in this energy resource over a period of many decades.

Non-renewable energy resources with an energy content of around 522 EJ were produced in 2014. This corresponds to a slight increase in production of around 1.35 % year-on-year. There were no significant changes in the individual proportions in the production mix with respect to energy content (Fig. 12). Crude oil (33.9 %) continues to be the most important natural resource, followed closely by coal (33.4 %) and then natural gas (24.5 %), uranium (1.9 %) and lignite (1.9 %).

Table 1: Reserves and resources of non-renewable energy resources

Fuel	Unit	Reserves (cf. left column)	EJ	Resources (cf. left column)	EJ
Conventional crude oil	Gt	171	7,144	163	6,815
Conventional natural gas	Tcm	191	7,260	320	12,162
Conventional hydrocarbons [total]	Gtoe	344	14,404	454	18,977
Oil sand	Gt	26	1,105	63	2,613
Extra heavy oil	Gt	21	886	61	2,541
Shale oil	Gt	< 0.5	< 14	57	2,377
Oil shale	Gt	–	–	102	4,248
Non–conventional oil [total]	Gtoe	48	2,005	282	11,779
Shale gas	Tcm	5.0 [1]	190 [1]	215	8,189
Tight gas	Tcm	– [2]	– [2]	63	2,385
Coal-bed methane	Tcm	1.8	68	52	1,963
Aquifer gas	Tcm	–	–	24	912
Gas hydrates	Tcm	–	–	184	6,992
Non–conventional gas [total]	Tcm	6.8	258	538	20,441
Non–conventional hydrocarbons [total]	Gtoe	54	2,263	770	32,221
Hydrocarbons [total]	Gtoe	399	16,667	1,224	51,198
Hard coal	Gtoe	593	17,391	14,970	438,729
Lignite	Gtoe	112	3,270	1,774	51,987
Coal [total]	Gtoe	705	20,661	16,743	490,716
Fossil fuels [total]	–	–	37,328	–	541,914
Uranium [3]	Mt	1.2 [5]	607 [5]	13 [6]	6,722 [6]
Thorium [4]	Mt	–	–	6,4	3,178
Nuclear fuels [total]	–	–	607	–	9,899
Non-renewable fuels [total]	–	–	37,934	–	551,813

– no reserves or resources

[1] partly status 2013

[2] included in conventional natural gas reserves

[3] 1 t U = 14,000 - 23,000 tce, lower value used or 1 t U = 0.5 x 10^{15} J

[4] 1 t Th assumed to have the same tce-value as for 1 t U

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

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

Fossil fuels continue to dominate the global energy mix overall, i.e. the actually consumed energy. Although there is a certain lack of precision due to storage activities amongst others, the shares largely correspond to the production. Of the renewables, only traditional hydroelectric power can make a significant contribution here overall. The other renewables – windpower, geothermal energy, solar power, biomass – and thermal waste recovery have a global share of only 2.5 % (BP 2015).

When the reserves (37,934 EJ) are added to the resources (551,813 EJ), all of the fossil energy sources world-wide have a total energy availability of 589,747 EJ. A comparison between the global annual production and the reserves and resources gives a ratio of 1 to 73 and 1 to 1,050 respectively (Fig. 12). According to today's information, there are therefore still enormous amounts of fossil energy available, which, from a geological point of view, could be used in principle to cover the future rise in energy demand as well. It is not possible to say now whether all energy resources specifically can always be made available in adequate quantities in future whenever they are required. This challenge applies in particular to crude oil because of the relatively low resources. Whether and when, which energy source can be used in a particular way depends amongst other things on the level of geological exploration, the technical and economic exploitability, and therefore, the demand-oriented availability. In the light of the largely uninterrupted and adequate supplies of energy resources enjoyed for many years, questions are now being increasingly raised concerning their sustainability and environmental-compatibility, as well as public acceptance.

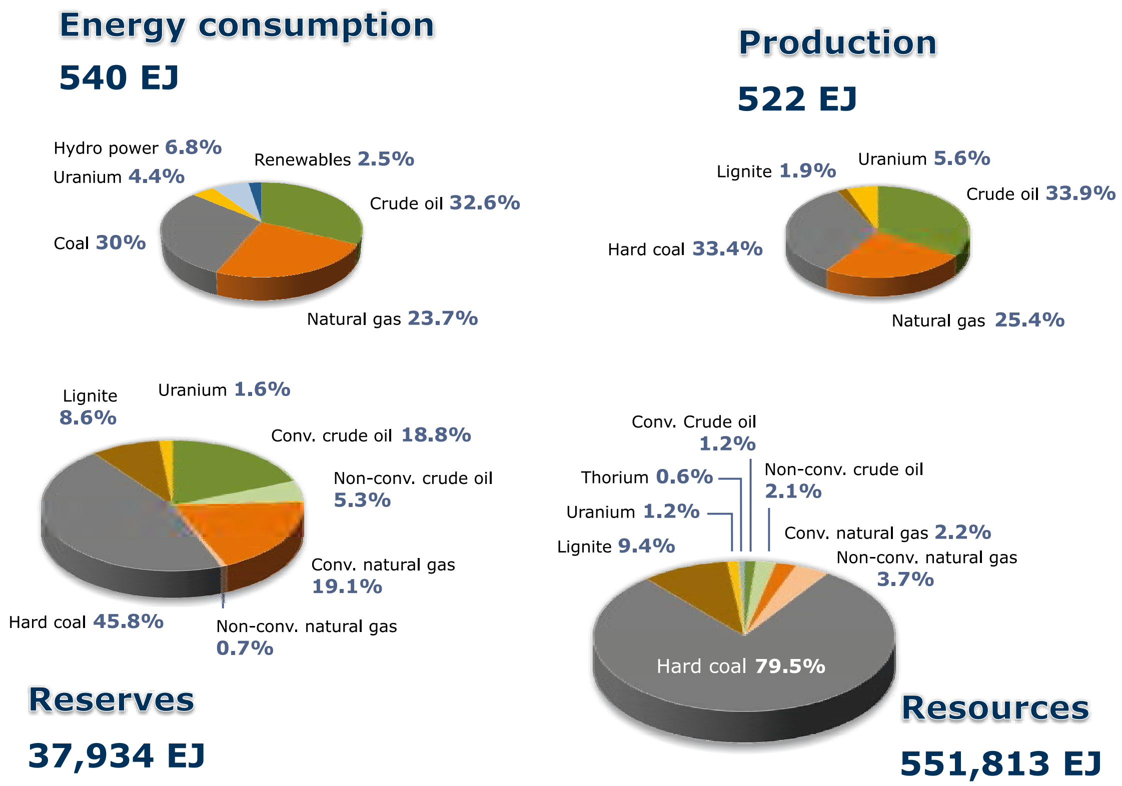

Figure 12: Global consumption shares of all energy sources (BP 2015), as well as the production, reserves and resources of non-renewable energy resources only at the end of 2014.

3.2 Crude oil

The most important energy source world-wide continues to be crude oil with a share of around 32 % of global primary energy consumption. Global oil production rose by only 1 %, to reach a new all-time high of 4,240 million t (2013: 4,204 million t). There were no major changes in either reserves or production in 2014. However, there are signs that there will be significant changes in 2015.

The resources (conventional and non-conventional) rose by around 2.8 % year-on-year to over 343 billion t (Fig. 13). The largest increases in conventional resources are reported for Norway, India, the United Kingdom and Peru. Estimates of tight oil resources (non-conventional) are available for the first time for Kazakhstan, Iraq, the United Arab Emirates, Chad and Oman. This led to an increase in non-conventional resources (bitumen, extra heavy oil, tight oil) of almost 8 billion t to give a total of over 180 billion t. The estimates for oil shale resources remain unchanged compared to the previous year and are in the order of 102 billion t of crude oil.

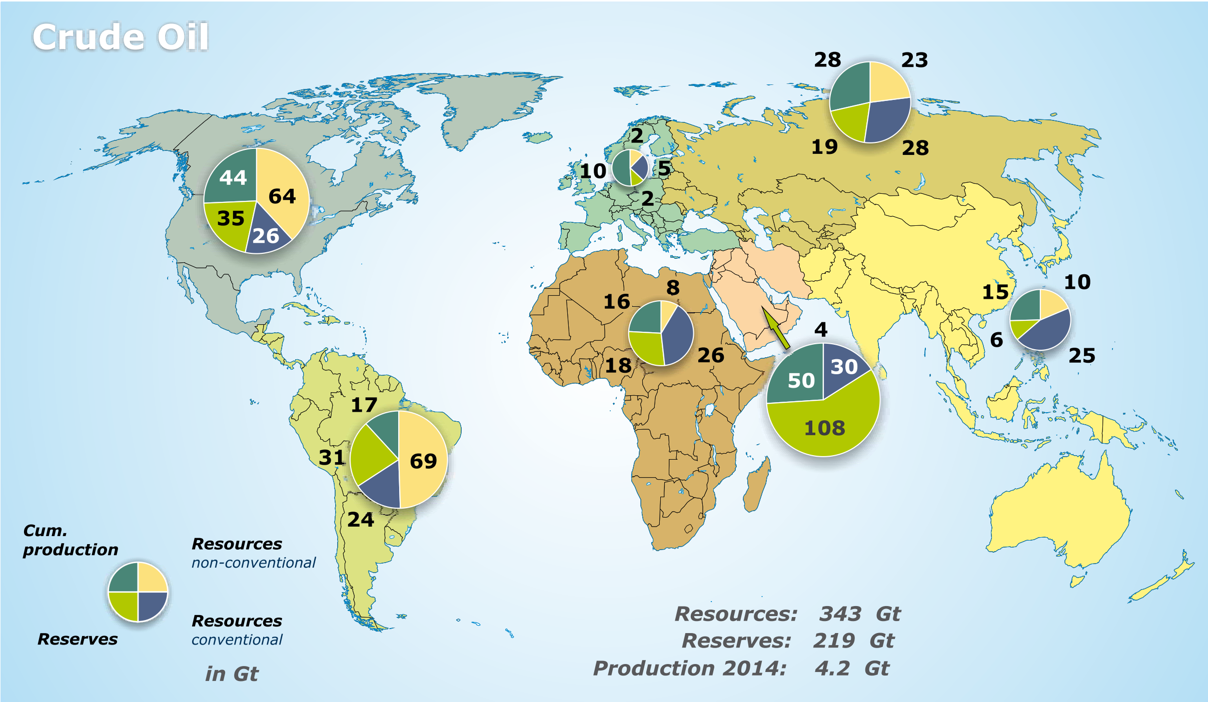

Figure 13: Total crude oil potential 2014 (excluding oil shale): regional distribution.

The total global crude oil reserves from conventional and non-conventional deposits have changed only marginally by 0.1 % (291 million t) to 218.9 billion t. There have also been no significant changes in the ranking of the most important reserves countries. As in the past, the list of countries with the largest reserves is led by Saudi Arabia, followed by Canada and Venezuela. Because of a slight rise in conventional reserves, the USA is now ahead of Libya. The reserves situation regarding non-conventional crude oil remains unchanged with the exception of the oil sands reserves in Canada, which have been reduced by the amount produced during the year. The 20 leading countries account for around 95 % of the crude oil reserves, whilst the remaining 5 % of the reserves are spread amongst 83 countries. The five most important countries – Saudi-Arabia, Canada, Venezuela, Iran and Iraq – account for around 60 % of the reserves. All of the OPEC member countries are amongst the 20 leading countries, and account for almost 70 % of global reserves. The share of crude oil reserves from non-conventional fields accounts for around 22 % of the total reserves. Around 54 % of global reserves lie in a region stretching from North Africa to the Middle East – the so-called MENA region – which highlights the strategic significance of this region for the availability and supply of crude oil. Europe’s share of the global reserves is only around one per cent. From the beginning of industrial crude oil production to the end of 2014, around 179 billion t of crude oil have been produced world-wide, and therefore 45 % of the original reserves (cumulative production plus reserves) of 398 billion t. Only around 20 % of global crude oil reserves are owned by private oil companies, whilst the remaining 80 % are controlled by state-owned companies (IEA 2013).

Crude oil production only rose year-on-year by 36.5 million tonnes to over 4,240 million t. This is one of the lowest rises in the recent past (Tab. 19 in the Appendix). As in the past, the most important production regions are in the Middle East, North America and the CIS countries. Almost 68 % of global crude oil production comes from these regions. The European region and OPEC supplied around 4 % and over 40 % of the global crude oil production, respectively.

Saudi-Arabia, Russia and the USA, the three countries with the highest production levels, were able to increase their production further. Crude oil production in the USA was boosted primarily by the growth in shale oil (crude oil from tight rocks), with overall growth in production of more than 7 %. A further rise as high as this is unlikely, however, because shale oil/tight oil production activities were strongly curtailed during 2015 because of the low crude oil prices. Of the OPEC member countries, only Saudi-Arabia (plus 1.2 %), Iraq (plus 5 %) and Nigeria (plus 1.8 %) were able to significantly increase their production rates. OPEC production overall declined by 1.6 %. Canada (ranked no. 5) was able to boost its crude oil production by around 8 % thanks to the massive expansion of its oil sands and tight oil production. Iran on the other hand (position no. 6) suffered a decline in production of around 5 % as a result of international sanctions. Increases in production were also achieved in Brazil (plus 12.9 %) as well as in Norway (plus 3.2 %), the only country in Europe with a production rise. In the United Kingdom (position no. 23), production rates tailed off slightly by around 2.7 %. Because of the ongoing unrest, production in Libya (position no. 29), which is one of Germany’s more important supply countries, declined by 43 % to only 27 million t. Before the situation in the country became precarious in 2010, Libya produced almost 74 million tonnes a year. Production in Syria (1.5 million t) shrunk considerably by more than 90 % compared to 2010 (19.4 million t).

Compared to the previous year, the global consumption of mineral oil products rose further by 1.8 % to 4,305 million t. The CIS countries, Africa, Middle East, North America and Latin America increased their consumption the most with rises of between almost three and five percentage points. Declines in consumption were only reported in Europe, where it dropped by 0.6 % to 657.5 million t. Almost half of the mineral oil is consumed by OECD countries, led by the USA which accounts for 20 %. The 20 largest consumer countries used around 75 % of the mineral oil available in 2014.

Crude oil is largely traded across borders in pipelines or in oil tankers. The amount of crude oil traded world-wide declined slightly compared to the previous year, although the export of mineral oil products cannot be taken into consideration in the crude oil export figures. Exports declined by 2.5 % to 2,039 million t. The strongest exporting regions are the Middle East, CIS countries and Africa. Although Saudi-Arabia reduced its crude oil exports by around 8 %, it was able to increase its production rate significantly by 1.2 %. However, there was also a strong rise in mineral oil consumption (11 %). In addition, there was also an expansion in refinery capacities during the course of the year by around 40 million t. Because of international sanctions, Russia suffered a decline in exports of almost 6 %. Canada and Iraq were able to increase their exports by 10 % and 5 %, respectively. Libya's exports collapsed from almost 100 million t in 2013 to 2 million t in 2014 because of the significant decline in the production rate. Crude oil exports from the USA, which require special permits, rose by a factor of almost three to 17.5 million t. Around 70 % of the total export amounts were accounted for by the 10 most important exporting countries (Tab. 21 in the Appendix).

In the case of crude oil imports, the traded volumes declined by around 1 % to 2,109 million t. The largest importers continue to be Austral-Asia, Europe and North America. Imports of crude oil to Africa in 2014 declined by 6 million t (minus 37 %). Despite a further rise in domestic crude oil production from tight oil deposits, the USA maintained its position as the leading crude oil importing country (minus 4.7 %). In second place, China increased its imports by around 11 %. Although its imports were further reduced by around 1 % to 89.4 million t, Germany is still the 6th largest crude oil importing country in the world.

The annual average price for the "Brent" crude oil reference type dropped significantly year-on-year by 9.72 USD/bbl to 98.97 USD/bbl. Whilst the price stayed at around the previous year's level of about 110 USD/bbl in the first half of the year, it halved during the course of the rest of the year to end 2014 at 55.3 USD/bbl. In the middle of January and at the end of August 2015, the price of crude oil bottomed out at 45.10 USD/bbl and 42.10 USD/bbl respectively. In the third quarter 2015, the price of Brent crude fluctuated around the 50 USD/bbl level. The average price of the US-American reference type "West Texas Intermediate" (WTI) declined from 97.92 USD/bbl in 2013 to 93.17 USD/bbl in 2014. Here as well, the price collapsed from a level of around 102 USD/bbl during the first half of the year to 53.50 USD/bbl by the end of the year. The difference in price between Brent and WTI in February 2014 was over 15 USD at times, but reached almost parity by the end of the year with a difference of between 1 to 2 USD. The OPEC basket price as well (average price of selected OPEC crude oil types) matched the price trends of the other reference types. The annual average price was down 9.58 USD/bbl on the previous year's price, averaging 96.29 USD/bbl in 2014.

Tables 16 to 22 in the Appendix summarise the country-specific resources, reserves, production levels and consumption, as well as crude oil exports and imports (for the 20 most important countries in each case).

Development in crude oil production according to regions and "types"

The significance of crude oil as the most important product traded world-wide, and the basis for our modern economic systems, remains unbroken. The global production of crude oil grew further in 2014 as well, to reach a new record (Fig. 14). There is therefore basically no identifiable change in the fundamental trend with respect to the use of crude oil and the production curve.

Crude oil production around the world grew strongly at the end of the 2nd world war when the USA was the largest crude oil producing country. The global crude oil market was still dominated by private international oil companies during this period. However, shortly after its establishment in 1960, OPEC became the most important crude oil producer, and still retains this position today. The influence of this organisation on global crude oil production was highlighted in particular during the two oil crises in 1973/74 and 1979/80 when OPEC cut back its production. The former Soviet Union began a considerable expansion in its oil production in the early 1960s. After the break-up of the Soviet Union, production – now from the CIS countries – declined over a long period of time before starting to recover at the beginning of the 2000s, a trend which has continued until today. From the 1980's onwards, global oil production diversified to more and more countries, reservoir types and production technologies, and has risen almost continually until today in parallel to the increase in globalisation. Advances in technology enabled the large-scale and economically successful development of crude oil from tight reservoir rocks in the USA. As a result, the USA has considerably expanded its production since 2008, to again come close in 2014 to its previous record production levels achieved in 1970.

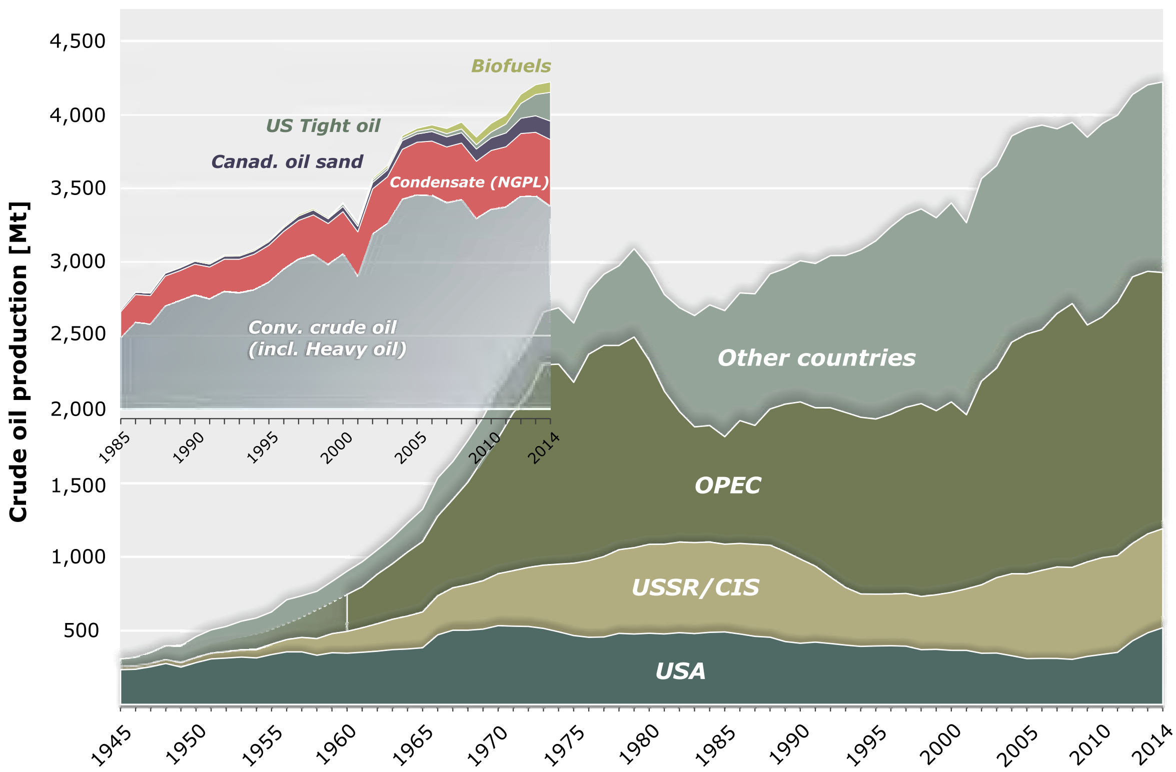

Figure 14: Development of global crude oil production from 1945 to 2014, also showing the shares of each type of liquid hydrocarbon (excluding coal liquefaction production) from 1985 (see box).

Since the beginning of crude oil production until today, conventional crude oil (including extra heavy oil) has easily accounted for the largest proportion of the global supply of crude oil and crude oil products (Fig. 14). However, there has only been minor growth in recent years. The second largest contributor to the production of liquid hydrocarbons is condensate (natural gas liquids, NGL) which is produced alongside gas in natural gas producing areas. The size of condensate production has grown alongside the almost completely unbroken growth in global natural gas production enjoyed over the last five decades. The Canadian production of crude oil from oil sands as well demonstrates a long history and a growth in production levels for many years. The expansion in the global production of liquid hydrocarbons in recent years is primarily attributable to the growth in the production of crude oil from tight rocks (shale oil, tight oil), and bio fuels.

In BGR's opinion, a moderate increase in the global production of liquid hydrocarbons is possible in the next few years under the current geological and technological conditions. A rise in the production of conventional crude oil is also possible because of the potential which has been unexploited so far in the Middle East region, and particularly in Iraq and Iran. There could also be increases in the production of condensate, non-conventional crude oil, and as a result of advances in technology. And new discoveries in frontier regions in particular will also continue to make a contribution to the supply situation. Despite the production potential still available, and notwithstanding the temporary oversupply situation[2], there is still a question concerning how long the high demand, and in some parts of the world still foreseeable growth in demand, can be adequately satisfied, because the depletion of crude oil has gone farther than any of the other energy resources (BGR 2009).

3.3 Natural gas

With a share of 23.7 % (BP 2015), natural gas retained its position behind crude oil and coal as the third most important energy source in 2014 as well. The 1.4 % rise in global natural gas consumption was similar to that in 2013, and was therefore again below the historic ten-year average of 2.6 %. The high forecasts for growth predicted for natural gas for many years now have therefore failed to materialise.

The highest natural gas resources by far (conventional and non-conventional) are located in Russia, followed by China, USA, Canada and Australia. With a share of more than one third, Russia also has the largest conventional natural gas resources in the world, ahead of the USA, China, Saudi-Arabia and Turkmenistan. The global natural gas resources of commercially exploited conventional and non-conventional deposits are estimated as totalling 650 trillion m³ (previous year 638 trillion m³) (Fig. 15). This increase is largely attributable to a reassessment of the shale gas resources in Kazakhstan, Oman, Chad, and the United Arab Emirates.

When aquifer gas and natural gas from gas hydrates are included, global resources are thought to be around 858 trillion m³ (Tab. 1). Of the already developed non-conventional natural gas resources, shale gas resources dominate world-wide with around 215 trillion m³ (previous year: 206 trillion m³), followed by tight gas and CBM (Tab. 1). Reliable country-specific estimates of natural gas in tight sandstones and carbonates (tight gas) are only patchily available, which means that the global potential of 63 trillion m³ is a significant underestimation.

2 at the date the study was published

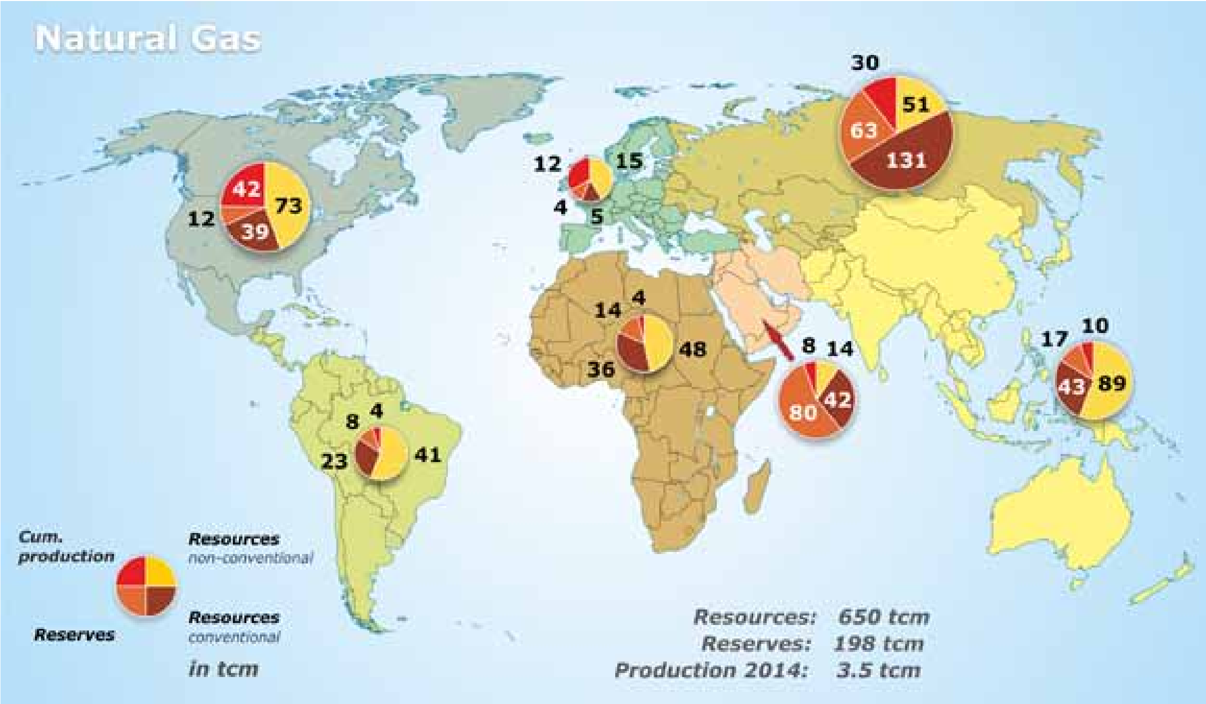

Figure 15: Total natural gas potential 2014 (excluding aquifer gas and gas hydrates): regional distribution.

It can generally be assumed that tight gas is present in most basins with natural gas potential, and in particular in Palaeozoic horizons. The information on the resources of aquifer gas and natural gas from gas hydrates is primarily only in the form of global estimates, with very few detailed regional studies. According to the information available today, there are 24 trillion m³ of natural gas in aquifers and 184 trillion m³ natural gas in gas hydrates in the world (Tab. 1). It is unclear at the moment whether and when this potential can be commercially utilised. In the case of gas hydrates in particular, countries with small domestic potential for conventional energy resources, such as Japan, are pushing ahead with ambitious projects to develop domestic gas hydrate deposits within their 200-mile zones (exclusive economic zones) as potential energy sources.

Compared to the previous year, global natural gas reserves only declined by 0.1 % in 2014 (minus 210 billion m³), and are therefore estimated at the end of 2014 to again be around 198 trillion m³. If the figures are adjusted, however, for the annual production of 3,486 billion m³, there has been an overall increase in global reserves. At a global scale, the share of non-conventional reserves is currently still small, and will probably remain so for the foreseeable future. However, tight gas reserves are usually not reported separately, which means that a more precise estimate of the size of these reserves is not possible as part of a global study. Significant shale gas reserves are primarily reported in the USA, where they were estimated at 4.5 trillion m³ at the end of 2013, and now make up a share of 46 % of the total reserves in the country. Over half of the global natural gas reserves (around 54 %) are located in only three countries – Russia, Iran and Qatar (Fig. 16). Around 80 % of the global reserves are in OPEC and CIS countries.

A slight rise in global natural gas production in 2014 of 63 billion m³ (plus 1.8 %) to 3,484 billion m³, is largely attributable to the further growth in demand in the Middle East, Austral-Asia, Africa

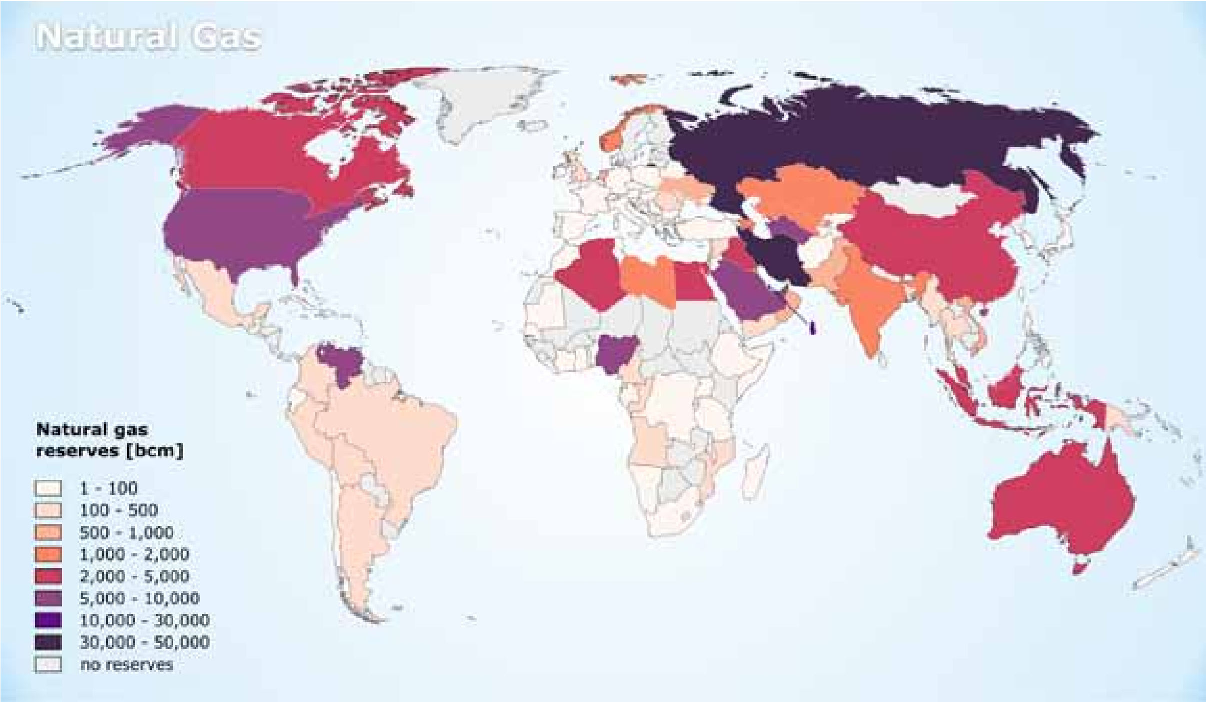

Figure 16: Global distribution of natural gas reserves (conventional and non-conventional).

and North America. The increase was therefore again below the ten-year average of 2.6 %, but managed to exceed the previous year's level of around 1 %. From a regional point of view, the largest percentage growth in production levels was in North America (5.3 %), followed by Austral-Asia (4.6 %) and the Middle East with a rise of 3.7 %. The European Union in contrast suffered a significant decline: production here dropped by 11.7 %, primarily because of the throttling back of production in the huge Groningen natural gas field in the Netherlands. This was in response to earthquakes resulting from decades of natural gas production. More than 1000 earthquakes had been registered since the middle of the 1980s, the largest of which had a magnitude of 3.6 on the Richter scale. More than 2 trillion m^3 of natural gas has been produced from the Groningen field so far. It still contains at least 700 billion m^3 of low-calorie natural gas (L-gas), which means it could remain in production for several decades to come. The field has been used for a long time now as a swing producer, and was able to balance out the high seasonal consumption fluctuations in northern Europe. With the decline in production from Groningen, Germany must now develop alternatives for the significant decline in the supply of L-gas in the affected regions.

The USA continues to be the world's largest natural gas producer ahead of Russia and Iran (Tab. 26 in the Appendix). With a rise of 6 %, growth in the USA was much higher even than in the previous year, and is a consequence of the increase in shale gas production. The low oil prices led to a shift in activities from liquid-rich fields to more gas-oriented fields. Despite the still relatively low prices (Henry Hub annual average 4.35 USD/million BTU), the US produced more gas in 2014 than ever before. Production was thus around 18 % higher than the peak achieved by conventional natural gas production at the beginning of the 1970s. The USA was able to cover around 95 % of its growing natural gas demand from domestic production in 2014. The Sabine Pass LNG export terminal in Texas will be commissioned at the beginning of 2016 to enable the USA to export liquefied natural gas from shale gas production for the first time.

The international sanctions and the decline in the price of oil were the main reasons why natural gas production in Russia declined by 2.8 %. The largest volumetric declines were therefore reported by Russia, and the Netherlands where the production also declined by around 18 billion m^3. Iran (plus 8.5 %) expanded its natural gas production considerably, as did China, which produced slightly more than 11 % more natural gas than in the previous year. The production includes 1.3 billion m^3 shale gas and around 4.5 billion m^3 coal mine methane. Turkmenistan was able to significantly boost its production (plus 11.2 %), because of the continuing development of the world's second largest natural gas field, Galkynysh. Indonesia, one of the world's largest exporters of liquefied natural gas, was able to boost its production by 2 % after reporting declines since 2012. Russia and the USA together again produced slightly more than 1.3 trillion m^3 in 2014. This corresponds to around 38 % of global natural gas production.

Global natural gas consumption rose in 2014 by around 1.4 % (previous year 1.3 %) or 49 billion m^3, to 3,483 billion m^3. Growth was therefore very similar to the previous year. The biggest natural gas consumers world-wide by far were the USA, followed by Russia, China, Iran and Japan. Natural gas demand in the EU declined in double figure percentage terms in a number of countries and was down overall by 10 % compared to the previous year. In terms of volumes, natural gas consumption dropped significantly by 46 billion m^3, of which around three quarters was attributable to the mild winter. In CIS countries, natural gas consumption declined by 1.5 % (9.4 billion m^3). Consumption rose in all of the other regions around the world. China's natural gas needs again grew by double figures in percentage terms (14.2 % compared to 13.8 % the previous year).There was also high growth in demand in the Middle East (plus 6.8 %) and particularly here in Iran, Israel and Qatar.

Japan imported slightly more than 115 billion m^3 natural gas in 2014, and was therefore the second largest consumer in Asia, behind China. Japan retained its status as the world's largest importer of liquefied natural gas, which was derived from many countries. Almost two thirds was imported from Australia, Qatar, Malaysia and Russia. Malaysia is the world's second largest exporter of LNG, although well behind Qatar.

Around 1,012 billion m^3 natural gas and therefore 29 % of all of the natural gas produced world-wide, was traded across borders in 2014 (excluding transit trade). Overall, global trade in natural gas declined year-on-year. The global trade in LNG, however, has risen at the expense of gas transported by pipelines, which declined by more than 6 %. Almost 30 % of the global LNG trade took place on spot markets or via short-term supply contracts, and primarily in the Asia-Pacific region.

There are supra-regional natural gas markets around the world which still largely operate independently of one another. Because of the large quantities which are still available, natural gas was comparatively cheap in the USA. The average natural gas price here in 2014 (Henry Hub spot price) was 4.35 USD/million BTU (previous year 3.7 USD/million BTU). Natural gas in Germany costs almost twice as much on average, while the prices for LNG imported by Japan were on average up to four times the prices in the USA. However, the prices in Asia have recently dropped down towards European levels thanks to the weak demand and the additional supplies in the region.

In general, the natural gas price is primarily influenced by the much higher specific transport costs compared to crude oil and coal.

With its expanding supply grid, Europe is connected to a large proportion of the global natural gas reserves, either via pipelines, or LNG terminals. This means that the European natural gas market is in a relatively comfortable position in principle, even though geopolitical risks are still a key factor governing natural gas supplies.

Tables 23 to 29 in the Appendix are a compilation of country-specific production, consumption, imports and exports, as well as the reserves and resources of natural gas.

3.4 Coal

Of all of the fossil energy resources, coal is the energy resource with the largest global reserves and resources by far. With a share of 30 % (hard coal 28.4 %, lignite 1.6 %) of global PEC, coal was the second most important energy source in 2014 behind crude oil (after BP 2015). 40.4 % of global power generation was fuelled by coal in 2013, the largest share of any energy source (IEA 2015a).

Total coal resources (reserves plus resources) increased slightly compared to the previous year. The proven coal reserves at the end of 2014 were 985 Gt, comprising 699 Gt hard coal (plus 1.5 %) and 286 Gt lignite (plus 2.2 %). The increase in lignite reserves is attributable to additional geological information and the associated re-evaluations, particularly in Turkey (after Edigera et al. 2014, TKI 2015). Coal resources rose slightly to 22,132 Gt (plus 0.2 %), due to exploration activity as well as re-evaluations.

Global coal production declined slightly year-on-year for the first time in the new millennium, and totalled around 8,176 Mt in 2014. This corresponds to a decline of 1 % compared to the previous year. Of this production, 7,153 Mt (minus 0.8 %) was accounted for by hard coal, and 1,023 Mt (minus 2.9 %) by lignite

Unlike conventional crude oil and natural gas, coal deposits and their production are spread amongst many countries and companies. Tables 30 to 41 in the Appendix are a compilation of country-specific production, consumption, imports and exports, as well as the reserves and resources of hard coal and lignite.

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. Because of the relatively high energy content, hard coal is cheaper to transport and is traded world-wide. Lignite on the other hand (energy content < 16,500 kJ/kg) is primarily used close to the deposits because of the lower energy and higher water contents, and is mostly used to generate electricity

Hard coal

Figure 17 shows the regional distribution of hard coal reserves, resources and the estimated cumulative production since 1950. The world's largest total resources of hard coal is in the Austral-Asian region with 7,521 Gt, followed by North America with 6,872 Gt and CIS with around 3,003 Gt. The USA has the world's largest hard coal reserves with 223 Gt (31.9 % global share). The People's Republic of China follows with around 124 Gt (17.8 %), followed by India with around 86 Gt (12.2 %). These countries are followed by Russia (10 %), Australia (8.9 %) and the Ukraine (4.6 %). The subsidised producible volumes (reserves) of hard coal in Germany up to the end of 2018 total around 0.02 Gt hard coal. In terms of resources, the USA alone with 6,458 Gt has 36.5 % of the global hard coal resources, followed by China (30.1%) and Russia (15 %).

The three largest hard coal producers in 2014 were China with a share of 52.1 % (3,725 Mt), the USA (11.7 %) and India (8.6 %). Whilst India and the USA were able to increase their production by 8.3 % (India) and 1.4 % (USA), production in China declined (minus 2.6 %). With only 106 Mt, the European Union (EU-28) currently only has a share of 1.5 % of global hard coal production.

With a volume of 1,340 Mt, around 19 % of the hard coal produced world-wide was traded, of which 1,187 Mt was transported by sea (VdKi 2015a). The global volume of traded hard coal was therefore at around the same level as the previous year. Indonesia dominated the global hard coal market with exports totalling 408 Mt (30.5 %), followed by Australia (28.9 %) and Russia (11.3 %).

The highest levels of hard coal imports went to China, Japan and India, with a total volume of around 694 Mt (52 %). Imports to China declined in 2014 compared to the previous year (327 Mt),

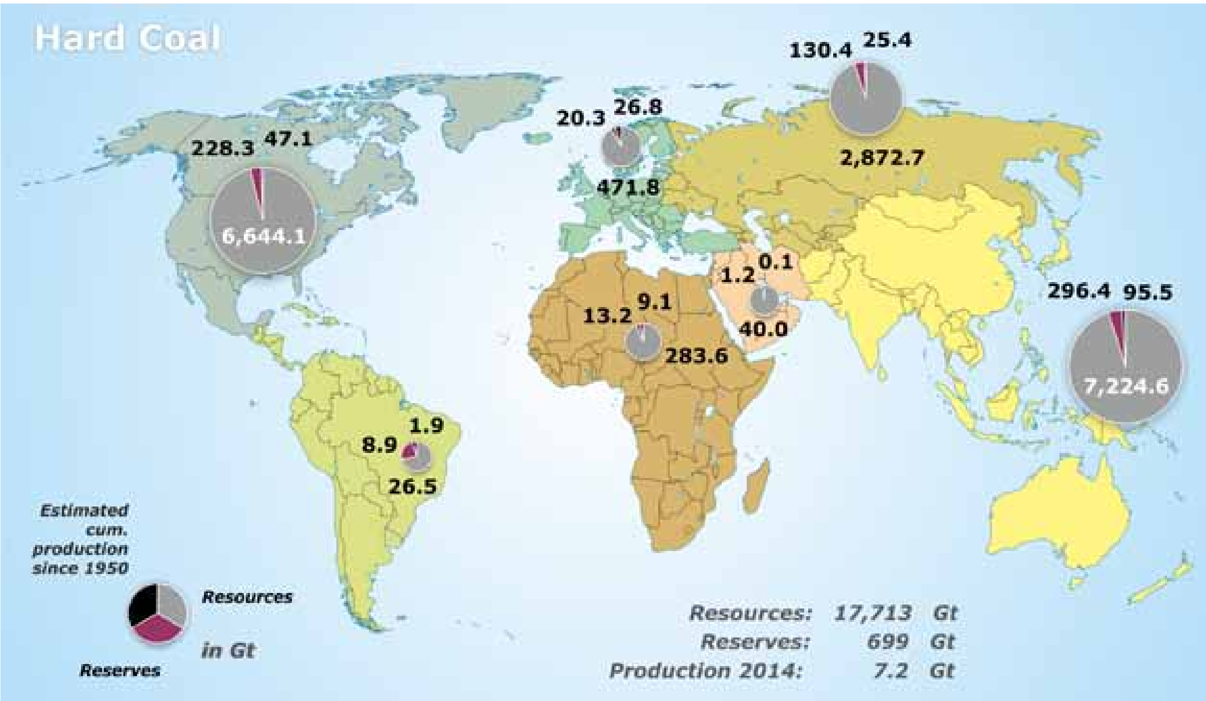

Figure 17: Total hard coal potential 2014 (18,412 Gt): regional distribution.

down 11 % to 291 Mt. This means that around a fifth of global hard coal imports were accounted for by China in 2014. India, which significantly increased its imports in 2014 by a quarter to 215 Mt, pushed Japan into third place – much earlier than expected by many market observers. Japan reduced its imports slightly by 2 % compared to the previous year to around 188 Mt. As in previous years, Asia dominated the global hard coal import market with a share of around 73 % in 2014. With a total volume of 209.6 Mt, only around one sixth of global hard coal imports were accounted for by the European Union (EU-28) which covers around two thirds of its hard coal requirements in this way.

The north-west European annual average spot prices for steam coal (ports of Amsterdam, Rotterdam and Antwerp; cif ARA) declined from 95.52 USD/tce in 2013 to 87.83 USD/tce in 2014, a decline of around 8 USD/tce (minus 8 %) (VDKI 2015b). This trend continued almost unchecked into October 2015, when the price reached 60.55 USD/tce. As in the previous year, the import prices for steam coal declined because of the continuing oversupply on the world market, which will probably remain unchanged in the medium term. Matching the previous year's trend as well, European coal imports in 2014 declined slightly by around 2% according to the preliminary estimates.

The decline in coking coal prices also continued in 2014 and 2015. The prices dropped from around 133 USD/t in January 2014, to around 114 USD/t in December 2014, and then even further to around 81 USD/t in October 2015 (VDKI 2015a, IHS Energy 2015).

One of the consequences of the further decline in global coal market prices was the further closure in 2014 of mines with high production costs, primarily in the USA, Australia and China. The producing side reacted at the same time to the changed global market prices with further cost reduction measures (redundancies and productivity increases). However, the closure of coal mines around the world because of economic deficits is not thought to have reached its peak even in 2014.

China, whose coal production capacities have more than tripled since the beginning of the new millennium, reduced its hard coal production by almost 3 % compared to the previous year for the first time for demand-side reasons. According to the China National Coal Association (CNCA), 52 coal companies each produced more than 10 Mt coal in 2014 (China Coal Resource 2015a).The total coal production from these 52 companies accounted for around 83 % of total Chinese coal production. Nine of these 52 coal companies even produced more than 100 Mt in 2014 (Tab. 2).

In the meantime, China accounts for more than half of the global demand for hard coal, and is pressing ahead with the restructuring of the coal sector, which primarily involves closing small mines with low production capacities (< 90 kt/a) and with a relatively high number of (fatal) accidents. This led to the closure of more than 1,100 mines in 2014, and the plans for 2015 are to close more than 2,000 more of them. According to the government's plans, these measures will reduce the number of Chinese coal mines to around 10,000 by 2016 (China Daily 2014). Despite the overcapacities in the Chinese coal sector, there is only a slight decline in the development of new production capacities compared to previous years (China Coal Resource 2015b). According to preliminary estimates from the Chinese National Bureau of Statistics (NBS) there will be a further demand-side reduction in Chinese coal production in 2015 (China Coal Resource 2015c) – at the same time as a reduction in imports.

Table 2: The largest Chinese coal companies according to production volumes (CNCA 2015)

Rank	Company	Production 2014 [Mt]
1	Shenhua Group	473.51
2	China National Coal Group	183.04
3	Datong Coal Mine Group	167.54
4	Shandong Energy Group	139.26
5	Shaanxi Coal & Chemical Industry Group	127.12
6	Shanxi Coking Coal Group	107.00
7	Yankuang Group	102.12
8	Jizhong Energy Group	102.00
9	Henan Coal Chemical Industry Group	101.86
10	Shanxi Lu'an Mining Group	90.18

The USA produced slightly more coal in 2014 than in the previous year. However, the number of active coal mines reduced by 397 to 1,032 in the period from 2008 to 2013 (EIA 2015a, EIA 2015b). In addition, three large US-American coal companies – Alpha Natural Resources, Arch Coal and Walter Energy – filed for bankruptcy during the course of 2015. In its domestic market, the US coal industry has been exposed to greater competition over the past few years, particularly because of the cheap natural gas (shale gas). In addition, several coal power plants are threatened with closure in the short to medium term because of more stringent environmental regulations, such as the Mercury and Air Toxics Standards (EPA 2015) and the Clean Power Plan (White House 2015). According to an EIA scenario (2015c), this could lead to the shutdown of 90 GW of coal power plant capacities by 2040 – with most of them closing before 2021. In addition to the difficulties of selling coal on the domestic market, US coal exports have also declined in recent years because the drop in world market prices for coal makes exporting coal decreasingly attractive for US coal producers. Against this background, it is understandable that the preliminary estimates for 2015 indicate a significant reduction in US-American coal production of the order of almost 9 % compared with the preceding year (EIA 2015d).

Of the three major coal producing countries, only India was able to significantly increase its (hard) coal production in 2014. And when taking into consideration the plans issued by the Indian government in early 2015, a further boost in Indian coal production can be expected in the years to come. However, the production target of 1.5 Gt (total coal) envisaged by the Indian government for 2020 – which corresponds to an increase in production volumes by a factor of 2.3 compared to 2014 – appear very ambitious, especially in the light of the relatively slow increase in production which has taken place in previous years. The largest part of this production target, namely around 1 Gt, is to be achieved by expanding the production of the state coal producing company Coal India Limited (CIL); (IEA 2015b, EIA 2015e). CIL published the associated strategy in a road map in early 2015 (CIL 2015), which reveals how the increases in production are to be implemented. If India succeeds in achieving the production target it has set itself for 2020, and thus covering almost all of the future coal demand in the country from domestic coalfields, this would result in a corresponding decline in

Indian coal imports. This will have a negative impact on the global coal market because many coal exporters are currently reckoning that India will have a rising need to import coal, and that this could compensate for the reduction in Chinese coal imports (IEA 2015b). In addition, this would mean India overtaking the USA within a few years as the second largest coal producer.

Lignite

With around 1,519 Gt, North America has the largest total resources of lignite in the world, followed by CIS (1,389 Gt, including sub-bituminous coal), and Austral-Asia (1,376 Gt) (Fig. 18). Of the known lignite reserves around the world of 286 Gt in 2014, around one third (90.7 Gt including sub-bituminous coal) is located in Russia (31.7 % global share), followed by Australia (15.4 %), Germany (12.7 %), the USA (10.7 %) and Turkey (4.4 %). The USA has the world's largest lignite resources with around 1,368 Gt (31 % global share), ahead of Russia (29.2 %, including sub-bituminous coal), and Australia (9 %). Around 83 % of global lignite production in 2014 totalling 1,023 Mt came from only 11 of the total of 37 producing countries. Germany, where domestic production declined by around 3 % compared to the previous year, was the world's largest lignite producer with a share of 17.4 % (178 Mt), followed by China (14.2 %) and the USA (7 %).

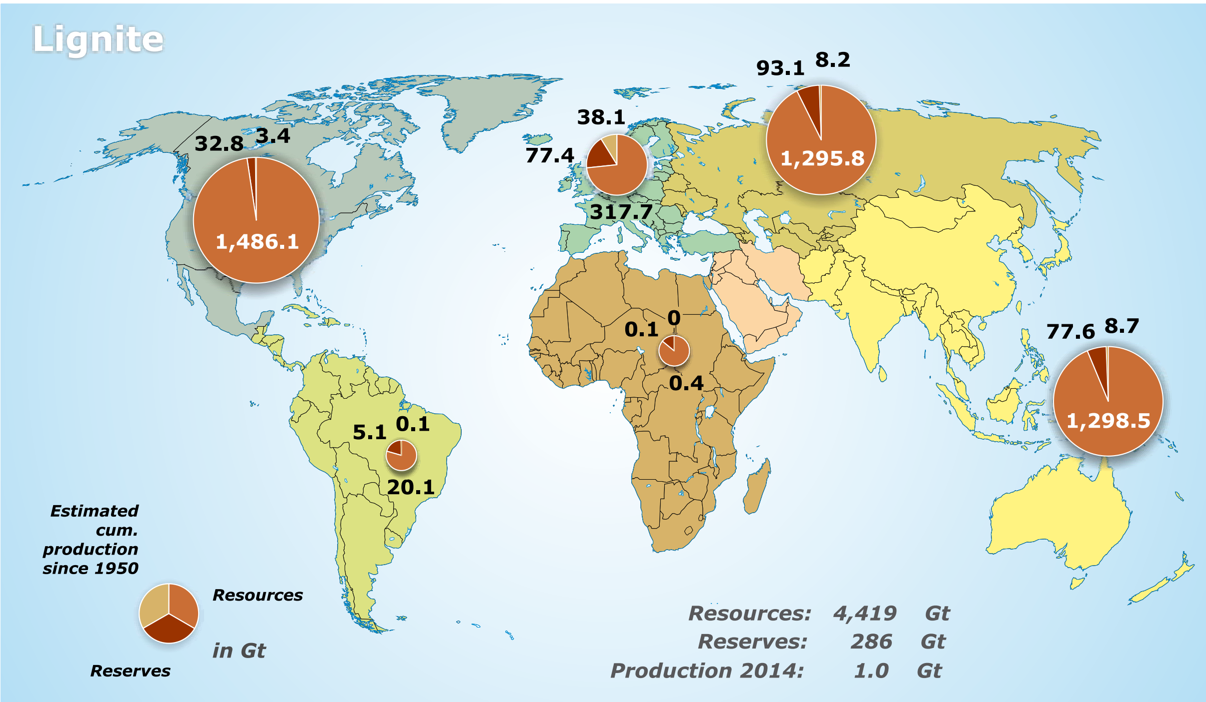

Figure 18: Total lignite potential 2014 (4,705 Gt): regional distribution.

3.5 Nuclear fuels

Uranium

Nuclear power is declining increasingly in importance in Germany, but is still a desirable energy source with a high degree of relevance from a global point of view. The demand for uranium will probably continue to decline further in Europe in future, but uranium consumption is expected to rise in Asia and the Middle East in particular. A moderate rise in uranium demand is also expected in the next decades in the North American, Latin American and African regions (IAEA 2015a; OECD-NEA/IAEA 2014).

With a total of 13.4 Mt, global uranium resources are very extensive, and have grown slightly by around 84 kt compared to the previous year. The growth is primarily attributable to the transfer of reserves from lower to higher cost categories. A new evaluation of the reasonably assured resources in Canada was the main reason for this increase. Exploration activities in recent years have only made a minor contribution to this rise. Growth here primarily came from Kazakhstan and Finland. A decline in resources came about as a result of the transfer of reserves from higher cost categories to lower categories. This was mainly due to the transfer of resources into reserves in the Ukraine. There was no further reduction in speculative resources as occurred in previous years. Argentina, Brazil, Iran, India and Vietnam published no data on speculative resources for the first time in 2013. Major producing countries such as Kazakhstan, Russia, South Africa and the USA have published no details on speculative resources any more since 2009. Australia stopped providing information of this kind over 15 years ago. Because of the uncertainties associated with this lack of reporting, the resource figures given in this study must be seen as conservative.

Unlike the other energy resources, the inventories of uranium (reserves and resources) are subdivided according to extraction costs. According to the definition for uranium reserves, the extraction cost limit is < 80 USD/kg U (definition in the Appendix).

However, a purely statistical analysis of the economically extractable inventories in the cost category < 80 USD/kg U only reflects the real conditions to a limited extent with respect to classifying uranium reserves (BGR 2014). The production costs of many mines are currently higher than the market price, and around one third of active uranium mines are producing at uneconomic levels (WNN 2015). Australia, one of the largest uranium production countries in the world, also produces uranium at higher costs, and reports uranium reserves at costs exceeding 80 USD/kg U (Tab. 44 in the Appendix). In the sense of the conservative approach taken by BGR (2014), reserves exclusively only include those uranium deposits in the extraction category < 80 USD/kg U. All inventories with higher extraction costs, are only considered as resources in this study, even if they are already being mined.

After the major changes in the 2013 reporting year as a result of re-evaluations (BGR 2014), hardly any changes were seen in the uranium reserves this year compared to the previous year. In previous years, reserves in countries with higher production costs were already reported in the higher cost categories. The removal of the Australian reserves (around 962,000 t U) from the < 80 USD/kg U cost category in 2013, led to a significant reduction in global uranium reserves (BGR 2014). Numerous other countries also transferred large proportions of their reserves to the < 130 USD/kg U cost category (cf. BGR 2014). The current uranium reserves in the < 80 USD/kg U cost category total 1.2 Mt (2013: 1.2 Mt). Around 96 % of the reserves are located in only 11 countries, led by Canada, and followed by Kazakhstan and Brazil. According to the latest data available, over half of the global reserves of uranium are found in these three countries (Fig. 19).

Global uranium production in 2014 fell for the first time since 2007, namely by 6 %, down to 56,218 t U. This was attributable to the higher production costs, and unchanged low spot market prices, which forced some mines to shut down their production. Around 85 % of global production came from only 6 countries. The largest producer in 2014 was again Kazakhstan, which produced 23,127 t U, and therefore again boosted its production against the overall global trend (2013: 22,567 t U), and thus alone produced over 41 % of the global uranium. Production in Kazakhstan has grown by 430 % since 2006. Canada, Australia, Niger, Namibia and Russia accounted for another 44 % of global production. Uranium production was again concentrated in only a few large companies as in previous years. Around 83 % of global production in 2014 was generated by only eight mining companies. Over half of the uranium produced world-wide was generated by three companies: Kazatomprom (Kazakhstan) with a 25 % global share; Cameco (Canada) with 16 %; and ARMZ/Uranium One (Russia/Canada) with 12 %. The largest single production site continues to be McArthur River, Canada (7,356 t U, 13 % of global production), followed by Tortkuduk and Myunkum, Kazakhstan (4,322 t U, 8 %); Olympic Dam, Australia (3,351 t U, 6 %); and Somair, Niger (2,085 t U, 4 %).

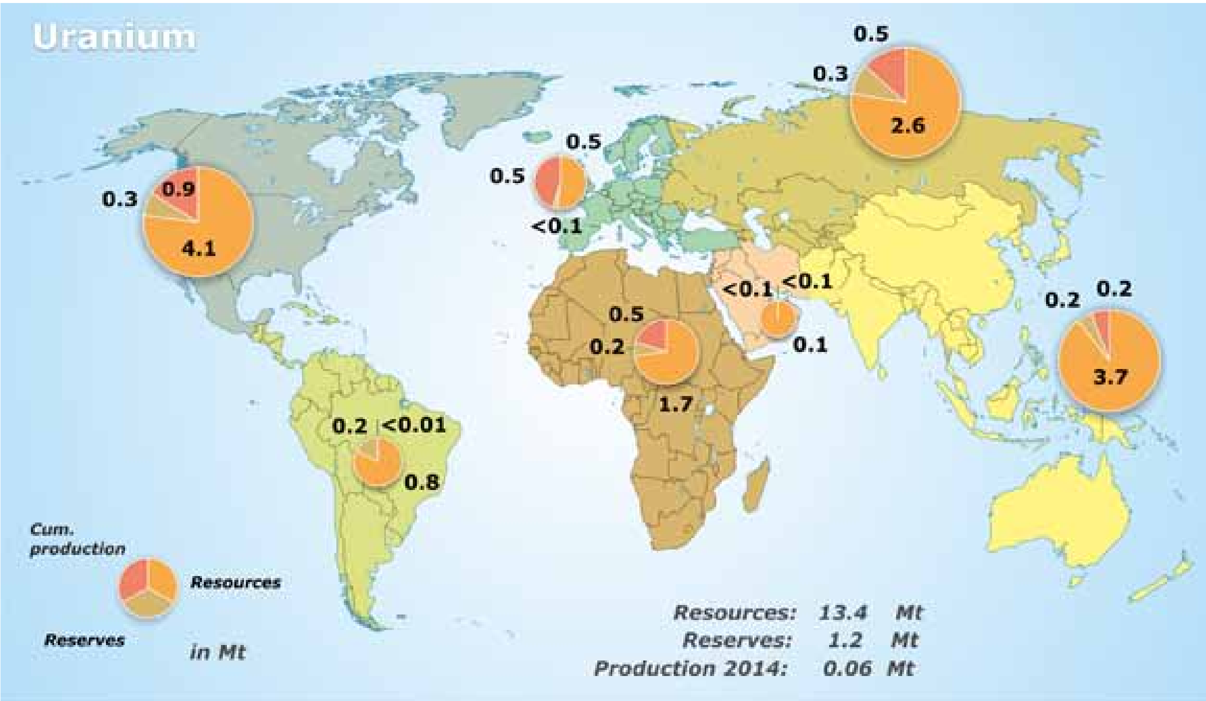

Figure 19: Total uranium potential 2014: regional distribution.

A similar low level of diversification also exists amongst the uranium consumers. Most of the produced uranium is consumed in a very small number of countries. Over half of global uranium demand is attributable to three countries: the USA, France and China. The global demand for uranium was 65,908 t U in 2014 (a slight increase of 840 t U compared to 2013). Some growth in demand was reported in Japan. Although Japanese uranium demand fell from 4,636 t U in 2012 to 366 t U in 2013, the demand rose again in 2014 to 2,119 t U because of the planned restart of Japanese reactors in 2014 (Table 47 in the Appendix). The growth in demand is also attributable to the start-up of three new reactors in China, as well as one new reactor in Argentina and one in Russia. Because of the shut-down of eight nuclear power plants in Germany in 2011, the country had a lower demand for uranium, which came to 1,889 t U in 2014, and thus exactly the same level as the previous year (Chapter 2).

World-wide, uranium is mainly traded on the basis of long-term supply contracts. Uranium supplies to EU member countries in 2014 totalled 14,751 t U (minus 2,272 t U or 13.4 %). The proportion of supplies based on spot market contracts was only 3.5 % (ESA 2015). The uranium market continues to be characterised by relatively low spot market prices, which jeopardise the economic viability of various mines and exploration projects. The trend of falling uranium prices which has existed since 2011 (as of January 2011: 188 USD/kg U), instigated by the consequences of the Fukushima reactor accidents and the consequential shut-down of 48 reactors in Japan and 8 reactors in Germany, continued into the third year. The spot market prices during the course of 2014 thus fell from 92 USD/kg U to 73 USD/kg U within six months, and then only rose again up to the level seen at the beginning of the year (92 USD/kg).

The uranium price only accounts for a small proportion of the power production costs (WNA 2014a), but is crucial for the development of new exploration and mining projects. Investments were stopped or reduced in many exploration projects. There was a rise in the number of shelved or delayed projects. Despite the rise in production costs, many uranium producers are still benefitting from existing long-term contracts which largely include higher price guarantees.

A growth in demand is expected world-wide in the medium to long term, even though this may not be as strong as forecast only a few years ago (IAEA 2015a). The growing energy demand in Asia in particular will probably stimulate a rise in the demand for uranium. Uranium will also continue to be in demand as an energy resource in Europe, despite the expected long-term decline in demand because of Germany's withdrawal from nuclear power generation, and the termination of expansion plans in Italy, Switzerland and Belgium. Other countries, however, such as Finland, France, the UK, Rumania, Russia, Sweden, Slovakia, Slovenia, Spain, the Czech Republic and Hungary, still rely on nuclear power as an important part of their national energy mixes. Poland plans to build its first nuclear power plant by 2025. Turkey also plans to build its first two reactors by 2023 with the help of Russia and France.

At the end of 2014, 70 nuclear power plants were in construction in 15 countries, including China (26), Russia (9), India (6), USA (5), South Korea (5), United Arab Emirates (3), Slovakia (2), Japan (2), Pakistan (2), Taiwan (2), Ukraine (2), Belarus (2), Argentina (1), Brazil (1), Finland (1) and France (1). Another 125 nuclear power plants world-wide are in the planning or authorisation phases. Nuclear power plants were decommissioned in Japan (1) and Spain (2). Since the beginning of the use of nuclear reactors, 150 have been decommissioned world-wide (as at December 2014). Of these, 15 reactors (including research reactors and prototype reactors) have been completely dismantled (WNA 2015e). In Europe, 4 decommissioning projects have been completely finished, of which 3 alone in Germany (BfS 2015). New nuclear reactors have been commissioned in China (3) and 1 each in Argentina and Russia. The 438 nuclear power plants operating world-wide in 2014, with a total net capacity of 376 GWe (IAEA 2015b), consumed around 65,908 t natural uranium. Most of this was derived from mine production (56,218 t).

The global production of uranium from mines in the last five years varied between 53,663 to 56,218 t U, compared to an annual consumption of over 60,000 t U. The disparity revealed here between annual demand and primary production was covered by civil and military stocks, particularly those held in Russia and the United States. These stocks were built up from uranium overproduction between 1945 and 1990 in response to forecasts of growing civil demand as well as in response to military strategy. The military stocks in particular were successively reduced. This is also in response to the START treaties signed by the United States and Russia in 1992 to convert highly enriched weapons-grade uranium (HEU) into low enriched uranium (LEU). Over a period of 20 years, 500 t of Russian HEUs – corresponding to around 20,000 warheads – were converted into 14,445 t LEU (WNA 2014b). Both countries initiated a new START Treaty in 2010 to demilitarise more nuclear weapons, and to use these for civilian purposes. This treaty was ratified in 2011 and is valid up until 2020.

This means that in addition to mine production, future uranium consumption can also be allocated to uranium from stockpiles, and the demilitarisation of nuclear weapons. Another source of uranium is the reprocessing of fuel elements. More research is currently being done by industry here on enhancing the efficiency of the reprocessed materials. The lifetimes of the materials in particular (reusability), and improvement of the active substances (resource conservation), are the main focus of this activity. Reprocessing is controversial because the first fuel cycle (nuclear fission) gives rise to by-products (including plutonium) which have much higher toxic and radioactive properties, and make reprocessing more difficult and more cost-intensive. Around 8 % of the nuclear reactors operating around the world currently use reprocessed material (so-called MOX fuels) (OECD-NEA/IAEA 2014).

Adequate potential is available from a geological point of view to satisfy the long-term global demand for uranium. The current reduction in exploration projects is exclusively attributable to temporary economic conditions. However, the development of new mining projects will be increasingly time consuming and cost intensive: whilst the development of a deposit took around five to seven years on average in the 1970s, this now takes around fifteen to twenty years (URAM 2014). Nevertheless, there is a decline in conventional cost-intensive extraction methods (open cast mining, deep mining). So-called in-situ leaching (ISL) is the leading uranium production method, accounting for 51 % of production. The average extraction costs here are below 80 USD/kg U (as at 2014).

Tables 42 to 47 in the Appendix provide a country-by-country listing of production, consumption, the 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). Thorium is generally three to four times more common in the earth's crust than uranium (approx. 6 - 10 g/t). More than 6.35 Mt thorium resources are reported for 2014.

3.6 Deep geothermal energy

Geothermal energy is classified as a renewable energy source because the decline in the geothermal heat present in the interior of our planet is negligible at human timescales. Although geothermal energy has an enormous energy potential, it has hardly been utilised at all to date. Country-specific data on geothermal energy use are published every five years as part of the World Geothermal Congress (WGC). This database is updated in accordance with information of varying levels of quality provided by individual countries. The numerical figures in this report are based on this most up-to-date and most comprehensive database as at 2014, as published for WGC 2015. In 2014, 237 TWh were extracted world-wide, of which 163 TWh_{th} thermal (Lund and Boyd 2015) and 73 TWh_e electrical (Bertani 2015). The latter is generated from 12.6 GW_e installed capacity, and corresponds to around 0.3 % of total globally generated electricity. Overall, 21 new geothermal power plants, with an installed capacity of around 610 MW, were commissioned in 2014. Geothermal energy is therefore continuing its growth trend, at similar expansion rates to 2013 (GEA 2015). Most of the world's power continues to be provided by non-renewable energy resources, with around 72 % of installed capacity (REN21 2015).

The use of geothermal energy is highly localised world-wide. Favourable regions are those with high enthalpy deposits. Countries such as the USA, Indonesia and the Philippines lead the way here because they have significant geothermal anomalies due to their geographical proximity to active plate margins. In Europe, many years of positive experience have also been gained in Iceland and Italy. The development in each case depends not only on the geological situation, but also on national objectives, energy infrastructure, water availability, state of technological expertise, the willingness to invest, as well as political and social frameworks. Geothermal projects are under way in 82 countries around the world, of which 25 countries produce geothermal electricity, including nine countries in Europe – of which six are in the European Union. The world's leading nation with respect to power production from geothermal energy continues to be the USA with 3,450 MW_e installed capacity, followed by the Philippines with 1,870 MW_e, Indonesia and Mexico unchanged at 1,340 MW_e and 1,017 MW_e respectively. Italy is the leading European country in this regard with 915 MW_e installed capacity. It is therefore ranked sixth in the world, followed by Iceland with 665 MW_e. Iceland has the highest value world-wide when calculated in per capita terms: its installed electrical capacity reaches 28 %, which makes it the second most important energy source for power generation behind hydroelectric power, which accounts for 72 %. Geothermal energy's share of primary energy consumption is 68 %. Figure 20 provides the present overview of the countries around the world using deep geothermal energy (Bertani 2015).

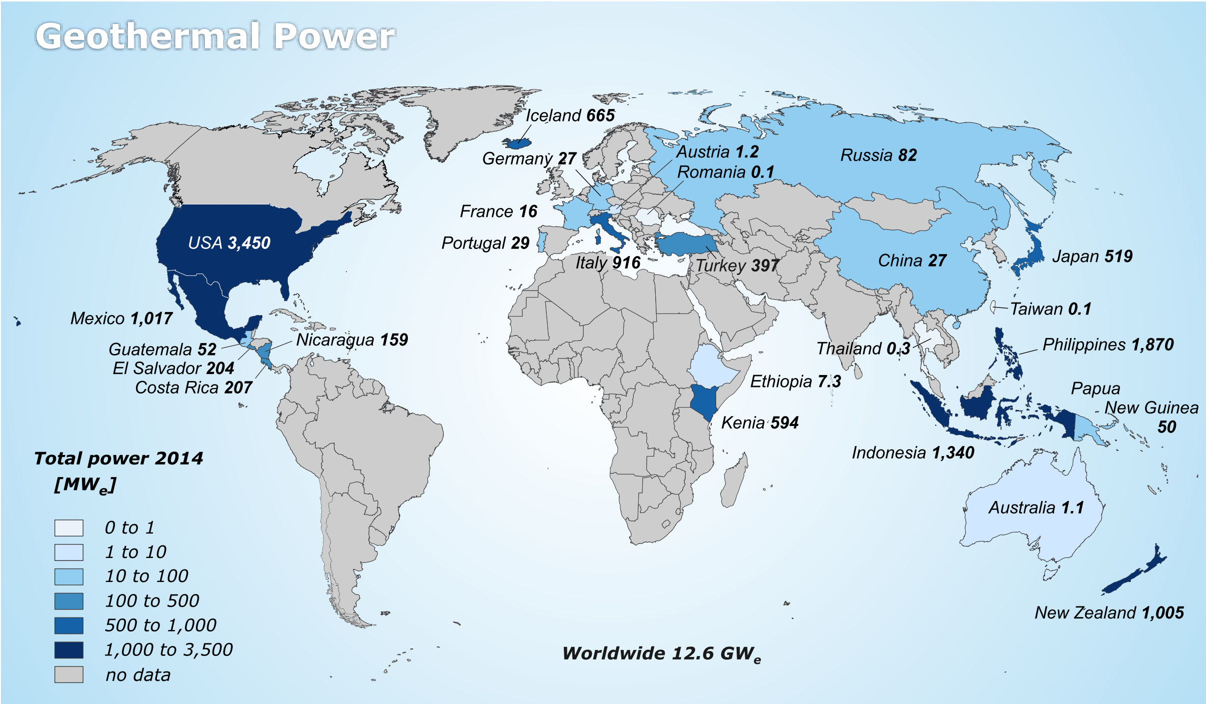

Figure 20: Countries which use deep geothermal energy to generate electricity. At the end of 2014, the global installed capacity reached 12.6 GW_e (Bertani 2015).

A clear differentiation between deep and shallow geothermal energy is not always definitively possible with respect to the use of geothermal energy for heat production. Unlike in Germany where there is a clear distinction between many different types of production method (deep geothermal energy: wells deeper than 400 metres, temperatures exceeding 20 °C), other countries often differentiate between categories of use (heat pumps, greenhouse heating, industrial use, heating swimming pools, etc.).

Geothermal energy is used for the production of heat in 82 countries around the world. Four new countries joined the list in the last five years. The installed capacity in 2014 totalled 70.3 GW_{th}, and therefore rose by almost 45 % compared to 2010. The use of geothermal heat in 2014 was around 163 TWh.

In a similar way to the generation of electricity using deep geothermal energy, the direct use of thermal water is highly localised (Fig. 21). There is also a wide variation in the degree of efficiency of the installed facilities. The capacity factor (or load factor) is a measure of the actual operation compared to the installed capacity. The lowest factor of 0.09 is found in Vietnam, the highest in Algeria with 0.99. With a value of 0.22, Germany lies slightly below the global average of 0.27. Complex reasons are the cause for the regional differences with respect to installed capacity, as well as the capacity factor. A role is played by the geological conditions, the existing energy infrastructure, the degree of industrialisation, the political frameworks, the acceptance of the population, and the distribution and type of heat users. The importance of the latter aspect can be demonstrated using the

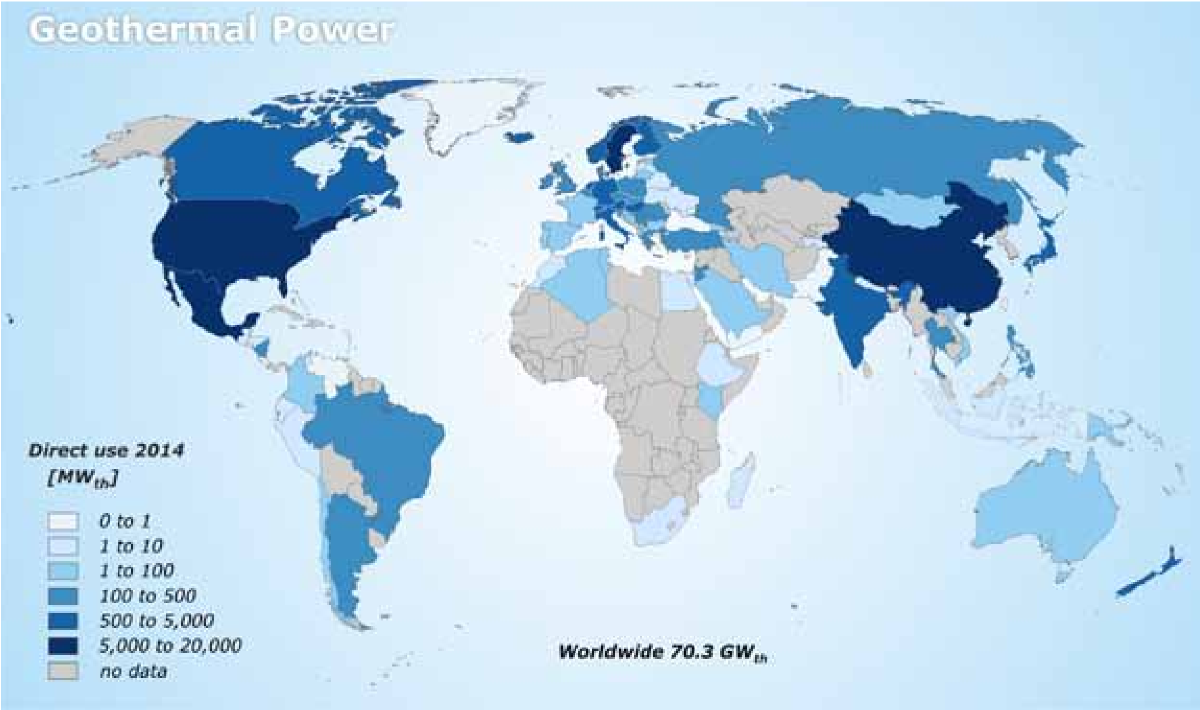

Figure 21: Countries using geothermal energy in the form of heat (direct utilisation). At the end of 2014, the installed global capacity was 70.3 GW_{th} (Lund and Boyd 2015).

Netherlands as an example: energy-intense industrial horticulture, with its specific localisation in each case, benefits from the constant provision of energy over time for the heating requirements of the greenhouses, as well as from the relatively low and relatively easily-estimated operating costs of this renewable energy source.

With an installed capacity of almost 2850 MW_{th}, Germany is ranked number four in the world behind the USA, China and Sweden (Lund and Boyd 2015). Direct utilisation is based on thermal water, but usually also with the involvement of heat pumps. At the end of 2013, approximately 286,000 heat pumps were installed to supply heat to industrial buildings, public sector buildings, as well as private households. The growth compared to the previous year was approximately 8 % (Weber et al. 2015). The disadvantages (high investment costs and lead times, high prospectivity risk) are counteracted by the benefits (base-load capable, low fluctuations in operating costs, environmental compatibility, low CO_2 and exhaust gas emissions, small surface footprints). The economic success of the usually local solutions is determined by the spatial and temporal utilisation of energy by the consumers. For instance, new housing estates and swimming pools could guarantee the necessary basic turnover over the whole year, and feeding the heat into an (existing) district heating system is also advantageous. The city of Munich for instance is planning to cover all of its heating requirements from renewables by 2040. A significant expansion in geothermal energy use is planned to help the city achieve this goal.

The development in costs compared to other energy sources, as well as the local geological and geopolitical situations, are the key aspects for the further expansion of geothermal energy use world-wide. IEA (2011) predicts that global geothermal energy use by 2050 will have grown to

1,400 TWh_e per year for electrical power, and 1,600 TWh_{th} per year for thermal energy. This corresponds in to a 3.5 % and 3.9 % share in global production respectively. IPCC (2011) forecasts similar figures: by 2050, geothermal energy could cover 3 % of global power demand and 5 % of global heat demand. In Europe, the economic potential for geothermally-produced power in 2050 is estimated at 4,160 TWh_e in total.

Tables 48 to 50 in the Appendix compile the country-specific installed capacities (electrical and thermal) and consumption (electrical) as well as the technical potential (resources) of deep geothermal energy. There is an overall trend towards an increasing use of geothermal energy.

The terms resources and reserves can only be applied to a limited degree when it comes to geothermal energy. This is why the so-called technical potential is frequently used instead when evaluating the geothermal potential. The technical potential is defined as the achievable energy amount (EJ/year) when completely implementing the standard technologies at the time, without any economic or socio-economic restrictions (IPCC 2011). The technical potential does not correspond to the term reserves usually applied to fossil energy resources – which includes proven amounts and can be economically produced using today's technology. The technical potential corresponds more closely to resources. The term resources in the geothermal energy sector is used to describe the portion of accessible energy inventories which can be extracted from underground using today's state-of-the-art technology, and for which there is a foreseeable potential (future) economic use (Schulz et al. 2013). This evaluation generally takes into consideration underground potential down to a maximum depth of 10 kilometres (IPCC). This classification has so far not been implemented along standard lines around the world. Work was therefore begun in 2014 at an international level (UNECE) to establish a standard classification for geothermal reserves and resources.

3.7 Renewables

The proportion of renewables grew further in 2014 in the transport sector as well as in the power generation sector, and achieved its biggest ever share of global primary energy consumption.

Around 13.5 % of global primary energy consumption is covered by renewables (IEA 2015a, Fig. 11, Chap. 3). Over three quarters are covered by biogenic energy sources, of which around 70 % involves solid biomass, and especially firewood. Even today, energy in developing countries in particular, is primarily provided by wood and charcoal. After biomass, hydroelectric power, as another "classic" renewable energy source, is the second most important renewable, with a share of around 2.5 % of global primary energy consumption. "Modern" renewables such as solar power and windpower still only cover around 1.3 % of global primary energy consumption. However, the expansion of these renewables has enjoyed the highest growth rates in recent years.

In 2014 alone, almost 60 % of the new power generation capacities installed world-wide involved renewables. Windpower in particular dominated the electricity sector with the addition of 51 GW in 2014, to give a global capacity of 370 GW. Additional capacities of 39 GW and 37 GW were added in 2014 in the photovoltaic and the hydroelectric power segments respectively.

The power generation capacity world-wide from renewables is around 1,800 GW (Fig. 22) (IEA 2015b, IRENA 2015). Compared to this, around 404 GW (gross) of nuclear power was available around the world in 2014. The main renewable energy source is hydroelectric power with around 1,170 GW of installed capacity (around 64 %), followed by windpower (370 GW; 20 %) and photovoltaics (175 GW; 10 %). With around one quarter of the global installed capacity (433 GW), China is the leader in renewables. Hydroelectric power in China accounts for 301 GW of this amount, followed by another 115 GW for windpower. Another 374 GW of renewables are installed in the USA (185 GW), Brazil (96 GW), and Germany (93 GW). These four countries cover almost half of the globally installed capacity from renewables. Germany leads the world in its photovoltaic capacity, with 38 GW installed capacity for power generation. Another 1.9 GW were installed in Germany alone in 2014. The strongest growth in photovoltaics in 2014 was recorded by China with over 10 GW.

There is a very large spectrum of renewables. They include "classic" renewable energy sources such as solid biomass (e.g. wood), and hydroelectric power, as well as "modern" renewables in the form of windpower, solar power, geothermal energy (see Geothermal energy chapter), tidal power, and various forms of biogenic natural resources. The range of applications is just as diverse, and includes power generation, heat and cold generation, as well as fuels for the passenger and goods transport sector. Renewables are mainly used for power generation.

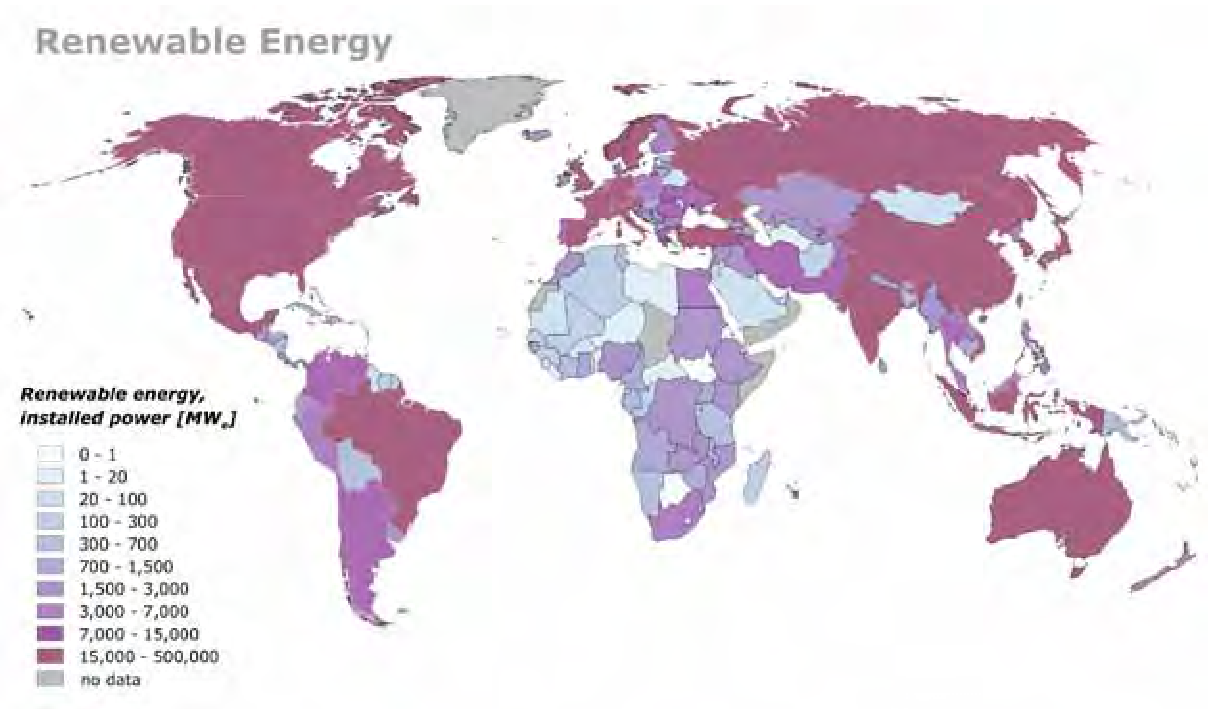

Figure 22: Total potential of the installed capacity of renewables for power generation (1,800 GW): regional distribution (IRENA 2015).

Even though there is a major expansion in capacities, primarily involving windpower and photovoltaics, power generation from these sources has so far been relatively low. Although the total share of global power generation covered by renewables is already 22.8 %, around 16.6 % of this (approximately 73 % of power generation from renewables) comes from hydroelectric power. Windpower (3.1 %), biomass (1.8 %), and photovoltaics (0.9 %) only made a contribution of around 6 % to power generation in 2014 (REN21 2015). The expected installation of new capacities will ensure that the share of renewables in overall power generation will also continue to grow in future. In addition to the geographical conditions, this will also crucially depend in particular on the specific strategies and objectives pursued by each country: which will define which course the expansion of renewables will follow. In Denmark, Nicaragua, Portugal and Spain for instance, windpower already covers more than 20 % of their power demand (REN21 2015). All of Iceland's power requirements are satisfied by renewables (71 % hydroelectric power; 28.9 % geothermal power; 0.04 % windpower), and over 60 % of its heat demand is covered by renewables, primarily geothermal energy (IEA 2015a). In Germany, over 26 % of the power demand was covered by renewables for the first time in 2014 (AGEB 2015). Unlike the global trend, over half of the power generated by renewables came from windpower (56 billion kWh; 9 % of the German power mix) and biomass (43 billion kWh; 7 % of the German power mix). Power generation from hydroelectric plants declined slightly in Germany in 2014, and accounted for 3.3 % of the German power mix. This was mainly attributable to weather-related differences in the amounts of rainfall between the two years. The third most important renewable is photovoltaics which generated 34.9 kWh of electricity (5.7 % of the German power mix) (AGEB 2015).

Renewables in the form of biofuels (ethanol and biodiesel) are also gaining increasingly in importance in the passenger and goods transport sectors. Biofuels currently account for 0.8 % of global final energy consumption. Global production of biofuels has more than quadrupled in the last ten years, from around 30 billion litres (2004) to around 128 billion litres (2014). A further rise is also expected in future. The leading producers are the USA and Brazil: over 70 % of ethanol fuels and biodiesel are produced in these two countries. The production of wood pellets for heat generation rose from around 4 million t (2004) to around 24 million t (2014). The main producing regions here are Europe and North America. Although only around 2 million t of wood pellets were produced in Europe (EU-28) in 2004, this had already grown to around 13 million t in 2013 (REN21 2015). Demand has grown significantly in Europe as well as in Asia in recent years (IEA 2015b), and can hardly be covered anymore by domestic production. The biggest exporter today is North America. Imports of North American wood pellets into Europe have quadrupled since 2011 (REN21 2015). The domestic demand in Germany alone is calculated at 1.8 million t/a, and is scheduled to grow further (2006: 470 kt) (DEPL 2015).

4 ENERGY RESOURCES IN FOCUS (SPECIAL TOPICS)

4.1 Enhanced recovery technologies for crude oil and natural gas production – current status and potential in Germany and world-wide

A peak in production has already been exceeded for conventional crude oil fields in many countries. These countries include Russia (peak oil in 1987), USA (1970), United Kingdom (1997), and Germany – which now produces only around 30 % of the peak volume of crude oil reached in 1968. Countries with significantly depleted fields are therefore particularly interested in technologies which can boost the production rates and enhance production efficiency. These methods for boosting the production of oil fields and gas fields are better known in the petroleum industry as enhanced oil recovery (EOR) and enhanced gas recovery (EGR). The following discusses the application of EOR and EGR and the production rates they can achieve both in the context of Germany as well as world-wide.

The production curve of every oil well always follows the same pattern in principle. After an initial growth phase with natural flow, the curve climbs to a production peak which can usually only be maintained for a few years. If no additional measures are implemented, this primary phase is followed by a decline in the production rate. There are many reasons for this decline, and they include a drop in pressure, increasing crude oil fractionation, or heterogeneities in the reservoir, so that some of the crude oil is unable to reach the production wells.

In an effort to maintain the production rates, or at least to minimise the decline, a secondary production phase usually involves the injection of reservoir water to reduce the decline in reservoir pressure. Another typical measure during the secondary production phase is the injection of associated gas into the gas cap. When the second phase ends, if no other measures are implemented, 60 % to 70 % of the crude oil still remains in the reservoir on average (Babadagli 2007). EOR can, however, be implemented in a tertiary production phase. A typical feature of these methods is that they influence the properties of the crude oil, or of the formation water, to enable more crude oil to be produced. The mechanisms involved are as follows:

- Reducing the viscosity of the crude oil, or raising the viscosity of the water (reduction in the mobility ratio)
- Reducing the interfacial tension in the pore space
- Reversible formation of emulsions to generate a crude oil-water mixture
- Releasing the crude oil from the matrix rock (changing the wettability)

Overview of today's EOR methods

EOR methods are measures which influence the properties of the crude oil or of the formation water in "the pore space". These differ from methods which open up new migration paths, such as hydraulic fracking, which are classified as "improved oil recovery (IOR)" (IEA 2013).

A large number of EOR methods have been developed in the last 40 years. These can be divided up into thermal and chemical methods, methods using gas injection, and measures which cannot be assigned to the classical methods (Fig. 23).

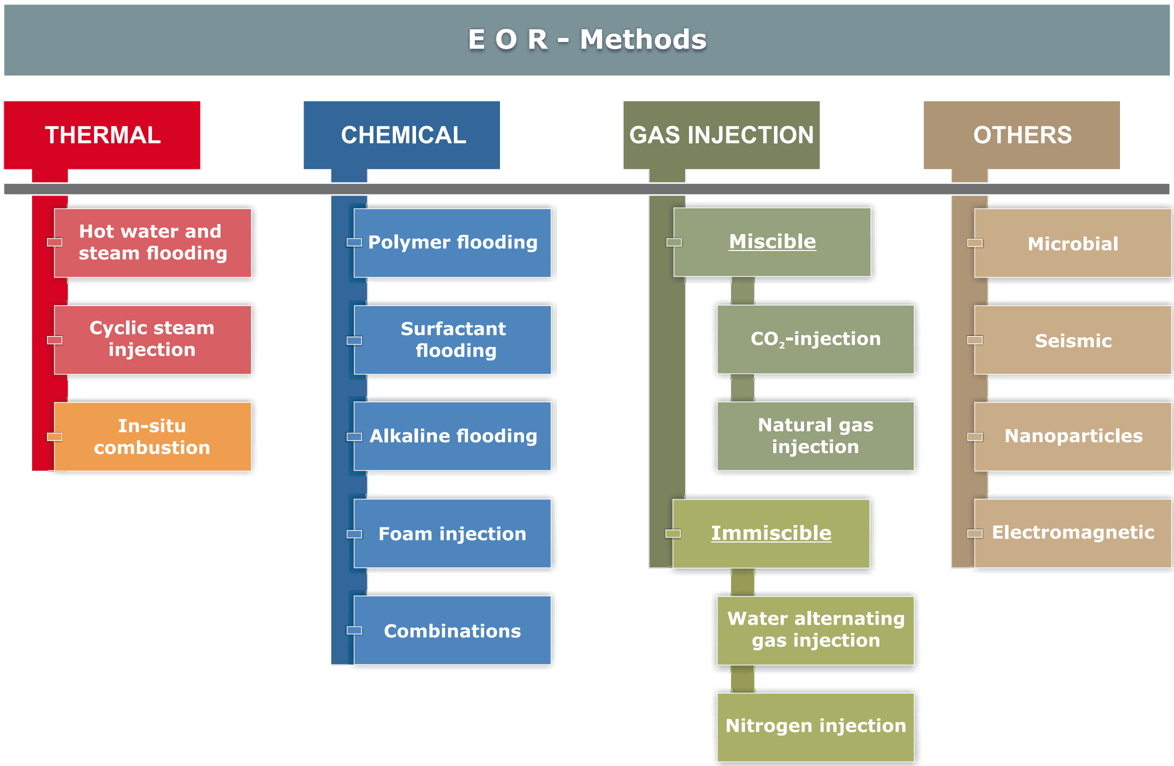

Figure 23: Schematic diagram showing the different EOR methods.

Thermal EOR methods

The viscosity of crude oil is reduced and its mobility enhanced by injecting hot water or steam into a reservoir. This method is relatively easy to implement, has been successfully used on many occasions, and is suitable for a broad spectrum of crude oil types, ranging from heavy oil to oil sands. Heavy oil is classified as a conventional crude oil type, is found throughout the world, and in many places, production only became possible by using steam injection. The latter can also be carried out cyclically and is then known as "cyclic steam stimulation" (CSS).

The "in-situ combustion" method relies on the injection of air or oxygen-rich gas mixtures into the reservoir. This ignites some of the crude oil, and the resulting heat reduces the viscosity so that the remaining crude oil is easier to produce.

Figure 24 shows the depth versus the relative density of the crude oil for thermal EOR projects implemented world-wide. Heavy crude oil types have a higher viscosity than light crude oil types, although the relationship is non-linear. As shown in the figure, steam and hot water methods are limited to depths shallower than 1,300 metres. This is because the amount of energy required for these enhanced oil recovery methods is usually too high below these depths.

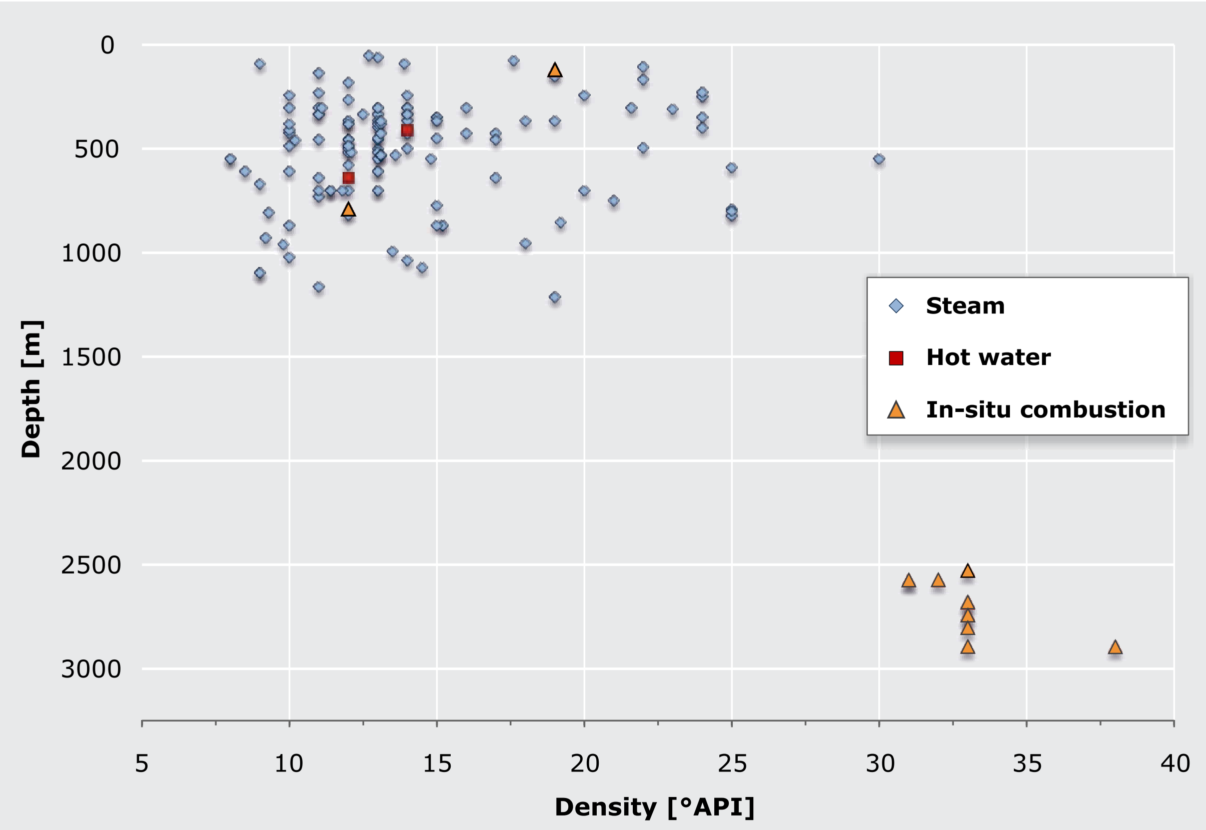

Figure 24: Overview of thermal EOR projects world-wide depending on the depth and density of the crude oil (Kootungal 2014).

Chemical EOR methods

Adding polymers to the injection water increases its viscosity with the aim of improving its ability to displace the crude oil. This so-called "polymer flooding" method is used in China, Russia and the USA amongst others. Pilot projects were and are being carried out in Germany (see below). The most frequently used polymers are synthetic components such as (hydrolysed) polyacrylamide (PAA), or natural polymers such as xanthan gum, guar or chemically-modified cellulose.

Surfactants on the other hand are used to reduce the interfacial tension between crude oil and water. These assist and stabilise the formation of emulsions. Surfactants can be created at an industrial scale, are cheap, and are only required in low concentrations. In addition to pure surfactants, it is also possible to inject alkaline compounds into reservoirs to "saponify" the crude oil constituents present in the reservoir ("alkaline surfactants") (Chang et al. 2006). Surfactants and polymers are frequently used in combination today around the world as part of so-called "alkaline surfactant polymer floods" (ASP). On top of the aforementioned, there are also a number of other chemical EOR methods: these include mixable polymers, which have the displacement properties of polymers but not the disadvantages such as temperature or salinity dependence (Zhu et al. 2013). Foams are used to block specific migration paths with the aim of activating new migration paths in parts of the reservoir which had not been properly de-oiled until that point

Gas injection

The injection of gases to increase the reservoir pressure is one of the oldest methods to have been used to boost production. Gas injection can be split into two different operating principles: in "miscible flooding" (MF), CO_2 or natural gas is injected. These dissolve in the crude oil, reduce its viscosity, and therefore make it easier for the oil to flow. In the case of "immiscible flooding" (IMF) the injected gases do not dissolve in the crude oil. Production enhancement in this case is achieved by the horizontal displacement of the crude oil. "Water alternating gas injection" (WAG) is the name for a technique involving the alternating injection of water and gas. This method makes use of the higher viscosity of the water and the better injectivity of the gas to displace the crude oil.

Other methods

Specific microorganisms can break down long-chain hydrocarbons in crude oil reservoirs. This gives rise to the formation of gases (including CH_4, CO_2, H_2) and extracellular secondary substances such as polymers and surfactants. These effects can enhance oil production. Although pilot projects on microbial EOR exist around the world (e.g. Wagner 1991), the method has so far not been used at a large scale.

The same applies to seismic methods where it is hoped that the vibrations will mobilise the crude oil. The vibrators can be used on the surface or within the reservoir.

Other methods being tested include the use of nanoparticles, and electromagnetic techniques which create eddy currents in conductive materials such as formation water, which then generates heat. Because the heat is formed in the reservoir formation itself, this method is depth-independent in principle, but a disadvantage is that the electromagnetic waves do not penetrate very far into the formation.

Enhanced Gas Recovery (EGR)

Because of the expansion of the gas during production, natural gas fields enjoy a much longer phase of peak production, and only leave behind around 20 % of the original gas volume after the end of the primary production phase. This means that enhanced gas recovery methods are much less relevant in the case of natural gas fields than EOR methods are for crude oil production. The only "real" EGR measure which is frequently used is the injection of N_2 or CO_2 (hydraulic fracking is regularly used in natural gas fields with poor permeability, but is classified as an improved gas recovery (IGR) method).

EOR in Germany

Almost all German oil fields are in an advanced stage of production. Steam flooding was tested and successfully established in the 1970s in the Emlichheim field (production began in 1944), Georgsdorf field (1944) and Rühle field (1948), all lying in Emsland in northwest Germany. These are the only three fields currently operated in Germany which use EOR methods to boost commercial production (Fig. 25). No EGR measures are used in Germany.

Steam flooding was shut down in the Rühlertwist part of the Rühle field in 1999. An additional 317,562 t crude oil was produced by using EOR in the three fields in 2013. This corresponds to 12.1 % of Germany's total production, and around 94 % of the production from the steam-flooded parts of the field (LBEG 2014). Table 3 lists the most important properties of the reservoirs and the crude oil from the Bentheimer Sandstone in the Emsland region, and the history of the EOR methods implemented in these fields.

Table 3: Details of the reservoirs, crude oil properties and production figures for the Emlichheim, Georgsdorf and Rühle (Rühlertwist and Rühlermoor) fields (Fabel et al. 1999; Möhring 2011; LBEG 2014; Dreier 2003; MastMann & Fabel 1998; Wintershall 2011a & 2014; Proyer et al. 1985).

Reservoir	Emlichheim	Georgsdorf	Rühlertwist	Rühlermoor
Operator	Wintershall (90%), EMPG (10%)	EMPG	Engie SA	EMPG
Depth [m]	700–900		700–870	520–870
Area [km^2]	4	20		24
Thickness [m]	30	30–37	20–45	20–45
Permeability [mD]	300–15,000	300–3,000	300–10,000	500–4,000
Porosity [%]	30–33	25–30	28	22–35
Initial reservoir pressure [bar]	85		85	80.6
Reservoir temperature [°C]	37	40	35–40	37
OOIP [Mio. t]	31.5	81	21.5	99.5
Fluid properties				
Viscosity [mPa*s]	175 (37 °C)	130	175	120
Concentration [g/cm^3 oder °API]	0.904 (25°API)	25°API	0.9 (25°API)	0.905 (25°API)
History				
Start production (year)	1944	1944	1948	1948
Primary hubbert peak (year)	1950	1966	1962	1666
Amount [kt/a]	150	584	160	756
Start steam flooding (year)	1981	1975	1978	1980
Production (2013) [kt]	173	98.4		184.7
Cumulative production (2013) [Mio.t]	10.3	18.9		34.3
Recovery (2013) [%]	32.7	23.3		28.3

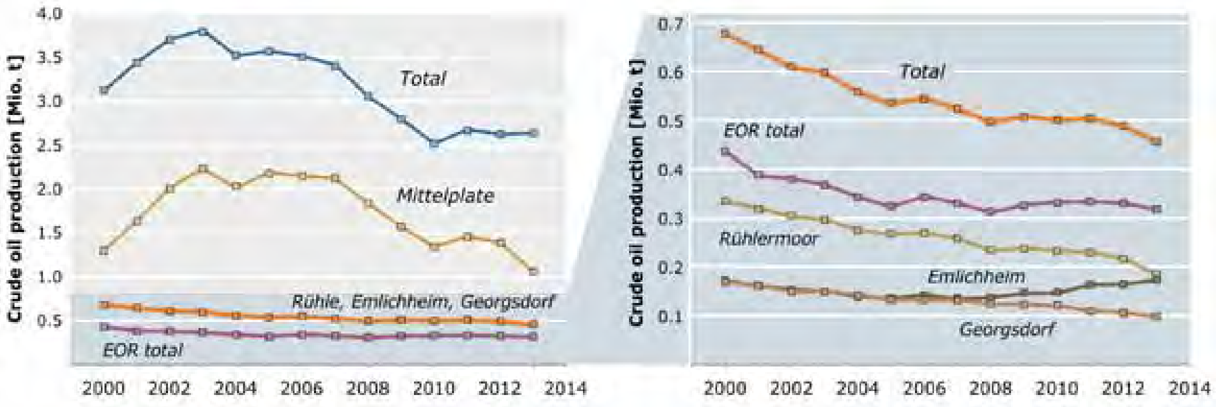

Figure 25: Comparison of crude oil production in Germany in the Mittelplate, Rühle, Emlichheim and Georgsdorf fields, as well as the additional production achieved by implementing EOR methods (NLfB 2001 to 2005; LBEG 2006 to 2014).

The Georgsdorf field was discovered in 1943. The first pilot tests for steam flooding in the Emsland region began here in 1975. The method was rolled out to the neighbouring Emlichheim and Rühle fields after the successful results of the pilot test

The first oil discovery well in Emlichheim was drilled by Wintershall Erdölwerke in 1943. The peak production from natural flow was already reached in the middle of the 1950s (Fig. 26). The injection of reservoir water to raise the pressure began back in 1952, and stimulation with steam began in 1966 – initially using the “huff and puff” method. This involves injecting steam into the well for several weeks, and then producing oil from the same well. Horizontal drilling has been used in Emlichheim to develop new parts of the field since 1999 (Wintershall 2011a). Today (as at 2015) around 75 t of steam are injected into the field every day. This enabled the production rate of the Emlichheim field to be maintained at a constant level for a long time. The recovery rate in Emlichheim is 32.7 %, and therefore higher than in Rühle (28.3 %), and Georgsdorf (23.3 %). The operator of the field, Wintershall, plans to continue with EOR in the Emlichheim field until beyond 2040.

The Rühle field is divided into two parts: Rühlermoor and Rühlertwist. Steam flooding was first undertaken in the Rühlertwist field in 1978 as part of a pilot test, before being rolled out to the Rühlermoor field in 1980. The operator’s current plans for the Rühlermoor field are to increase production again to 250 kt/a (EMPG 2014). The plans therefore involve drilling 140 new wells: which includes a significant increase in the number of injection wells. Extra steam generators with cogeneration capacities will also be built in the field with a capacity to generate up to 240 t of steam per hour. Projects are also planned for Rühlertwist (Saeed et al. 2015).

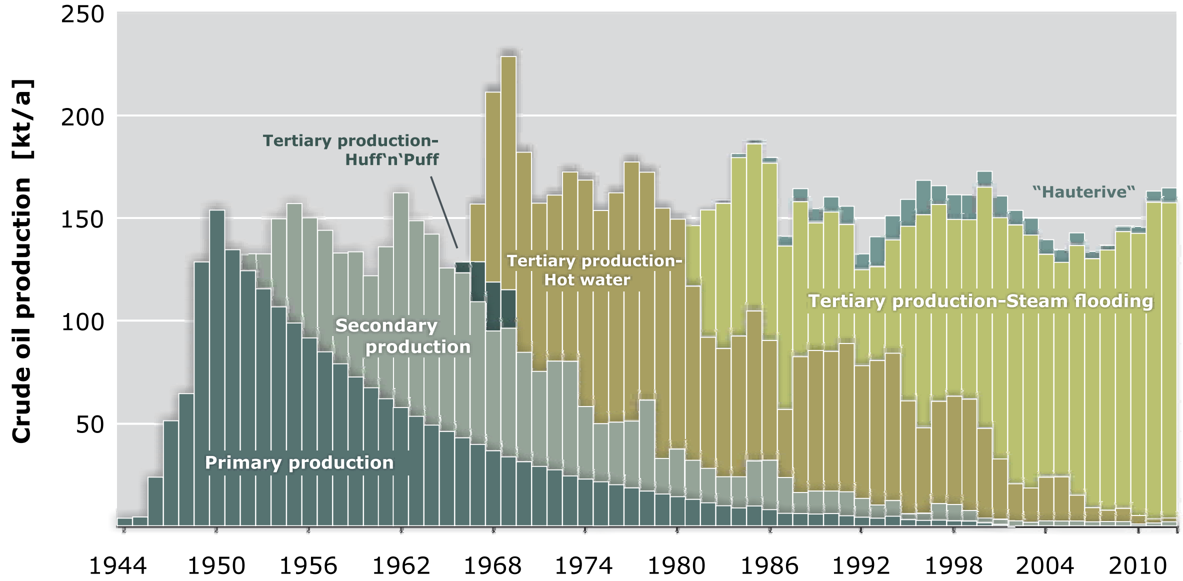

Figure 26: Production over time in the Emlichheim field (modified after Pusch 2007 and Wintershall 2014).

Polymer flooding pilot tests in Germany

Pilot tests with polymer flooding already took place in a number of fields in the 1980s and 1990s. For instance, Deutsche Texaco (now DEA) and Preussag (which later changed its name to GdF Suez, and now to Engie SA) operated various projects involving the addition of polymers. Although the projects were considered successful in some cases from a scientific and technical point of view, the method was not rolled out to the rest of the field. Pilot tests on the use of polymer flooding are currently under way in Germany in the Bramberger and Bockstedt fields.

Engie SA is investigating the use of polymer-surfactant flooding in the Bramberge field (Tabary & Douarche 2012). Because of the high salinity, it is not possible to use a conventional polymer-surfactant mixture. By using the ASP method instead, up to 38 % of the original crude oil was successfully extracted from a test core (Tabary & Douarche 2012). No information is available on any further progress made by the project after 2012.

Wintershall is investigating the use of the biopolymer Schizophyllan in the Bockstedt field (Liu et al. 2013). Schizophyllan is produced by the tree fungus italics (italics used for species names) and is temperature-stable for a short time at temperatures of up to 135 °C, and therefore more stable than the xanthan gums conventionally-used used for EOR measures (Leonhardt et al. 2014). According to the manufacturer, the viscosity of Schizophyllan is independent of the salinity of the formation water, and in addition, Schizophyllan forms no stable emulsions with crude oil. The biopolymer is also completely biodegradable, which means that biocides have to be added (Leonhardt et al. 2014). Polymer injection began in December 2012 at a rate of 80 bbl/d. Between 2011 and 2013, 35,000 m^3 of water and 45,000 m^3 of Schizophyllan were injected into the reservoir. After evaluating the first results and on the basis of modelling, additional production of around 25 % is expected compared to water flooding (Ogezi et al. 2014).

EOR and EGR world-wide

The International Energy Agency (IEA) estimates that around 1.5 % of the total oil production in 2013 and 2014 is attributable to enhanced production as a result of the use of EOR technologies (IEA 2013, 2014). However, it is difficult to assess the absolute figures for EOR production volumes. The main reasons are as follows:

- Missing, contradictory or obsolete data from producing countries
- Lack of any distinction between production and enhanced production in specific fields
- Different classifications of production volumes from heavy oil reservoirs with respect to conventional versus non-conventional
- Differences in classifying gas reinjection and “smart water injection” with respect to “secondary measures” versus “EOR” measures

Despite the restricted nature of the database, Figure 27 shows the development of enhanced recovery associated with the various EOR methods. The technologies with the highest additional production volumes world-wide are steam flooding, CO_2 injection and natural gas injection. The volumes of oil produced using EOR methods has declined continuously between 2000 and 2006, which may be attributable to the relatively low price of crude oil between 2001 and 2003. Because the IEA does not include statistics on EOR projects from heavy oil reservoirs, large volumes of production from Venezuela are not incorporated in its figures. In addition, there are also no figures on China because of the poor database (IEA 2013).

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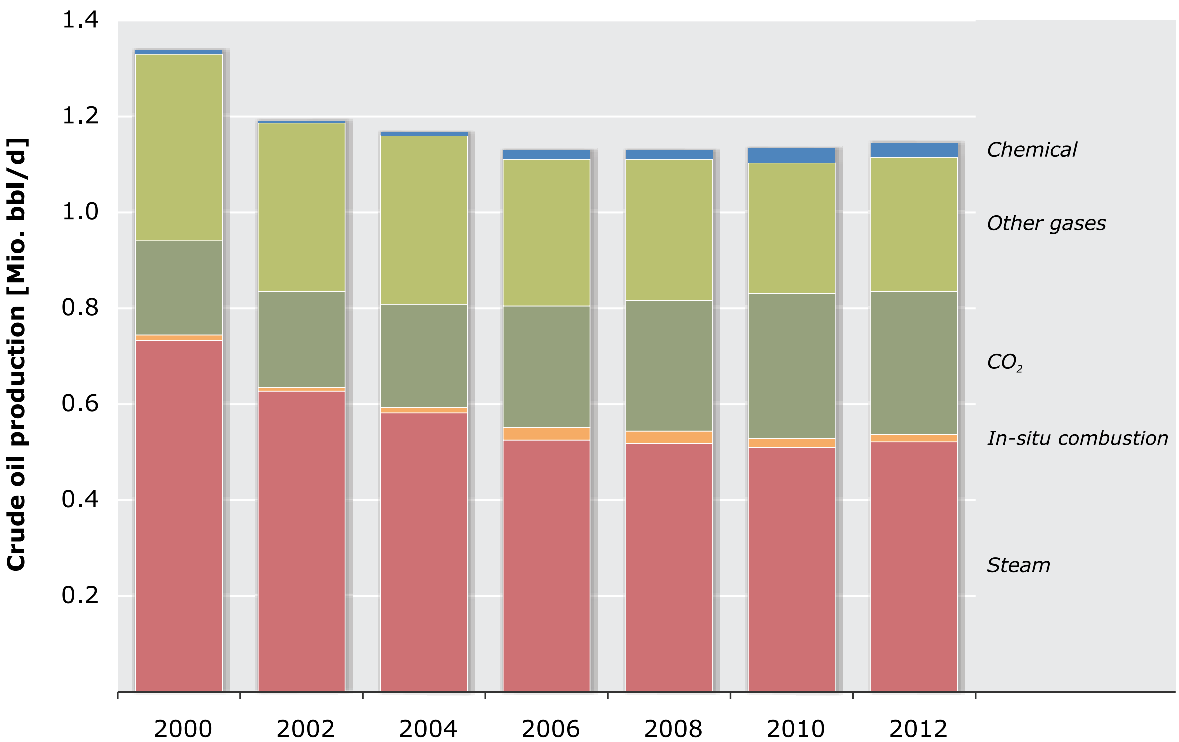

Figure 27: Contribution of EOR to crude oil production around the world from 2000 to 2012 (modified after IEA 2013).

Table 4 supplements the IEA figures (2013) by providing an overview of the current status in countries with proven production quantities from EOR. This table lists the countries which use EOR, and where at least some of the enhanced production is backed up by figures. The table includes figures for heavy oil, but none on oil sands because these are classified as non-conventional deposits. Because of a lack of good data, there are also no numbers from long-established and important producing countries including Algeria, Libya, Angola, not to mention Russia, Mexico and Colombia.

Table 4: Countries with proven production volumes derived from EOR (IEA 2013; Kootungal 2014; LBEG 2014; al Mutairi & Kokal 2011)

Country	Total-Production (bbl/d)	of that from EOR (bbl/d)	Percent (%)
USA	10,003,000	778,048	7.8
Venezuela*	2,623,000	> 387,898	> 14.7
Oman **	≈ 942,000	≈ 300,000	≈30
Indonesia	882,000	> 190 000	> 21.5
China	4,180,000	> 170 000	> 4.25
Canada	3 948 000	47,535	8.5
Brasilia	2,114,000	> 21,560	> 1.0
Norway	1,785,000	> 14,950	> 0.83
Turkey	56,650	7,000	12.3
United Kingdom	866,000	> 6,000	> 0.7
Germany	45,000	5,500	12.1
Trinidad & Tobago		1,400	
Wafra (Neutral Region, Middle East)		500	
Sum	86,000,000	> 1,930,391	> 2.2

* including extra heavy oil, ** valuations

IEA forecasts that crude oil consumption will grow world-wide up to 2040 (IEA 2014). The proportion of EOR production of the overall production will probably increase in future because of the age of many fields (Fig. 28). IEA is currently forecasting a global rise in the share of EOR production to 5.8 million bbl/d by 2040. This corresponds to approx. 5.5 % of the expected total production.

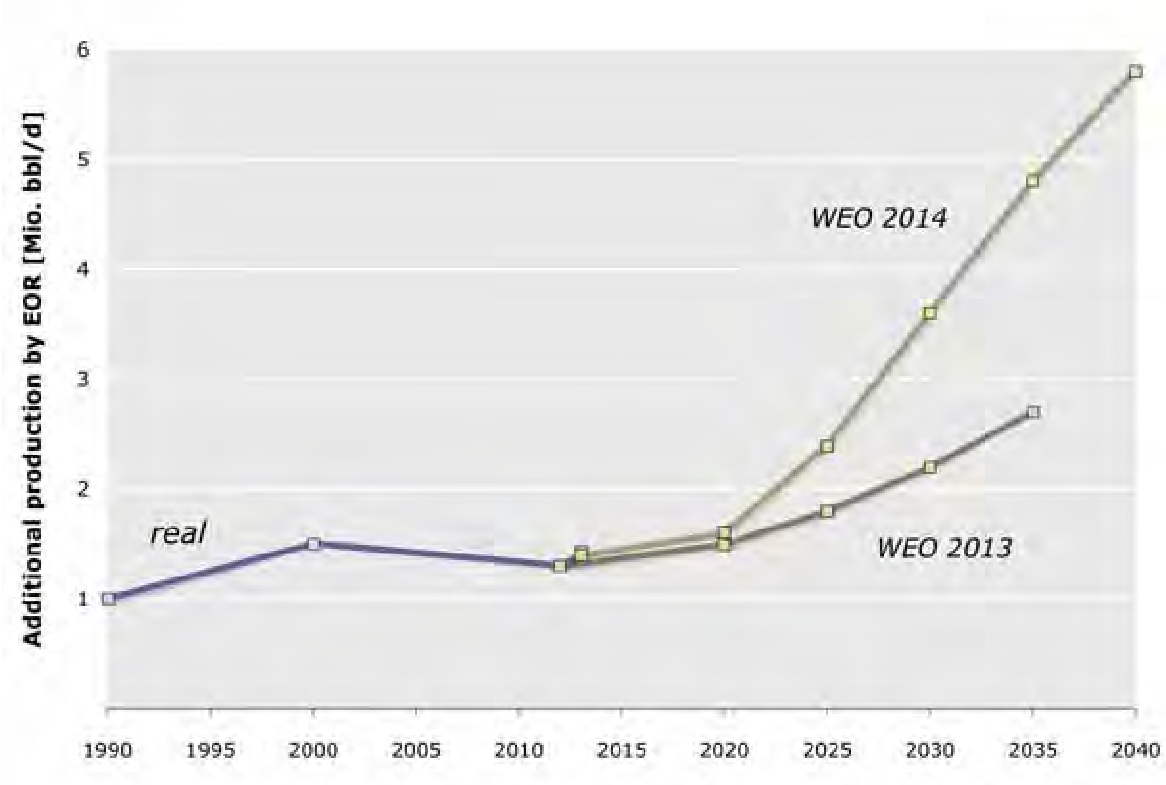

Figure 28: Historic and future production volumes due to EOR (IEA 2013, 2014).

Future development and importance of EOR technologies

Thermal methods are amongst the oldest EOR methods. They have been tried and tested world-wide and are very appropriate for the extraction of heavy oil, but they are relatively expensive because steam generation requires a great deal of energy input. Many of today's developments are therefore aimed at reducing the costs. These include the better utilisation of the input energy by combined heat and power technologies (Wintershall 2011b), improving the steam-crude oil ratio (Chaar et al. 2014), optimised field management, and the recovery of the thermal energy from the produced oil-water mixture (Yang 2007). Pilot projects in the Middle East are investigating the use of solar energy to generate the steam (Anderson 2014). It is likely that thermal EOR methods will remain highly relevant in future as well.

In North America, CO_2 flooding is the technique which accounts for the largest volumes of EOR-generated crude oil production (Pusch 2007, Koottungal 2014). The biggest challenge for CO_2 flooding is the availability of (cheap) CO_2 and the frequent lack of infrastructure. This means that fields close to natural CO_2 sources, such as the Lula field in Brazil (US Department of Energy 2014; Kang et al. 2014) or fields near to power plants and factories with CO_2 separators, such as Sharon Ridge, Weyburn and Rangely in the USA and Canada (Gozalpour et al. 2005), have advantages when it comes to using CO_2. Despite the aforementioned difficulties, expansion of this method world-wide in the coming decades is likely because of the high efficiency of CO_2 flooding for EOR recovery rates, and the potential utilisation synergies (EOR combined with carbon capture and storage (CCS) measures).

Despite all of the technical advances which have been made to date, conventional production is still the cheapest oil production method in most cases. As a result, the development of new (conventional) fields, or previously unused parts of fields, also leads to increases in production without using EOR, and in many cases, clearly represents a lower level of corporate risk. This also applies to Germany where the expansion of production capacities in the last 70 years has primarily been achieved by new wells and the reinjection of formation water. One of the reasons why EOR technologies are hardly used in Africa and the Middle East is because reserves are still very high, and there are still a large number of fields which only require the use of conventional production methods.

The price of crude oil began to decline rapidly from the middle of 2014 because of the rising production rates from non-conventional reservoirs in the USA, and the continuation of high production rates in Russia and the Middle East. An immediate consequence of this was to make many EOR projects unprofitable. SAGE (steam assisted gravity drainage) projects in Canada and the USA for instance are only profitable at crude oil prices above 60 USD/bbl (Oilprice.com 2015). Depending on the source, the costs for CO_2 are between 40 USD/t to 60 USD/t. When the additional costs for transport and infrastructure are included, CO_2 flooding as an EOR measure only becomes profitable above a crude oil price of around 75 USD/bbl (Condor et al. 2010).

The IEA forecasts that the rise in the level of production from non-conventional reservoirs will be a much larger than that achievable using EOR (IEA 2013, 2014). For this reason, and because of the current low crude oil price, it is likely, in the short term at least, that there will be a decline in boosting production using EOR methods (Fig. 28). Long-term forecasts, however, predict a significant increase in the proportion of EOR compared to crude oil produced by other means up to 2040 (IEA 2014).

EGR world-wide

Because of the strong expansion of natural gas during production, it is usually possible to recover up to 80 % of the gas originally present in a reservoir. This is much higher than the oil recovery rate from an oil field. Instead of EGR, the use of fracking (an IGR method, see above) is the most important method for boosting the production in natural gas fields. Nevertheless, research is being carried out around the world on the use of N_2 and CO_2 for EGR methods. For instance, the use of CO_2 has been frequently discussed in recent years in the same breath as the simultaneous storage of CO_2. However, only a very small number of EGR field tests were carried out before 2008 (Turt et al. 2008, Pápay 1999). One example is the “Budafa Szinfelleti” gas field in Hungary. A CO_2-rich natural gas (80 % CO_2, 20 % CH_4) was used from a neighbouring field between 1986 and 1994 to produce a qualitatively improved natural gas. This enhanced the recovery by around 25 %. In the “St. Claire sur Epte” natural gas storage in France in the 1980s, N_2 was used as part of the cushion gas – which always remains in the storage. During the observation period, no problems were identified, such as the mixing of the gases (Laille et al. 1988). The use of N_2 and CO_2 as an EGR method was investigated in the DeWijk field in the Netherlands in 2014. The field test and simulations revealed that the use of CO_2 and N_2 enhanced similarly the production, but that enhanced recovery of only 1 % could be expected (Leeuwenburgh et al. 2014). EGR is therefore considered to have much lower potential than EOR.

Conclusions

- There is a very wide range of EOR methods, and some techniques have been successfully used for many decades. This means that the use of EOR can be seen as highly reliable, and with a high probability of success.
- The International Energy Agency (IEA) forecasts that enhanced recovery from EOR around the world will account for around 1.5 % of total production in 2013 and 2014. This share is predicted to rise to around 5.5 % of global annual production in 2040.
  - A share of additional oil produced using EOR methods in Germany is currently 12.1 %. Steam flooding is the only method used commercially in Germany.
  - Around 7.8 % of crude oil produced in the USA is derived from EOR projects. The highest proportion of this comes from the use of the CO_2 flooding method.
- Despite the considerable amount of energy involved, thermal EOR methods, such as steam flooding, will continue to be very important in the future as well. The relevance of CO_2 flooding will probably also increase because this method has a high degree of efficiency and can be combined with CO_2 storage.
- For countries in particular with strongly depleted oil fields, EOR offer the potential to maintain production levels. However, competition with other sources of crude oil, such as shale oil, as well as the current low crude oil price, mean that enhanced production by the use of EOR methods will probably decline in the next few years at least, as forecast by the IEA.

This section is based on a study undertaken in 2014/2015 on BGR's behalf by Prof. M. Amro at TU Freiberg. Other references, data and the content of the study can be provided by BGR upon request.

4.2 The importance of geothermal energy for the East African energy sector

The energy demand of the countries in East Africa has risen over proportionally for many years. Of the measures implemented to improve the infrastructure, those involved in expanding the power generation capacity and enlarging the power gridplay a crucial role in the industrialisation, economic development, and therefore improvement in prosperity of this region. In addition to considerable deposits of crude oil, natural gas and coal in some parts, the East African region also has a huge, so far barely harnessed potential for renewable energy throughout the region. The use of geothermal energy along the East African Graben system has been discussed and pursued in this context since the 1970s. Because of the reliable base-load capacity, the development of geothermal resources for power generation, as well as for a large number of direct thermal application possibilities, plays a key role in the overall development of the region.

Economic situation, energy and power production

Around 390 million people live in the countries along the East African Graben system (Ethiopia, Burundi, D.R. Congo, Djibouti, Eritrea, Kenya, Comoros, Malawi, Mozambique, Rwanda, Zambia, Tanzania, and Uganda). More than two thirds live in rural settlements, where four fifths of the energy requirements are covered by firewood and charcoal. Electricity is almost only available in urban areas. Less than one quarter of all households have access to electricity (Tab. 5, Fig. 29). The further development of agriculture, the trades, industry and the services sector therefore depends on a continuous growth in electricity generation. Economic growth in the region is currently around 5.9 %, and therefore well above the current global average of 3.5 %. This, and the huge amount of work still required to create a modern energy infrastructure, are behind the rapid expansion in power generation capacities.

The growth between 2005 and 2012 alone was 26 %, a rise from 10.64 GW_e to 13.36 GW_e. Power generation rose from 45.61 GWh to 61.37 GWh (plus 35 %) by the commissioning of new hydroelectric power plants in Ethiopia, by raising the efficiency of thermal heavy oil power plants, and by commissioning of several new geothermal power plants in Kenya. Hydroelectric power plants currently generate 84 % of the total electricity in the region, thermal power plants account for 11 %, and the geothermal power plants in Kenya supply 4 %. Photovoltaics, windpower and biomass play a minor role, and none of the countries plans to use nuclear power (Tab. 6). Mozambique, Tanzania and Uganda are considering the development and use of their own natural gas and oil fields, as well as the construction of coal-fired power plants. The rising energy demand in Kenya, Rwanda, Tanzania and Uganda can only be satisfied by increasing the imports of crude oil, and enhancing the capacity of thermal heavy oil power plants.

Table 5: Countries along the East African Graben system, with data on population and the economy

	Population 2015 (Million)[1]	GDP 2014 (USD)[2]	Growth GDP 2014 (%)[2]	Poor Population (%)[3]	Urban Population 2015 (%)[4]	Household connected to grid (%)[5]
Ethiopia	90.076	568	9.9	29.6	18	41
Burundi	9.824	295	4.7	n. s.	12	2
D.R. Congo	77.267	3,101	9.0	46.5	62	11
Djibouti	0.888	1,784	5.5	n. s.	78	50
Eritrea	5.228	590	1.7	n. s.	21	32
Kenya	46.050	1,338	5.3	n. s.	25	23
Comoros	0.785	861	3.0	n. s.	28	46
Malawi	16.310	272	5.7	72.2	16	8
Mozambique	25.728	451	7.4	n. s.	31	14
Rwanda	11.263	652	7.0	44.9	24	7
Zambia	15.474	1,802	6.0	60.5	39	19
Tanzania	53.470	998	7.0	28.2	28	14
Uganda	34.857	677	4.5	19.5	15	9
Total	**387.219**	**1,030**	**5.9**	**43.1**	**31**	**21**

Sources [1] Population Statistics by Country 2010 and 2015 (http://www.en.wikipedia.org/wiki/List_of_countries_and_dependencies_by_population)

[2] World Bank (2014a) (GDP: per capita, per year)

[3] World Bank (2014b)

[4] UN-ESA (2014)

[5] Reegle (2015)

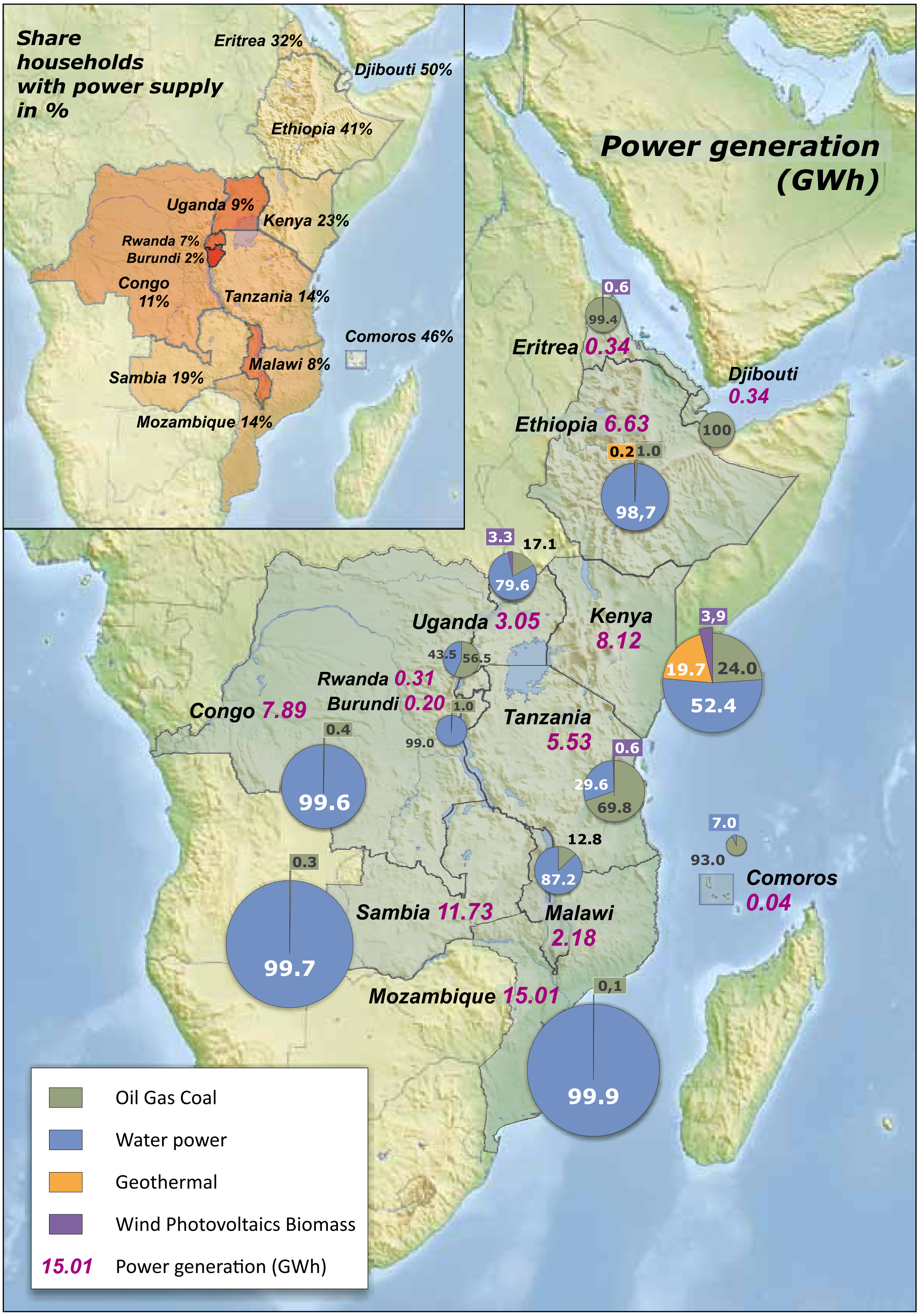

Figure 29: Countries along the East African Graben system with shares of primary energy sources in overall power production, and number of households with electricity (see box).

Table 6: PEV, power generation and shares of the primary energy sources (DATABASE as at 2012)

	PEV 2012 (PJ)	Installed capacity (GW_e)	Power Production (GWh)	Losses (%)	Anteile an der Stromerzeugung: Crude oil, Natural gas, Coal (%)	Hydro-power (%)	Geother-mal (%)	Wind, PV, Biomass (%)
Ethiopia	66.5	2.47	6.63	15	1.0	98.7	0.2	
Burundi	2.1	0.06	0.20	7	1.0	99.0		
D.R. Congo	127.7	2.48	7.89	8	0.4	99.6		
Djibouti	0.0	0.13	0.34	7	100.0	0.0		
Eritrea	10.6	0.14	0.34	16	99.4	0.0		0.6
Kenya	251.1	1.85	8.12	19	24.0	52.4	19.7	3.9
Comoros	2.1	0.02	0.04	7	93.0	7.0		
Malawi	20.0	0.30	2.18	7	12.8	87.2		
Mozambique	414.6	2.44	15.01	15	0.1	99.9		
Rwanda	1.1	0.10	0.31	7	56.5	43.5		
Zambia	117.1	1.82	11.73	24	0.3	99.7		
Tanzania	54.9	0.85	5.53	19	69.8	29.6		0.6
Uganda	25.3	0.71	3.05	7	17.1	79.6		3.3
Total	**1,093**	**13.36**	**61.37**	**16**	**10.6**	**84.2**	**4.4**	**0.8**

Source: EIA (2015f)

Djibouti, Eritrea and the Comoros have very minor or no hydroelectric power potential, and produce their electricity almost exclusively from imported heavy oil. The hydroelectric power potential has also been largely harnessed, except in Ethiopia and D.R. Congo. Ethiopia already produces 99.6 % of its total electricity needs from hydroelectric power, and expanded its capacities from 0.8 GW_e to 2.5 GW_e from 2005 to 2012. A planned capacity of 45 GW_e is scheduled. The Grand Ethiopian Renaissance Dam on the border to Sudan, with an installed capacity of 6 GW_e will be the largest hydroelectric power plant in Africa, and is scheduled to be commissioned in 2017 with an annual production of 15,000 GWh (EEPCO 2015). Transnational power trading is currently insignificant, but will gain in regional importance with the development of all Ethiopian hydroelectric power capacities. One of the bottlenecks for regional power transmission is the quality of the electricity grid, with its high transformer and distribution losses averaging 16 % (EIA 2015f). These losses currently total around 9.6 GWh, which corresponds to more than the electricity generated in Kenya per year.

Potential and development of geothermal energy in East Africa

The geothermal resources suitable for power generation in the countries along the East African Rift system are patchily distributed (Tab. 7). In general, the potential decreases from north to south. Around 95 % are located in the northern and central sections of the eastern rift, but only around 5 % in the western rift. The eastern rift is characterised by active volcanism and shallow high-enthalpy reservoirs (> 200 °C). This region includes the coastal area of the Red Sea, and the Afar triangle (Eritrea, Djibouti, Ethiopia), the Ethiopian Main Rift, the Kenyan Gregory Rift, as well as northern Tanzania (Kilimanjaro), and the Ngozi region in south-western Tanzania, where the eastern and western rift come together. The western rift (Uganda, D.R. Congo, Ruanda, Burundi, Tanzania, Zambia, Malawi, Mozambique) is older, and filled with thick packages of sediment, covered by lakes, has either minor or extinct volcanic activity, and is characterised by low to medium enthalpy reservoirs (< 100 °C and/or 100 °C to 200 °C respectively; Mcnitt 1982; Chorowicz 2005, Hochstein 2005).

A total geothermal potential of around 17 GW_e could be developed in East Africa using today's conventional exploration methods and power plant technologies (single flash, binary), as well as feed-in payments which cover the costs (0.08 USD/kWh to 0.10 USD/kWh in the eastern rift, and 0.30 USD/kWh to 0.35 USD/kWh in the western rift) (Tab. 7; RGCU 2015a). This means that the exploitable geothermal potential is much higher than the total hydroelectric and thermal capacities currently installed in the region (13.6 GW_e). Further developed exploration and production methods, drilling technologies, and well treatment methods (e.g. EGS), as well as advances in power plant technologies, will presumably also enhance the currently identifiable potential in East Africa in the next decades as well.

Table 7: Geothermal power generation: exploitable and estimated potential; installed and produced capacities 2010 and 2015, as well as a projection for 2020

		2010		2015		2020
	Potentiel (MW_e) [1]	Installed (MW_e) [2]	Produced (GWh) [2]	Installed (MW_e) [2]	Produced (GWh) [2]	Installed (MW_e) [3]
Ethiopia	7.000	7,3	0	7,3	0	50
Burundi	25					
D.R. Congo	150					
Djibouti	1.000					60
Eritrea	1.000					50
Kenya	7.000	202	1.430	627	2.942	1.500
Comoros	100					20
Malawi	50					
Mozambique	25					
Rwanda	100					20
Zambia	25	0,12	0	0,12	0	2
Tanzania	650					
Uganda	150					
Total	**17.275**	**209,4**	**1.430**	**634,4**	**2.942**	**1.702**

Sources: [1] RGCU (2015a)
[2] Bertani (2015), Omenda & Simiyu (2015)
[3] RGCU (2015b)

Fumaroles and hot springs – which can be visible surface indicators of geothermal reservoirs – were already described and mapped across the whole of East Africa as early as the first half of the 20th century. The Kenyan government has had plans for geothermal power generation since the middle of the 1960s. The first systematic geophysical and geochemical surface studies and drilling programmes were carried out in Ethiopia and today's Eritrea and Djibouti between 1969 and 1984 as part of a UNDP programme (UNDP 1973). The secession of Eritrea, and the civil wars in Ethiopia and Djibouti, delayed further developments in these areas, whilst the first geothermal power plant in Africa was commissioned in Olkaria in Kenya in 1982, with a capacity of 15 MWe (Moussa et al. 2015; Omenda & Teklemariam 2010). Although a power plant was constructed in Zambia in the middle of the 1980s as part of an Italian-Zambian co-operation project, it has never been commissioned. Development wells were drilled in Aluto Langano in Ethiopia from 1991 onwards, and a power plant with a capacity of 7.3 MW_e was built in 1998 (Kebeda 2009; Kebede & Assaye 2014).

The development of geothermal energy has now become the basis for an ambitious government overall development plan in Kenya ("Vision 2030", Tab. 8), with the aim of significantly improving the industrialisation of the country, and the living standards in Kenya (Government of Kenya 2008). The public energy utility KenGen, and the private sector company ORMAT, have already now connected 13 power plants in the Olkaria field to the grid, with a total capacity of 627 MW_e. KenGen, and the state exploration service provider GDC, founded in 2009, have plans to develop another 980 MW_e by 2018 in co-operation with private sector companies. Electricity generated using geothermal energy already had a share of 38 % of total power production in Kenya in 2014. Despite their successes to date, there is still enormous optimisation potential in Kenya as well: an international comparison reveals that the exploration costs are high, and comparable geothermal power plants in Europe and New Zealand produce 50 % more electricity (around 6.9 GWh/MW_e annually, compared to 4.6 GWh/MW_e in Kenya; Bertani 2015), not to mention the approximately 18 % losses in the transformer, long-distance power line and distribution systems (Tab. 8).

In 2009, the 13 East African countries considered here officially requested the African Union (AU) to promote the development of the geothermal sector in the region. The key challenge was identified as the high exploration and financial risk of loss during the exploration phase. Based on the experience gained from the BGR GEOTHERM programme, the AU and the Kreditanstalt für Wiederaufbau (KFW) developed the Geothermal Risk Minimisation Facility (GRMF) in 2011. This facility was stocked with funding totalling USD 130 million by the Federal Ministry for Economic Co-operation and Development (BMZ), the EU-Africa Infrastructure Fund (EU-Africa ITF), and the Department for International Development (DFID) in the UK. The GRMF awards grants to private investors and public sector developers (state geological surveys) for surface studies, exploration drilling, and the necessary infrastructure measures (Mayer 2014). The aim of the subsidies is to support projects during the development phases, and thus enable the construction of geothermal power plants with a planned total capacity of 2.7 GW_e.

Table 8: Geothermal power plants in Kenya (as at September 2015)

Site	Plant	Operator	Connected to grid since	Status	Type*	Installed Capacity (MW_e)	Work-load (MWe)	Energy Produced (GWh/y 2014)	Planned
Olkaria	Olkaria I	KenGen	1981	Connected to grid	SF	15.0	15.0	125.9	
		KenGen	1982	Connected to grid	SF	15.0	15.0	125.9	
		KenGen	1985	Connected to grid	SF	15.0	15.0	125.9	
Olkaria	Olkaria II	KenGen	2003	Connected to grid	SF	70.0	70.0	488.8	
	Olkaria II - Unit 3	KenGen	2010	Connected to grid	SF	35.0	35.0	275.9	
Eburru	Eburru	KenGen	2010	Connected to grid	B	2.5	2.5	19.7	
Oserian	Oserian	KenGen	2003–2006	Connected to grid	B	4.0	1.8	1.8	
Olkaria	Olkaria Wellhead OW37	KenGen	2013	Connected to grid	SF	5.0	5.0	39.4	
Olkaria	Olkaria Wellhead OW43	KenGen	2014	Connected to grid	SF	12.8	12.8	100.9	
Olkaria	OrPower 4 - Unit I	ORMAT	2000	Connected to grid	B	52.8	52.8	416.3	
	OrPower 4 - Unit II	ORMAT	2008	Connected to grid	B	39.6	39.6	312.2	
	OrPower 4 - Unit III	ORMAT	2014	Connected to grid	B	17.6	17.6	138.8	
Olkaria	Olkaria IV - Unit 1	KenGen	2014	Connected to grid	SF	70.0	70.0	148.2	
	Olkaria IV - Unit 2	KenGen	2014	Connected to grid	SF	70.0	70.0	148.2	
Olkaria	Olkaria I - Unit 4	KenGen	2014	Connected to grid	SF	70.0	70.0	148.2	
Olkaria	Olkaria Wellhead	KenGen	2014	Connected to grid	SF	32.8	32.8	92.6	
Olkaria	Olkaria Wellhead	KenGen	2014	Connected to grid	SF	30.0	30.0	84.7	
Olkaria	Olkaria I - Unit 5	KenGen	2014	Connected to grid	SF	70.0	70.0	148.2	
Menengai	Menengai	KenGen	2015	under con-struction	SF				105
Silali	Silali	KenGen	2017	planned					200
Longonot	AGIL	AGIL	2017	planned					70
Suswa	Suswa	KenGen	2017	planned					150
Olkaria	Akiira One	Akiira One	2017	planned					70
Menengai	Menengai	KenGen	2017	planned					360
Eburru	Eburru	KenGen	2018	planned					25
Total						**627.1**	**624.9**	**2,941.6**	**980**

* SF = Single Flash, B = Binary

In addition to ameliorating the risk of loss of unsuccessful drilling activity, the core of the AU's regional geothermal programme also includes creating positive regulatory, legislative and investment-promoting conditions, and the targeted training of experts. The implementation of this regional programme is supported by BGR, the Department for International Development (DFID) in the UK, The development agencies in Iceland (ICEIDA), New Zealand (MFAT), and the USA (USAID), as well as the UN-financed African Rift Geothermal Development Facility (UNEP-ARGeo), the World Bank and the African Development Bank AfDB. This support includes ICEIDA advising geological surveys on exploration plans, whilst UNEP-ARGeo developed the regional geothermal database, and the concept for the African Geothermal Centre of Excellence (AGCE) – an initiative for training 1,000 East African experts in the next five years. Together with the AU, and representatives of all countries in the region, BGR's contribution in 2015 included binding drilling guidelines for deep geothermal wells, as well as environmental and safety standards. In addition, in a co-operation with geological surveys, and energy and mining ministries in Kenya, Uganda, Rwanda, Ethiopia, Eritrea and Tanzania, a large number of projects were implemented to identify drilling locations, and undertake surface studies, aerial surveys with thermal cameras, seismological monitoring, and workshops on geochemical and geophysical exploration measures, structural geology and GIS.

Outlook

Over the past 15 years, the states in the region have identified the huge economic importance of their high-enthalpy geothermal reservoirs. Ethiopia, Tanzania and Djibouti in particular are now pursuing strategies derived from the successful Kenyan model. BGR has supported this development since 2003 as part of the GEOTHERM programme. After early difficulties, the GRMF risk-minimisation facility of the AU/KfW has currently entered the 4th application round, and is now considered a success with respect to the number of applications. An AUC forecast predicts that the installed capacity will rise from its current level of 634 MW to 1,702 MW in 2020. And in addition to the current geothermal countries Kenya and Ethiopia, it is forecasted that another five countries will begin to utilise their resources. The GRMF projects funded in the first two application rounds will already add an installed capacity of around 1 GW once they have been completed, and another 1.6 GW could be added after implementation of the projects approved in the third application round. The fact that additional fields are already being developed in Kenya, Ethiopia and the Comoros indicates that geothermal energy has now moved on from Kenya alone, and made its break-through in East Africa as a whole.

4.3 Crude oil and natural gas – Significance and potential for developing and emerging economies

The crude oil and natural gas production in developing and emerging economies is of major importance for both the global market as well as for the countries themselves. Nevertheless, there are many challenges involved in effectively and sustainably using the hydrocarbon sector as a basis for development. The following therefore looks at the potential and opportunities which the production of hydrocarbons offers developing and emerging economies, as well as reviewing the risks and challenges. Approaches for German development co-operation are also highlighted.

Status of crude oil and natural gas production

According to the definition of the Organisation for Economic Co-operation and Development (OECD 2015), the world's 20 largest oil and gas producing countries include eleven and ten developing and emerging economies respectively. In 2014, developing and emerging countries accounted for a share of over 40 % of global crude oil production, and a share of over 30 % of natural gas production worldwide (Fig. 30). Hydrocarbon production in developing and emerging countries is therefore of major importance for the global market. The largest oil producing countries amongst the developing and emerging economies include China, Iran, Iraq, Venezuela and Mexico. The two largest oil producers in Africa are Nigeria and Angola. Iran also plays an important role for natural gas production, and was the third largest natural gas producer world-wide in 2014. Other major natural gas producers amongst developing and emerging countries are China, Algeria, Indonesia and Turkmenistan.

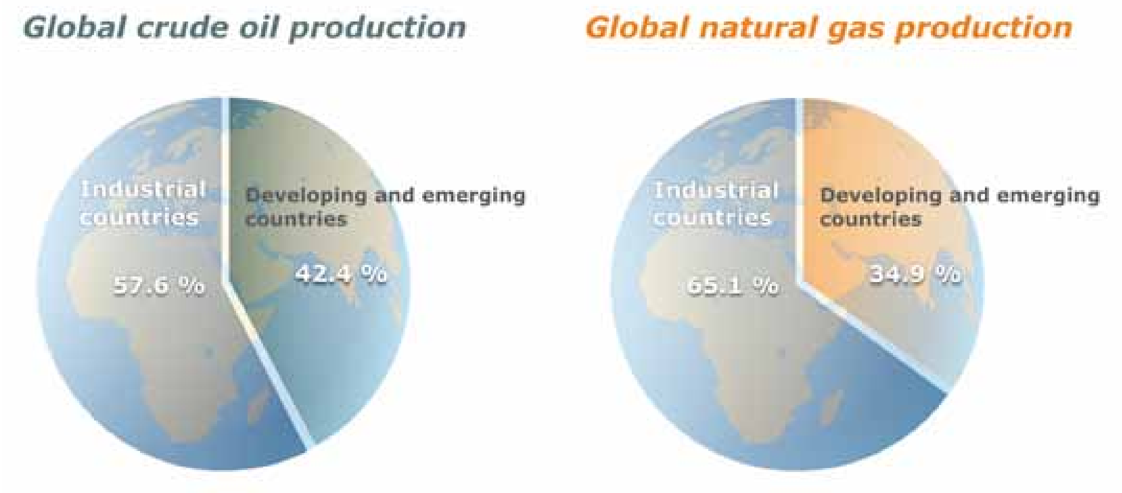

Figure 30: Share of developing and emerging economies in the global production of hydrocarbons in %.

Germany imported almost 35 % of its oil needs from developing and emerging economies in 2014. The most important suppliers include Nigeria, Kazakhstan, Azerbaijan and Algeria. With regard to natural gas, developing countries have so far played hardly any role at all for imports to Germany.

A look at the reserves and resources of crude oil and natural gas reveals that the significance of developing and emerging economies for the global supply of hydrocarbons is likely to rise even more in the future. A typical example here is the East African region where major oil and gas discoveries in Tanzania, Mozambique, Kenya and Uganda in recent years have attracted a great deal of international attention. In Tanzania alone, the natural gas resources are estimated to lie in the range of 1,500 billion m^3 – primarily offshore – which corresponds to a major potential even at a global scale. In the light of this potential, multinational resource companies have strengthened their exploration activities in these countries. Production has already begun from the Songo Songo and Mnazi Bay natural gas fields which are located predominantly onshore. The natural gas from these fields is used to generate electricity in Dar-es-Salaam and Mtwara, as well as by local industries. Oil and gas exploration by international companies has also begun in other countries in the region, such as Kenya, Somalia, Uganda and the Comoros.

Economic significance of the oil and gas sector

In addition to the importance of developing countries oil and gas production for the global market, the hydrocarbon sector is also of crucial economic importance for the countries themselves. According to estimates made by the World Bank, of the 20 countries in which the crude oil sector accounted for the largest share of gross domestic product (GDP) in 2013, 13 were developing countries. In this group, the oil sector had a share of over 20 % in each case. Among these countries were also four of the least developed countries in the world: Angola, Chad, Equatorial Guinea and South Sudan (Fig. 31). In four other developing countries – Ecuador, Yemen, Nigeria and Turkmenistan – the oil sector accounted for a share of over 10 % of GDP (World Bank 2015b). With the exception of Nigeria and Angola, none of the aforementioned countries are ranked in the top 20 oil producing countries world-wide, but because of the relatively small national economies, and/or their lack of economic diversification, the oil sector plays a major role.

In terms of economics, the natural gas sector is generally less significant than the oil sector. It only accounts for a share of GDP of over 10 % in Uzbekistan and Turkmenistan. Here as well though, 13 of the 20 countries in which the natural gas sector accounts for the largest proportion of GDP, were developing countries (World Bank 2015c).

Government revenues from the oil and gas sector are enormous in some cases. According to a report by the Extractive Industries Transparency Initiative (EITI), the oil and gas sector generated revenues exceeding USD 60 billion in Nigeria in 2012 (EITI 2014). This is many times higher than the USD 1.9 billion in development aid which the country also received in the same year according to the World Bank (World Bank 2015a). In addition to crude oil exports, the domestic use of hydrocarbons in the transport sector in particular, opens up considerable economic potential.

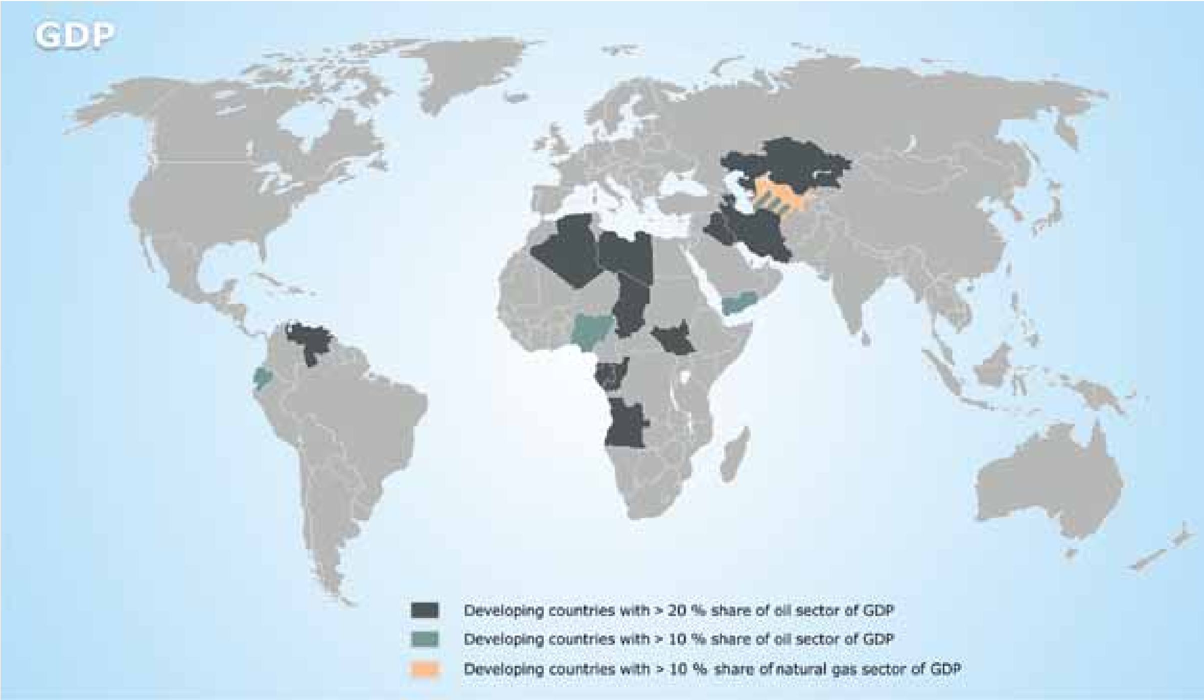

Figure 31: Developing and emerging economies with over 10 % and 20 % shares in gross domestic product of the crude oil and natural gas sectors respectively (World Bank 2015b, World Bank 2015c).

Natural gas can play an important role in improving power supplies in developing countries, particularly in Africa. Whilst between 80 % to 90 % of the population in Asia and Latin America already have access to electricity, the same applied to only 32 % of the population of sub-Saharan Africa in 2012. In many East African countries, only 20 % or less of the population have access to electricity (IEA 2015c). The deficits here alongside poorly developed power grids, also include the lack of generation capacity. These deficits could be reduced by using natural gas which could also balance out the fluctuations in output which are typical of power generation from renewables. Natural gas production in Tanzania has increased the share of natural gas in power generation to over 30 %. In addition to power generation, natural gas products such as liquefied petroleum gas (LPG) are also a relatively clean alternative to traditional fuels (dung and wood), whose use in private households in developing countries has often been associated with detrimental health effects.

Risks and challenges

In general, oil and gas exploration, as well as production and utilisation, in developing countries face similar challenges and risks to those associated with other mined resources. It is first necessary to have the proper infrastructure in-place – e.g. for transport and reprocessing – before crude oil and natural gas can even be utilised. For instance, the refinery capacities for crude oil in many African countries are inadequate, because there are not enough plants, the capacities of the existing refineries are too small or the refineries are out of date, and they can therefore no longer operate at full capacity. As a result of such shortcomings, Nigeria, the largest crude oil producer in sub-Saharan Africa, exports a large proportion of its crude oil, and then re-imports refined petroleum products.

A major challenge in many countries is implementing environmentally sustainable crude oil and natural gas production. There is a general lack of environmental regulations for the hydrocarbon sector, and even if legislation is in-place the competent authorities often lack the capacities to enforce compliance. One of the most well-known examples of environmental damage caused by the oil sector is in the Niger delta. Amnesty International (2015) estimates that more than 500 oil spills took place there in 2014 from facilities operated by Shell and ENI. The pollution was caused by accidents or failure to maintain the facilities properly, as well as the sabotage of facilities with the aim of stealing the crude oil. The Nigeria Extractive Industries Transparency Initiative (NEITI) estimates that more than 136 million barrels of crude oil were stolen between 2009 and 2011, corresponding to an estimated loss of USD 10.9 billion in revenues for the Nigerian government. These uncontrolled leaks simultaneously damage the surrounding areas, and thus detrimentally affect the livelihoods of some of the local inhabitants (e.g. fishermen).

Other associated negative impacts are economic risks such as the "Dutch disease". This foreign trade paradox can occur when the export of large quantities of natural resources gives rise to foreign trade surpluses and thus to a strengthening of the national currency. This decreases the competitiveness of other industrial sectors, which in extreme cases, can lead to their complete disappearance. These problems have been or are observed in many oil and gas-producing countries, such as Nigeria and Mexico. In addition, there is a risk of insular exploitation in the oil and gas sector without any local value added, and in particular without any significant positive effect on the national employment situation.

Good governance, state regulation, and well trained personnel in the relevant state authorities can counteract these challenges. However, this is precisely where capacity is lacking. There is often a shortage of basic information, such as geological information on the size of the country's own oil and gas resources. Badly negotiated contracts and insufficient regulations, as well as corruption, can also lead to the natural resources sector not being adequately harnessed for the benefit of the affected countries.

German development co-operation in the oil and gas sector

There have only been isolated projects in the past in the hydrocarbons sector as part of German development co-operation activities. The Federal Ministry for Economic Co-operation and Development (BMZ) published the position paper "Does oil develop?" in 2006. This paper evaluates the extent to which the development objectives can be financed by revenues from the crude oil sector – and determined that the oil sector has major potential for funding development. Financial transparency and improvement in the administration of revenues from the oil sector are already being supported in some oil producing developing countries such as Ghana, by supporting the adoption and implementation of EITI. However, beyond this, only limited assistance has been provided on how to utilise the development potential offered by this sector, and how to minimise the risks which are associated with the production of hydrocarbons. The BMZ strategy paper "Sustainable Energy for Development" (2007), primarily focuses on the promotion of renewables in developing and emerging economies. The strategy paper "Extractive Resources in German Development Cooperation" published by BMZ in 2010 however focuses on the extractive sector in general, and also includes energy resources such as crude oil and natural gas. Nevertheless, implementation so far has mainly focused on the mineral resources sector.

Potential development cooperation activities in the hydrocarbon sector can be derived from the BMZ strategy paper "Extractive Resources in German Development Cooperation", such as:

- Assistance in the establishment and administration of the necessary databases (maps, geophysical data, field and reservoir registry)
- Training experts in the hydrocarbons sector, such as geophysicists to interpret data, and to evaluate feasibility studies
- "Institution building" by advising the ministries involved, establishing and strengthening of competent authorities
- Support in creating legal frameworks and regulations, in particular to improve environmental sustainability and occupational health standards.

The socially and environmental-friendly production of hydrocarbons is of fundamental importance for the sustainable economic development of developing and emerging economies. Stable conditions in producing countries are an important prerequisite for safeguarding the energy supplies to industrial countries in general, and Germany in particular, which imports a large proportion of its crude oil from such countries.

5 FUTURE AVAILABILITY OF FOSSIL ENERGY RESOURCES AND DEEP GEOTHERMAL ENERGY

5.1 Supply situation and future demand

This study analyses the global capacities and potential for energy and energy resources. The main focus continues to be the provision of information on non-renewable energy resources. The quantities that will be extracted and consumed in future are dependent on many factors, and only foreseeable to a limited extent. The projected consumption of these energy sources until 2040 according to the IEA's New Policies Scenario (2015f) can be used as the basis for the long-term comparison of supply and demand (Fig. 32). 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 reserves which far exceed the demand. And the comprehensive level of resources (compared to the reserves) indicates that large and so far unexploited potential exists which can be reclassified as economically extractable resources. Non-conventional hydrocarbon deposits in particular – which are already being extracted at a large scale – 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. In addition, oil production is also beginning to drop for technical reasons even though large reserves and resources are still available. According to the IEA scenario, around half of the crude oil reserves identified today will have been consumed by 2040.

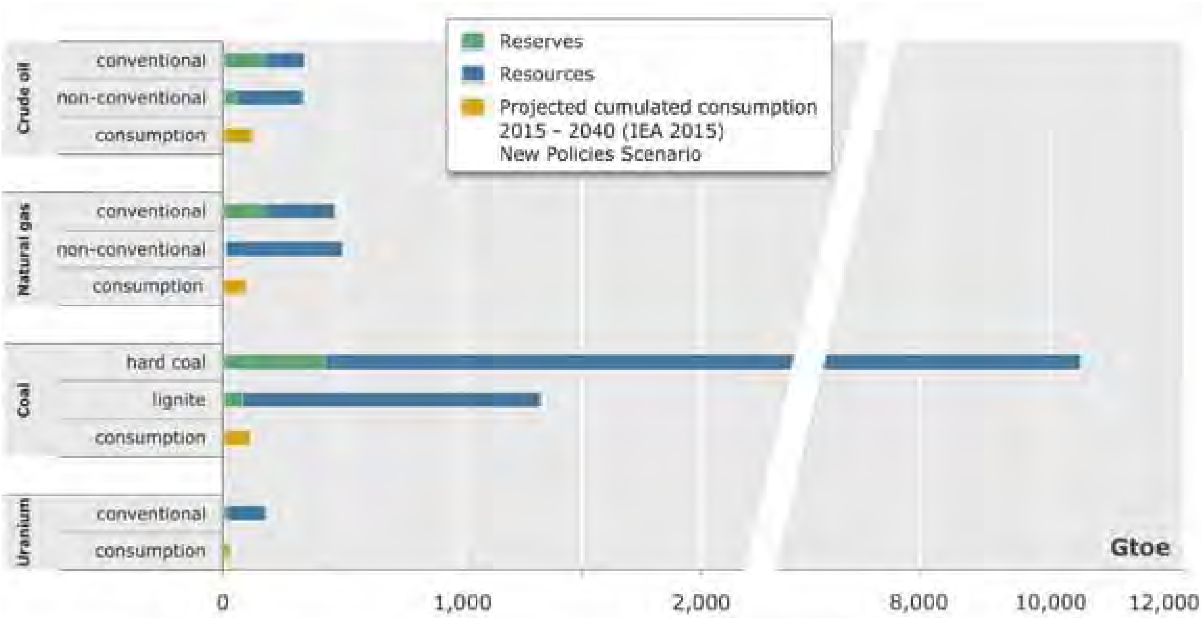

Figure 32: Supply situation of non-renewable energy resources at the end of 2014.

5.2 Summary and outlook

Crude oil

During the 2014 reporting period, there were only minor changes for crude oil compared to the previous year. Resources alone have risen significantly by around 2.8 % as a result of re-evaluations in some countries of the crude oil resources in tight rocks. Because of the low oil price, the continuing high production levels, the increase in demand, and lower investments in the hydrocarbon sector, major changes are expected from 2015 onwards. Independent of these short-term influencing factors, however, supplies of crude oil are expected to be safe in the next few years from a geological point of view, even with a further moderate rise in demand. The decline in production from some OPEC and African countries was more than compensated for, mainly by increases in production in North America and Latin America, as well as OECD countries (plus 4.8 % in this case). There was also another steep rise in the USA in the production of tight oil in 2014.These production capacities only showed signs of levelling off during the course of 2015. There has been no global expansion in the production of tight oil, and this is also deemed unlikely given the low oil price at the moment. In addition to the USA and Canada, Argentina has also begun to produce small amounts of tight oil.

The oil industry reacted with cost savings measures in the second half of 2014 as a consequence of the oversupply of crude oil on the global markets and the associated low oil price. The losses in revenues are to be curtailed by implementing efficiency boosting measures in drilling and production operations, as well as postponing or cancelling development projects – particularly in expensive frontier regions such as the Arctic or in deep water areas, as well as measures including the sale of licenses and shrinking the size of the workforce. Depending on the future development in the price of oil, many companies are facing serious and in some cases existential challenges which could lead to considerable structural adjustments in the sector. The savings in investments being made by the oil industry could lead to production shortages again in the medium to long term, which in turn would lead to increases in prices.

Natural gas

With a share of 23.7 % of global primary energy consumption in 2014, natural gas was again the third most important energy source behind crude oil and coal. The high growth forecasts predicted for natural gas only a few years ago, have proven over optimistic. When adjusted for production, 2014 saw another increase in global natural gas reserves. Even in the light of the foreseeable rise in demand, the high remaining natural gas potential can ensure that the world continues to be supplied with gas for many decades to come. By expanding its shale gas production, the USA was able to cover around 95 % of its high natural gas demand from domestic fields in 2014. The global trade in natural gas has declined overall compared to the previous year. However, the trade in LNG has risen at the expense of pipeline-transported natural gas. Rising quantities of LNG will come onto the market in the next few years, which could make the supply situation more comfortable. Thanks to an integrated and growing supply grid, Germany and Europe are connected to a large proportion of global natural gas reserves via pipelines and LNG unloading terminals. Geopolitical risks are a key factor governing natural gas supplies.

Coal

The global inventories of hard coal and lignite would also be able to cover growing demand for many decades from a geological point of view. For the first time in the new millennium, global coal production declined year-on-year in response to the demand situation. Production sank by around 1 % in 2014 to around 8,176 Mt. This is relativized, however, by the fact that production almost doubled in the last 15 years, during which time it boasted the highest growth rates by far of all of the fossil energy resources. Despite a further decline in global market prices for coal, and the continuing low freight rates, global coal trading stagnated in 2014. There is a constant rise in the importance of the Pacific market: almost three quarters (73 %) of global coal imports are accounted for by Asia. The largest hard coal producer by far is China, which has also been the world's largest hard coal importer since 2011, currently accounting for around one fifth of all global hard coal imports. India is currently aiming to displace the USA as the world's second largest coal producer by the end of this decade. India has experienced strong growth in the import of hard coal in recent years, and overtook Japan for the first time as the second largest importer.

The consolidation phase in the global coal sector which began in 2012 will also continue beyond 2015. On the one hand, mines with high production costs are being closed, and on the other hand, new, highly productive coal mines are still being commissioned world-wide. A comfortable market situation from the point of view of consumers can be expected in the short to medium term in the light of the slower growth or even temporarily stagnating demand for coal predicted from today's point of view. The global trend of continuous and strongly growing demand for coal was broken in 2014 for the first time in the new millennium. Nevertheless, the demand for coal will foreseeably continue to grow further although at a lower rate than previously, and also continue to be primarily influenced by Asian countries.

Nuclear fuels

Because of the very comprehensive global inventories of uranium, no shortage in the supplies of nuclear fuels is expected in the foreseeable future from a geological point of view. Unlike in Europe where the demand for uranium will probably continue to decline in future, a rise in uranium consumption is expected particularly in emerging and developing economies in the Asian and Middle East regions. A moderate rise in uranium demand is also expected in the following decades in North America, Latin America and Africa. The uranium market continues to be characterised by relatively low spot market prices, which jeopardise the economic viability of some mines and exploration projects because these are becoming increasingly expensive and time-consuming. Global mine production failed to rise for the first time since 2007, and declined by 6 % compared to the previous year. An increase in production is expected again in the medium term in the light of the foreseeable rise in global demand.

Deep geothermal energy

There is an increasing trend in the use of geothermal heat in general. Further expansion will be primarily influenced by the development in costs compared with other energy sources, as well as the geopolitical situation in each case. IEA (2011) forecasts a global expansion in geothermal energy of up to 1,400 TWh_e for electricity, and 1,600 TWh_{th} for thermal energy by 2050. This corresponds to a share of global production of 3.5 % and 3.9 %, respectively. IPCC (2011) forecasts similar figures: geothermal energy could cover 3 % of global power demand, and 5 % of global heat demand by 2050. The economic potential for geothermally-generated power in Europe in 2050 is forecast to total 4,160 TWh_e

Renewables

“Modern” renewables such as windpower and solar power moved out of their small market niches long ago, and are now well established global energy resources. Renewables now account for around 1,800 GW of installed power generation capacity world-wide. A major challenge in this sector continues to be the discrepancy between the potential availability and the actually produced output: as a consequence, only around 14 % of global primary energy consumption has been covered by renewables so far. A further expansion and consolidation covering all aspects of energy supplies can be expected in future. Around 164 countries have already formulated plans for the expansion of renewables. The global financial investment volume in renewables has risen in the past ten years from 45 billion USD/a to over 270 billion USD/a in 2014. Investments have risen in particular in developing and emerging economies. Their share of total investment volumes rose from 20 % to over 48 % in 2015. Investments and capacity expansions will further enhance the global impact of renewables in the power sector in particular. Their influence in the heat and transport sectors will probably only grow moderately by comparison in the medium term.

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APPENDIX

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Table 9: Reserves of non-renewable fuels 2014: Regional distribution [EJ]

Region	Crude oil		Natural gas		Coal		Uranium	Total	Share [%]
	conven-tional	non-conven-tional	conven-tional [1)]	non-conven-tional	Hard coal	Lignite			
Europe	86	< 0.5	138	–	539	691	13	1,467	3.9
CIS	776	–	2,408	2	3,282	1,354	170	7,992	21.1
Africa	739	–	548	–	309	1	83	1,680	4.4
Middle East	4,529	–	3,035	–	30	–	–	7,595	20.0
Austral-Asia	243	–	564	70	7,260	793	102	9,032	23.8
North America	355	1,119	275	186	5,739	388	157	8,219	21.7
Latin America	415	886	293	–	232	43	81	1,950	5.1
World	**7,144**	**2,005**	**7,260**	**258**	**17,391**	**3,270**	**607**	**37,934**	**100.0**
OECD 2010	461	1,119	519	228	7,963	1,458	171	11,918	31.4
EU-28	46	–	64	–	515	479	10	1,114	2.9
OPEC 2009	5,380	886	3,616	–	59	1	–	9,941	26.2

[1] including tight gas

Table 10: Ressources of non-renewable fuels 2014: Regional distribution [EJ]

Region	Crude oil		Natural gas		Coal		Uranium	Thorium	Total	Share [%]
	conven-tional	non-conven-tional	conven-tional	non-conven-tional [1)]	Hard coal	Lignite				
Europe	211	95	208	560	12,612	2,972	264	286	17,207	3.2
CIS	1,155	966	4,973	1,933	70,292	18,958	1,292	103	99,672	18.5
Africa	1,071	320	1,353	1,814	6,656	4	842	264	12,324	2.3
Middle East	1,251	171	1,605	524	1,008	–	53	–	4,613	0.9
Austral-Asia	1,062	436	1,650	3,369	176,781	12,335	1,838	771	198,241	36.7
North America	1,075	2,675	1,494	2,778	166,869	17,546	2,042	427	194,904	36.1
Latin America	990	2,869	879	1,560	686	173	389	466	8,013	1.5
World	**6,815**	**7,531** [2]	**12,162**	**12,537**	**438,729** [3]	**51,987**	**6,722**	**3,178** [4]	**539,661**	**100.0**
OECD 2010	1,341	2,884	1,982	4,342	220,352	23,987	3,188	1,010	259,085	48.0
EU-28	109	68	119	524	12,573	2,725	263	55	16,436	3.0
OPEC 2009	1,818	2,935	1,756	1,717	1,220	3	18	150	9,617	1.8

[1] without natural gas in gas hydrates and aquifer gas (7,904 EJ)
[2] without oil from oil shale (4,248 EJ)
[3] including hard coal in the Antarctic (3,825 EJ)
[4] including Thorium without country allocation (62 EJ)

Table 11: Production of non-renewable fuels 2014: Regional distribution [EJ]

Region	Crude oil	Natural gas	Hard coal	Lignite	Uranium	Total	Share [%]
Europe	7.0	9.8	2.9	4.5	0.2	24.4	4.7
CIS	28.1	30.7	11.6	1.1	14.7	86.2	16.5
Africa	17.0	7.6	6.2	< 0.05	4.1	35.0	6.7
Middle East	55.7	22.3	0.1	–	–	78.1	15.0
Austral-Asia	16.2	19.6	128.3	3.4	3.5	170.9	32.7
North America	36.2	35.5	22.7	0.9	5.5	100.9	19.3
Latin America	17.1	6.8	2.7	< 0.05	0.1	26.7	5.1
World	**177.3**	**132.4**	**174.5**	**10.0**	**28.1**	**522.2**	**100.0**
OECD 2010	43.7	47.6	37.5	5.1	8.1	142.0	27.2
EU-28	2.9	5.6	2.8	3.5	0.2	15.1	2.9
OPEC 2009	73.4	25.9	0.1	–	–	99.5	19.1

Table 12: Consumption of non-renewable fuels 2014: Regional distribution [EJ]

Region	Crude oil	Natural gas	Hard coal	Lignite	Uranium	Total	Share [%]
Europe	27.5	17.9	8.6	4.5	10.2	68.8	13.0
CIS	9.2	23.8	8.1	1.1	4.0	46.2	8.7
Africa	7.8	4.7	4.6	< 0.05	0.2	17.3	3.3
Middle East	16.6	17.8	0.4	–	0.1	34.9	6.6
Austral-Asia	59.7	26.0	130.7	3.4	7.8	227.7	43.0
North America	44.6	35.6	20.3	0.9	10.4	111.9	21.1
Latin America	14.5	6.5	1.3	< 0.05	0.3	22.5	4.3
World	**180.0**	**132.4**	**174.0**	**10.0**	**33.0**	**529.3**	**100.0**
OECD 2010	87.2	60.8	39.0	5.1	24.0	216.1	40.8
EU-28	24.7	15.7	7.7	3.5	9.9	61.6	11.6
OPEC 2009	18.9	19.1	0.1	–	0.1	38.3	7.2

– no reserves, resources, production or consumption

Table 13: Germany: Supply of crude oil 2013/2014 [kt]

Country / Region	2013	2014	%	Changes 2013 / 2014	%
Russia	31,480	30,025	33.6	-1,455	-4.6
Norway	10,953	15,183	17.0	4,230	38.6
United Kingdom	9,445	9,727	10.9	282	3.0
Nigeria	7,306	7,120	8.0	-186	-2.5
Kazakhstan	7,128	6,685	7.5	-443	-6.2
Azerbaijan	3,692	4,132	4.6	440	11.9
Algeria	2,608	3,624	4.1	1,016	39.0
Libya	6,650	3,194	3.6	-3,456	-52.0
Egypt	1,172	1,487	1.7	315	26.9
Saudi Arabia	2,433	1,415	1.6	-1,018	-41.8
Colombia	961	1,275	1.4	314	32.7
Iraq	799	919	1.0	120	15.0
Brazil	281	704	0.8	423	150.5
Netherlands	554	626	0.7	72	13.0
Côte d'Ivoire	614	443	0.5	-171	-27.9
Mexico	198	433	0.5	235	118.7
Poland	403	420	0.5	17	4.2
Tunisia	309	307	0.3	-2	-0.6
Denmark	1,170	273	0.3	-897	-76.7
Angola	796	251	0.3	-545	-68.5
Kuwait	563	234	0.3	-329	-58.4
Italy	160	216	0.2	56	35.0
Turkmenistan	0	158	0.2	158	
Trinidad and Tobago	56	135	0.2	79	141.1
Guatemala	0	109	0.1	109	
Equatorial Guinea	41	68	0.1	27	65.9
Pakistan	0	39	0.0	39	
Estonia	0	32	0.0	32	
Georgia	65	31	0.0	-34	-52.3
Albania	66	10	0.0	-56	-84.8
Venezuela	325	8	0.0	-317	-97.5
Cameroon	0	6	0.0	6	
France	5	5	0.0	0	0.0
Belize	0	5	0.0	5	

continuation of table 13
[kt]

Country / Region	2013	2014	%	Changes 2013 / 2014	%
Ghana	197	0	0.0	-197	-100.0
Latvia	13	0	0.0	-13	-100.0
U. Arab Emirates	31	0	0.0	-31	-100.0
Canada	93	0	0.0	-93	-100.0
Total imports	**90,567**	**89,299**	**100.0**	**-1,268**	**-1.4**
OPEC 2009	21,511	16,765	18.8	-4,746	-22.1
Middle East	3,826	2,568	2.9	-1,258	-32.9
Africa	19,693	16,500	18.5	-3,193	-16.2
CIS	42,365	41,031	45.9	-1,334	-3.1
Europe	22,769	26,492	29.7	3,723	16.4

Table 14: Germany: Origin of consumed natural gas [bcm]

Country of origin	2013	%	2014	%
Russia	37.9	34.1	36.4	34.2
Netherlands	29.4	26.4	26.0	24.5
Norway	27.8	25.0	30.2	28.4
Others	5.4	4.8	3.7	3.5
Domestic production	10.7	9.6	10.1	9.5
Total	**111.1**	**100.0**	**106.4**	**100.0**
re-export	20.9	18.8	21.4	20.1
storage change	0.9	0.8	-0.3	-0.3
Total consumption	**91.0**	**82.0**	**84.7**	**79.6**

Table 15: Germany: Imports of hard coal and coke by supplying countries [kt]

Country / Region	2010	2011	2012	2013	2014	Changes 2013/2014	%
EU	8,506	7,025	6,704	8,364	11,024	2,660	31.8
hard coal	4,974	3,524	4,089	5,891	8,817	2,926	49.7
coke	3,533	3,501	2,615	2,473	2,207	-266	-10.8
Non-EU	36,677	41,353	41,218	44,502	45,182	680	1.5
hard coal	36,096	40,626	40,858	44,228	44,854	626	1.4
coke	581	727	360	274	328	54	19.7
Australia	4,303	4,280	4,451	4,739	5,673	934	19.7
hard coal	4,303	4,280	4,451	4,739	5,673	934	19.7
coke	0	0	0	0	0	0	
Indonesia	70	34	0	0	0	0	
hard coal	70	34	0	0	0	0	
coke	0	0	0	0	0	0	
Canada	1,203	1,736	1,516	1,214	1,462	248	20.4
hard coal	1,203	1,736	1,516	1,214	1,462	248	20.4
coke	0	0	0	0	0	0	
Colombia	7,628	10,826	9,352	9,999	7,381	-2,618	-26.2
hard coal	7,588	10,764	9,319	9,974	7,381	-2,593	-26.0
coke	39	62	33	25	0	-25	-100.0
Norway	856	857	395	680	435	-245	-36.0
hard coal	856	857	395	680	435	-245	-36.0
coke	0	0	0	0	0	0	
Poland	6,058	5,139	3,971	4,325	4,389	64	1.5
hard coal	3,659	2,659	2,406	3,008	2,931	-77	-2.6
coke	2,399	2,481	1,565	1,317	1,458	141	10.7
CIS	10,590	11,092	11,546	13,091	13,722	631	4.8
hard coal	10,342	10,731	11,227	12,842	13,495	653	5.1
coke	248	361	319	249	227	-22	-8.8
South Africa	3,331	2,644	1,972	2,533	5,082	2,549	100.6
hard coal	3,331	2,644	1,972	2,533	5,082	2,549	100.6
coke	0	0	0	0	0	0	
Czech Republic	443	360	323	690	659	-31	-4.5
hard coal	63	30	7	365	362	-3	-0.8
coke	379	330	316	325	297	-28	-8.6

continuation of table 15
[kt]

Country / Region	2010	2011	2012	2013	2014	Changes 2013 / 2014	%
United States	5,727	8,140	9,809	12,044	11,099	-945	-7.8
hard coal	5,727	8,140	9,809	12,044	11,099	-945	-7.8
coke	0	0	0	0	0	0	
Venezuela, Bolivarian Republic	432	161	112	59	0	-59	-100.0
hard coal	431	161	111	59	0	-59	-100.0
coke	2	0	1	0	0	0	
China	206	196	11	8	124	116	1,450.0
hard coal	7	12	9	8	23	15	187.5
coke	199	184	2	0	101	101	
other Non-EU	2,332	1,389	2,054	135	204	69	51.1
hard coal	2,239	1,269	2,049	135	204	69	51.1
coke	93	120	5	0	0	0	
total	**45,183**	**48,378**	**47,922**	**52,866**	**56,206**	**3,340**	**6.3**
hard coal	41,069	44,151	44,947	50,119	53,671	3,552	7.1
coke	4,114	4,228	2,975	2,747	2,535	-212	-7.7

Table 16: Crude oil 2014 [Mt]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
EUROPE	Albania	1.4	57	26	23	106	49
	Austria	0.9	123	7	10	141	17
	Bosnia & Herzegovina	–	–	–	10	10	10
	Bulgaria	0.1	9	2	32	43	34
	Croatia	0.7	103	7	20	130	27
	Cyprus	–	–	–	35	35	35
	Czech Republic	0.7	12	2	30	44	32
	Denmark	8.4	347	83	187	617	270
	Estonia	0.7	7	–	–	7	–
	Finland	0.7	4	–	–	4	–
	France	0.8	127	11	710	848	721
	Germany	2.4	302	31	115	448	146
	Greece	0.1	17	1	35	53	36
	Hungary	1.0	101	4	20	125	24
	Ireland	–	–	–	244	244	244
	Italy	5.7	191	85	193	469	278
	Lithuania	0.2	4	1	60	65	61
	Malta	–	–	–	5	5	5
	Netherlands	2.0	147	30	455	632	485
	Norway	93.1	3,633	880	2,330	6,844	3,210
	Poland	0.9	64	19	260	342	278
	Romania	4.7	772	82	200	1,054	282
	Serbia	1.2	46	7	20	72	27
	Slovakia	< 0.05	3	1	5	9	6
	Slovenia	< 0.05	n. s.	n. s.	n. s.	n. s.	n. s.
	Spain	0.3	38	19	34	92	53
	Turkey	2.3	145	46	710	900	756
	United Kingdom	39.6	3,620	716	1,579	5,915	2,295
CIS	Azerbaijan	42.0	1,846	952	1,245	4,044	2,197
	Belarus	1.6	139	27	30	196	57
	Georgia	< 0.05	24	5	51	79	55
	Kazakhstan	82.1	1,704	4,082	12,140	17,926	16,222
	Kyrgyzstan	< 0.05	12	5	10	27	15
	Moldova, Republic	–	–	–	10	10	10
	Russia	526.7	22,745	13,187	34,801	70,733	47,988
	Tajikistan	< 0.05	8	2	60	69	62
	Turkmenistan	13.2	549	178	1,700	2,427	1,878
	Ukraine	3.0	366	54	300	720	354
	Uzbekistan	3.2	199	81	400	680	481

continuation of table 16
[Mt]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
AFRICA	Algeria	70.6	3,028	1,660	2,375	7,063	4,035
	Angola	83.0	1,558	1,723	5,200	8,481	6,923
	Benin	–	4	1	70	75	71
	Cameroon	3.7	187	18	350	555	368
	Chad	4.1	74	204	2,365	2,643	2,569
	Congo, DR	1.3	46	24	145	215	169
	Congo, Rep.	14.5	370	190	451	1,010	641
	Côte d'Ivoire	1.0	32	14	300	345	314
	Egypt	34.0	1,622	599	2,233	4,454	2,832
	Equatorial Guinea	13.1	222	150	350	721	500
	Eritrea	–	–	–	10	10	10
	Ethiopia	–	–	< 0,5	20	20	20
	Gabon	11.8	548	272	1,400	2,220	1,672
	Gambia	–	–	–	20	20	20
	Ghana	5.2	23	90	210	322	300
	Guinea	–	–	–	150	150	150
	Guinea–Bissau	–	–	–	40	40	40
	Kenya	–	–	–	250	250	250
	Liberia	–	–	–	160	160	160
	Libya	27.1	3,810	6,580	4,750	15,140	11,330
	Madagascar	< 0.05	n. s.	n. s.	90	90	90
	Mauritania	0.3	7	3	164	174	167
	Morocco	< 0.05	2	< 0.5	1,627	1,629	1,627
	Mozambique	n. s.	n. s.	2	2,000	2,002	2,002
	Namibia	–	–	–	150	150	150
	Niger	1.0	n. s.	20	30	50	50
	Nigeria	120.4	4,463	5,044	5,090	14,597	10,134
	São Tomé and Príncipe	–	–	–	180	180	180
	Senegal	–	–	–	140	140	140
	Seychelles	–	–	–	470	470	470
	Sierra Leone	–	–	60	200	260	260
	Somalia	–	–	–	20	20	20
	South Africa	0.1	16	2	400	418	402
	South Sudan, Republic of	7.4	–	633	365	998	998
	Sudan	5.5	–	200	365	565	565
	Sudan & South Sudan	12.9	210	833	730	1,774	1,563
	Tanzania	–	–	–	400	400	400
	Togo	–	–	–	70	70	70
	Tunisia	2.7	206	58	300	564	358
	Uganda	–	–	136	300	436	436
	Western Sahara	–	–	–	57	57	57
	Zimbabwe	–	–	–	10	10	10

continuation of table 16
[Mt]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
MIDDLE EAST	Bahrain	10.1	251	15	200	466	215
	Iran	169.2	9,733	21,433	7,200	38,366	28,633
	Iraq	160.3	5,133	19,465	6,320	30,918	25,785
	Israel	< 0.05	2	2	371	375	373
	Jordan	< 0.05	–	< 0.5	19	19	19
	Kuwait	158.1	6,207	13,810	700	20,717	14,510
	Lebanon	–	–	–	150	150	150
	Oman	46.2	1,443	701	1,490	3,633	2,191
	Qatar	83.5	1,670	3,435	700	5,805	4,135
	Saudi Arabia	530.1	19,771	35,524	11,800	67,095	47,324
	Syrian	1.5	744	340	400	1,484	740
	U. Arab Emirates	167.3	4,662	13,306	4,160	22,128	17,466
	Yemen	6.6	398	317	500	1,215	817
AUSTRAL-ASIA	Afghanistan	n. s.	n. s.	n. s.	290	290	290
	Australia	17.5	1,033	542	3,480	5,055	4,022
	Bangladesh	0.2	4	4	30	38	34
	Brunei	6.2	520	150	160	830	310
	Cambodia	–	–	–	25	25	25
	China	211.4	6,293	2,514	20,724	29,531	23,238
	India	37.9	1,296	740	1,720	3,756	2,460
	Indonesia	41.8	3,393	502	3,545	7,441	4,047
	Japan	0.6	52	4	24	79	28
	Korea, Rep.	< 0.05	n. s.	n. s.	n. s.	n. s.	n. s.
	Laos	–	–	–	< 0.5	< 0.5	< 0.5
	Malaysia	31.2	1,095	499	850	2,444	1,349
	Mongolia	1.0	4	35	1,010	1,049	1,045
	Myanmar	0.8	56	3	560	620	563
	New Zealand	1.8	60	17	243	321	260
	Pakistan	3.7	103	50	1,390	1,544	1,440
	Papua New Guinea	1.7	68	24	290	382	314
	Philippines	1.0	18	15	270	303	285
	Sri Lanka	–	–	–	90	90	90
	Taiwan	< 0.05	5	< 0.5	5	10	5
	Thailand	11.1	192	53	335	580	388
	Timor–Leste	3.8	46	59	175	280	234
	Viet Nam	15.5	336	599	600	1,535	1,199
NORTH AMERICA	Canada	208.0	5,672	27,065	56,891	89,629	83,956
	Greenland	–	–	–	3,500	3,500	3,500
	Mexico	137.1	6,419	1,339	4,761	12,520	6,100
	USA	519.9	31,880	6,857	24,553	63,289	31,409

continuation of table 16
[Mt]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
LATIN AMERICA	Argentina	29.5	1,570	317	4,175	6,061	4,492
	Barbados	< 0.05	2	< 0.5	30	33	30
	Belize	0.1	1	< 0.5	15	17	15
	Bolivia	3.4	83	22	280	386	302
	Brazil	118.5	2,150	2,202	13,720	18,072	15,922
	Chile	0.3	62	20	330	413	350
	Colombia	52.2	1,243	314	1,790	3,347	2,104
	Cuba	3.7	66	3	1,008	1,078	1,011
	Dominican Rep.	–	–	–	150	150	150
	Ecuador	29.3	772	1,126	107	2,005	1,233
	Falkland Islands	–	–	–	800	800	800
	(French) Guiana	–	–	–	800	800	800
	Guatemala	0.5	21	11	40	72	51
	Guyana	–	–	–	450	450	450
	Haiti	–	–	–	100	100	100
	Panama	–	–	–	122	122	122
	Paraguay	–	–	–	575	575	575
	Peru	8.1	385	183	1,408	1,976	1,591
	Puerto Rico	–	–	–	75	75	75
	Suriname	0.7	15	12	700	727	712
	Trinidad and Tobago	4.6	521	113	65	699	178
	Uruguay	–	–	–	275	275	275
	Venezuela	157.8	9,892	26,807	65,320	102,019	92,127
	World	**4,240.7**	**179,240**	**218,864**	**343,212**	**741,316**	**562,077**
COUNTRY GROUPS	Europe	168.0	9,873	2,060	7,323	19,256	9,383
	CIS	671.8	27,592	18,572	50,747	96,910	69,319
	Africa	406.9	16,427	17,682	33,277	67,386	50,959
	Middle East	1,332.9	50,015	108,347	34,010	192,372	142,357
	Austral-Asia	387.2	14,576	5,810	35,816	56,202	41,627
	North America	865.1	43,972	35,261	89,705	168,937	124,965
	Latin America	408.9	16,785	31,132	92,335	140,252	123,467
ECCONOMIC COUNTRY GPG.	OPEC 2009	1,756.8	70,700	149,912	113,722	334,334	263,634
	OPEC–Gulf	1,268.5	47,177	106,972	30,880	185,029	137,852
	OECD 2010	1,044.9	54,063	37,782	101,070	192,915	138,852
	EU–28	69.9	5,993	1,102	4,230	11,324	5,331

n. s. not specified

– no production, reserves or resources

Table 17: Crude oil resources 2014 [Mt]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional	non-conventional		
				oil sand	extra heavy oil	tight oil [1]
1	Venezuela	65,320	3,000	–	60,500	1,820
2	Canada	56,891	3,500	50,000	1	3,390
3	Russia	34,801	20,000	4,500	1	10,300
4	USA	24,553	15,727	850	76	7,900
5	China	20,724	16,200	25	119	4,380
6	Brazil	13,720	13,000	–	–	720
7	Kazakhstan	12,140	4,000	6,700	–	1,440
8	Saudi Arabia	11,800	11,800	–	–	–
9	Iran	7,200	7,200	–	–	–
10	Iraq	6,320	6,100	–	–	220
11	Angola	5,200	5,000	200	–	–
12	Nigeria	5,090	5,000	90	–	–
13	Mexico	4,761	2,980	–	1	1,780
14	Libya	4,750	1,200	–	–	3,550
15	Argentina	4,175	500	–	–	3,675
16	U. Arab Emirates	4,160	1,100	–	–	3,060
17	Indonesia	3,545	2,400	70	–	1,075
18	Greenland	3,500	3,500	–	–	–
19	Australia	3,480	1,100	–	–	2,380
20	Algeria	2,375	1,600	–	–	775
	...					
95	Germany	115	20	–	–	95
	...					
	other countries [118]	48,593	38,111	82	85	10,315
	World	**343,212**	**163,038**	**62,517**	**60,783**	**56,875**
	Europe	7,323	5,057	30	30	2,206
	CIS	50,747	27,635	11,201	21	11,890
	Africa	33,277	25,630	331	8	7,308
	Middle East	34,010	29,925	–	1	4,084
	Austral-Asia	35,816	25,395	95	119	10,207
	North America	89,705	25,707	50,850	78	13,070
	Latin America	92,335	23,689	10	60,526	8,110
	OPEC 2009	113,722	43,500	290	60,507	9,425
	OPEC-Gulf	30,880	27,600	–	–	3,280
	OECD 2010	101,070	32,081	50,880	106	18,003
	EU-28	4,230	2,607	30	27	1,566

[1] crude oil from tight reservoirs

– no resources

Table 18: Crude oil reserves 2014 [Mt]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional	non-conventional		
				oil sand	extra heavy oil	tight oil [1]
1	Saudi Arabia	35,524	35,524	–	–	–
2	Canada	27,065	566	26,431	–	68
3	Venezuela	26,807	5,607	–	21,200	–
4	Iran	21,433	21,433	–	–	–
5	Iraq	19,465	19,465	–	–	–
6	Kuwait	13,810	13,810	–	–	–
7	U. Arab Emirates	13,306	13,306	–	–	–
8	Russia	13,187	13,187	–	–	–
9	USA	6,857	6,594	–	3	260
10	Libya	6,580	6,580	–	–	–
11	Nigeria	5,044	5,044	–	–	–
12	Kazakhstan	4,082	4,082	–	–	–
13	Qatar	3,435	3,435	–	–	–
14	China	2,514	2,514	–	n. s.	–
15	Brazil	2,202	2,202	–	–	–
16	Angola	1,723	1,723	–	–	–
17	Algeria	1,660	1,660	–	–	–
18	Mexico	1,339	1,339	–	–	–
19	Ecuador	1,126	1,126	–	n. s.	–
20	Azerbaijan	952	952	–	n. s.	–
	...					
58	Germany	31	31	–	–	–
	...					
	other countries [82]	10,724	10,721	–	3	–
	World	**218,864**	**170,899**	**26,431**	**21,206**	**328**
	Europe	2,060	2,057	–	3	–
	CIS	18,572	18,572	–	–	–
	Africa	17,682	17,682	–	–	–
	Middle East	108,347	108,347	–	–	–
	Austral-Asia	5,810	5,810	–	–	–
	North America	35,261	8,499	26,431	3	328
	Latin America	31,132	9,932	–	21,200	–
	OPEC 2009	149,912	128,712	–	21,200	–
	OPEC-Gulf	106,972	106,972	–	–	–
	OECD 2010	37,782	11,020	26,431	3	328
	EU-28	1,102	1,102	–	–	–

[1] crude oil from tight reservoirs

n. s. not specified
– no reserves

Table 19: Crude oil production 2009 – 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2009	2010	2011	2012	2013	2014	Share [%]	
					Mt			country	cumulative
1	Saudi Arabia	459.5	467.8	525.8	547.0	523.6	530.1	12.5	12.5
2	Russia	493.7	505.1	509.0	517.9	522.6	526.7	12.4	24.9
3	USA	325.3	339.1	352.3	431.2	485.2	519.9	12.3	37.2
4	China	189.0	203.0	203.6	207.5	208.1	211.4	5.0	42.2
5	Canada	155.7	162.8	165.3	179.2	192.4	208.0	4.9	47.1
6	Iran	202.4	203.2	205.8	185.8	177.7	169.2	4.0	51.1
7	U. Arab Emirates	120.6	128.9	138.4	155.0	165.7	167.3	3.9	55.0
8	Iraq	121.8	117.1	134.2	148.1	152.6	160.3	3.8	58.8
9	Kuwait	121.3	120.3	134.3	151.6	164.7	158.1	3.7	62.5
10	Venezuela	167.9	166.1	166.7	161.7	162.9	157.8	3.7	66.2
11	Mexico	130.1	146.3	145.1	126.6	143.5	137.1	3.2	69.5
12	Nigeria	99.1	101.7	120.2	123.8	118.3	120.4	2.8	72.3
13	Brazil	100.4	106.1	114.6	108.2	105.0	118.5	2.8	75.1
14	Norway	115.5	106.2	92.2	87.5	90.2	93.1	2.2	77.3
15	Qatar	57.9	71.0	78.5	83.0	84.2	83.5	2.0	79.3
16	Angola	87.4	90.7	85.2	86.9	87.4	83.0	2.0	81.2
17	Kazakhstan	76.4	81.6	82.4	79.2	83.8	82.1	1.9	83.2
18	Algeria	77.6	77.7	90.7	76.1	72.6	70.6	1.7	84.8
19	Colombia	34.1	39.9	45.4	46.9	52.9	52.2	1.2	86.1
20	Oman	38.5	41.0	42.1	45.8	46.1	46.2	1.1	87.1
	...								
57	Germany	2.8	2.5	2.7	2.6	2.6	2.4	0.1	99.3
	...								
	other countries [82]	680.7	672.4	586.8	596.7	562.1	542.7	12.8	100.0
	World	**3,857,8**	**3,950.6**	**4,021.3**	**4,148.3**	**4,204.2**	**4,240.7**	**100.0**	
	Europe	216.3	206.4	178.8	165.0	164.8	168.0	4.0	
	CIS	640.9	656.8	656.8	660.7	671.3	671.8	15.8	
	Africa	460.3	461.9	436.2	461.6	430.5	406.9	9.6	
	Middle East	1,164.0	1,190.0	1,296.1	1,343.0	1,333.5	1,332.9	31.4	
	Austral-Asia	385.3	399.0	388.5	387.8	383.6	387.2	9.1	
	North America	611.1	648.2	662.7	737.0	821.1	865.1	20.4	
	Latin America	379.9	388.3	402.0	393.2	399.4	408.9	9.6	
	OPEC 2009	1,617.8	1,643.7	1,728.3	1,818.0	1,785.4	1,756.8	41.4	
	OPEC-Gulf	1,083.4	1,108.4	1,217.0	1,270.6	1,268.4	1,268.5	29.9	
	OECD 2010	848.6 [1]	875.4	859.1	917.0	997.1	1,044.9	24.6	
	EU-28	97.4 [2]	96.5 [2]	82.7 [2]	73.4 [2]	70.0	69.9	1.6	

[1] including Estonia (cf. economic country groupings)
[2] including Croatia (cf. economic country groupings)

Table 20: Oil consumption 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	USA	866.6	20.1	20.1
2	China	518.0	12.0	32.2
3	Japan	213.5	5.0	37.1
4	India	180.7	4.2	41.3
5	Russia	161.0	3.7	45.1
6	Brazil	155.0	3.6	48.7
7	Saudi Arabia	142.0	3.3	52.0
8	Germany	110.3	2.6	54.5
9	Canada	103.0	2.4	56.9
10	Korea. Rep.	103.0	2.4	59.3
11	Mexico	97.7	2.3	61.6
12	Iran	91.7	2.1	63.7
13	France	80.3	1.9	65.6
14	Indonesia	73.9	1.7	67.3
15	United Kingdom	67.2	1.6	68.8
16	Singapore	66.2	1.5	70.4
17	Italy	58.8	1.4	71.7
18	Spain	53.9	1.3	73.0
19	Taiwan	49.1	1.1	74.1
20	Australia	48.5	1.1	75.3
	...			
	other countries [179]	1,064.8	24.7	100.0
	World	**4,305.2**	**100.0**	
	Europe	657.5	15.3	
	CIS	220.1	5.1	
	Africa	186.3	4.3	
	Middle East	397.5	9.2	
	Austral-Asia	1,428.0	33.2	
	North America	1,067.5	24.8	
	Latin America	346.9	8.1	
	OPEC 2009	451.6	10.5	
	OPEC-Gulf	344.0	8.0	
	OECD 2010	2,086.9	48.5	
	EU-28	591.9	13.7	

Table 21: Crude oil export 2014
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	346.1	17.0	17.0
2	Russia	221.2	10.9	27.9
3	Canada	158.8	7.8	35.7
4	Iraq	124.8	6.1	41.8
5	U. Arab Emirates	124.1	6.1	47.9
6	Nigeria	105.4	5.2	53.1
7	Kuwait	99.1	4.9	57.9
8	Venezuela	94.2	4.6	62.6
9	Angola	81.5	4.0	66.6
10	Kazakhstan	67.4	3.3	69.9
11	Norway	63.7	3.1	73.0
12	Mexico	56.7	2.8	75.8
13	Iran	55.1	2.7	78.5
14	Oman	40.0	2.0	80.5
15	Colombia	38.0	1.9	82.3
16	United Kingdom	37.7	1.9	84.2
17	Azerbaijan	37.5	1.8	86.0
18	Algeria	31.0	1.5	87.6
19	Qatar	29.6	1.5	89.0
20	Brazil	24.8	1.2	90.2
	...			
70	Germany	< 0.05	< 0.05	100.0
	...			
	other countries [56]	198.9	9.8	100.0
	World	**2,035.6**	**100.0**	
	Europe	119.0	5.8	
	CIS	332.1	16.3	
	Africa	280.5	13.8	
	Middle East	823.8	40.5	
	Austral-Asia	64.0	3.1	
	North America	232.7	11.4	
	Latin America	183.4	9.0	
	OPEC 2009	1,113.9	54.7	
	OPEC-Gulf	778.8	38.3	
	OECD 2010	365.9	18.0	
	EU-28	54.8	2.7	

Table 22: Crude oil import 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	USA	365.4	17.3	17.3
2	China	308.4	14.6	32.0
3	India	189.7	9.0	40.9
4	Japan	173.7	8.2	49.2
5	Korea, Rep.	126.2	6.0	55.2
6	Germany	89.4	4.2	59.4
7	Spain	59.1	2.8	62.2
8	Italy	54.0	2.6	64.8
9	France	53.6	2.5	67.3
10	Netherlands	47.6	2.3	69.6
11	United Kingdom	46.5	2.2	71.8
12	Taiwan	42.9	2.0	73.8
13	Thailand	39.6	1.9	75.7
14	Singapore	39.0	1.9	77.5
15	Belgium	35.5	1.7	79.2
16	Canada	32.1	1.5	80.7
17	Greece	25.8	1.2	82.0
18	Australia	24.6	1.2	83.1
19	Poland	23.7	1.1	84.3
20	Sweden	19.3	0.9	85.2
	...			
	other countries [64]	312.4	14.8	100.0
	World	**2,108.7**	**100.0**	
	Europe	572.0	27.1	
	CIS	28.5	1.4	
	Africa	10.4	0.5	
	Middle East	35.8	1.7	
	Austral-Asia	1,009.7	47.9	
	North America	397.9	18.9	
	Latin America	54.4	2.6	
	OECD 2010	1,285.6	61.0	
	EU-28	541.7	25.7	

Table 23: Natural gas 2014 [bcm]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
EUROPE	Albania	< 0.05	8	2	50	60	52
	Austria	1.3	98	11	33	142	44
	Bulgaria	0.3	8	5	575	588	580
	Croatia	1.7	72	22	50	144	72
	Cyprus	–	–	–	250	250	250
	Czech Republic	0.4	15	4	130	149	134
	Denmark	4.6	182	35	950	1,167	985
	France	0.1	229	9	3,984	4,222	3,993
	Germany	10.5	1,020	89	1,860	2,968	1,949
	Greece	< 0.05	1	1	10	12	11
	Hungary	1.9	229	10	347	586	357
	Ireland	0.2	56	10	50	116	60
	Italy	6.6	750	49	405	1,203	454
	Malta	–	–	–	10	10	10
	Netherlands	66.3	3,528	818	1,135	5,481	1,953
	Norway	108.8	1,985	1,922	2,075	5,982	3,997
	Poland	4.6	261	85	1,005	1,351	1,090
	Portugal	–	–	–	40	40	40
	Romania	11.2	1,298	110	1,611	3,019	1,721
	Serbia	0.5	33	20	10	63	30
	Slovakia	0.1	26	4	10	40	14
	Slovenia	< 0.05	n. s.	1	10	11	11
	Spain	< 0.05	12	3	2,425	2,439	2,428
	Sweden	–	–	–	280	280	280
	Turkey	0.5	14	6	1,153	1,173	1,159
	United Kingdom	38.7	2,498	407	1,746	4,651	2,153
CIS	Armenia	–	–	–	10	10	10
	Azerbaijan	16.9	561	1,166	1,800	3,527	2,966
	Belarus	0.2	13	3	10	26	13
	Georgia	< 0.05	3	8	102	113	110
	Kazakhstan	32.1	535	1,929	4,180	6,644	6,109
	Kyrgyzstan	< 0.05	7	6	20	33	26
	Moldova, Republic	–	–	–	20	20	20
	Russia	610.1	21,690	47,768	152,050	221,508	199,818
	Tajikistan	< 0.05	9	6	20	34	26
	Turkmenistan	69.3	2,563	9,934	15,000	27,497	24,934
	Ukraine	19.6	2,004	952	7,130	10,086	8,082
	Uzbekistan	59.3	2,254	1,632	1,400	5,286	3,032
	Algeria	79.7	2,307	4,504	26,720	33,531	31,224
	Angola	0.8	23	275	1,200	1,498	1,475

continuation of table 23
[bcm]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
AFRICA	Benin	–	–	1	100	101	101
	Botswana	–	–	–	1,840	1,840	1,840
	Cameroon	0.5	n. s.	135	200	335	335
	Chad	–	–	–	1,450	1,450	1,450
	Congo, DR	n. s.	n. s.	1	10	11	11
	Congo, Rep.	0.2	n. s.	115	200	315	315
	Côte d'Ivoire	2.0	28	16	400	444	416
	Egypt	48.7	824	2,167	10,830	13,821	12,997
	Equatorial Guinea	6.6	48	109	150	307	259
	Eritrea	–	–	–	100	100	100
	Ethiopia	–	–	5	100	105	105
	Gabon	0.4	5	26	600	631	626
	Gambia	–	–	–	25	25	25
	Ghana	n. s.	n. s.	23	300	323	323
	Guinea	–	–	–	200	200	200
	Guinea-Bissau	–	–	–	50	50	50
	Kenya	–	–	–	600	600	600
	Liberia	–	–	–	200	200	200
	Libya	12.2	307	1,506	4,650	6,463	6,156
	Madagascar	–	–	2	4,700	4,702	4,702
	Mauritania	n. s.	n. s.	28	200	228	228
	Morocco	0.1	3	1	2,220	2,224	2,221
	Mozambique	3.7	33	127	5,500	5,660	5,627
	Namibia	–	–	62	300	362	362
	Niger	–	–	–	250	250	250
	Nigeria	40.3	490	5,100	3,200	8,790	8,300
	Rwanda	–	–	–	50	50	50
	São Tomé and Príncipe	–	–	–	100	100	100
	Senegal	–	–	2	200	202	202
	Seychelles	–	–	–	600	600	600
	Sierra Leone	–	–	–	300	300	300
	Somalia	–	–	6	400	406	406
	South Africa	1.3	42	8	12,620	12,670	12,628
	Sudan & South Sudan	n. s.	n. s.	85	250	335	335
	Tanzania	1.0	n. s.	37	1,500	1,537	1,537
	Togo	–	–	–	100	100	100
	Tunisia	3.3	53	65	750	868	815
	Uganda	–	–	5	100	105	105
	Western Sahara	–	–	–	50	50	50
	Zimbabwe	–	–	–	10	10	10

continuation of table 23
[bcm]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
MIDDLE EAST	Bahrain	15.0	280	181	200	661	381
	Iran	172.6	2,380	34,020	10,000	46,400	44,020
	Iraq	7.2	126	3,588	4,000	7,713	7,588
	Israel	7.5	31	224	2,000	2,255	2,224
	Jordan	0.2	5	6	350	361	356
	Kuwait	16.4	337	1,784	500	2,621	2,284
	Lebanon	–	–	–	850	850	850
	Oman	30.9	405	705	3,020	4,130	3,725
	Palestinian territories	–	–	30	350	380	380
	Qatar	160.0	1,428	24,528	2,000	27,956	26,528
	Saudi Arabia	108.2	1,791	8,167	24,664	34,622	32,831
	Syrian	4.4	137	285	300	722	585
	U. Arab Emirates	55.6	1,202	6,091	7,310	14,603	13,401
	Yemen	9.6	46	269	500	815	769
AUSTRAL-ASIA	Afghanistan	0.1	57	50	400	507	450
	Australia	55.3	1,090	3,738	32,430	37,257	36,168
	Bangladesh	23.6	348	253	800	1,401	1,053
	Brunei	11.9	410	270	200	880	470
	Cambodia	–	–	–	50	50	50
	China	132.8	1,507	3,459	67,980	72,946	71,439
	India	31.7	761	1,427	7,020	9,208	8,447
	Indonesia	71.8	2,079	2,908	9,980	14,967	12,888
	Japan	2.8	135	21	10	166	31
	Korea, Rep.	0.3	n. s.	1	50	51	51
	Laos	–	–	–	10	10	10
	Malaysia	66.4	1,267	2,351	1,900	5,517	4,251
	Mongolia	–	–	–	133	133	133
	Myanmar	14.6	185	283	2,000	2,468	2,283
	New Zealand	5.3	161	37	353	550	390
	Pakistan	42.0	839	700	4,570	6,108	5,270
	Papua New Guinea	0.1	3	151	1,000	1,155	1,151
	Philippines	3.7	40	80	502	622	582
	Sri Lanka	–	–	–	300	300	300
	Taiwan	0.3	52	3	5	60	8
	Thailand	42.1	574	238	740	1,552	978
	Timor-Leste	n. s.	n. s.	88	300	388	388
	Viet Nam	10.2	101	617	1,355	2,073	1,972
NORTH AMERICA	Canada	161.3	5,995	2,030	37,493	45,518	39,523
	Greenland	–	–	–	3,900	3,900	3,900
	Mexico	44.8	1,615	347	17,770	19,732	18,117
	USA	729.1	34,283	9,769	53,246	97,299	63,016

continuation of table 23
[bcm]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
LATINAMERICA	Argentina	35.4	1,139	328	23,710	25,178	24,038
	Barbados	n. s.	n. s.	2	100	102	102
	Belize	–	–	–	10	10	10
	Bolivia	22.0	262	296	1,620	2,178	1,916
	Brazil	22.8	289	464	18,446	19,198	18,910
	Chile	0.9	109	40	1,510	1,659	1,550
	Colombia	13.1	257	156	2,282	2,695	2,438
	Cuba	1.1	15	71	400	486	471
	Ecuador	0.6	7	6	20	33	26
	Falkland Islands	–	–	–	1,500	1,500	1,500
	(French) Guiana	–	–	–	400	400	400
	Grenada	–	–	–	25	25	25
	Guatemala	–	–	–	10	10	10
	Guyana	–	–	–	300	300	300
	Haiti	–	–	–	40	40	40
	Paraguay	–	–	–	2,420	2,420	2,420
	Peru	12.9	116	414	2,550	3,080	2,964
	Puerto Rico	–	–	–	30	30	30
	Suriname	–	–	–	350	350	350
	Trinidad and Tobago	42.1	630	347	500	1,476	847
	Uruguay	–	–	–	828	828	828
	Venezuela	28.6	1,108	5,581	7,130	13,819	12,711
	World	**3,483.9**	**109,720**	**197,841**	**649,992**	**957,553**	**847,833**
COUNTRY GROUPS	Europe	258.2	12,321	3,622	20,203	36,146	23,825
	CIS	807.6	29,639	63,404	181,742	274,784	245,146
	Africa	200.9	4,162	14,412	83,325	101,899	97,737
	Middle East	587.6	8,167	79,878	56,044	144,089	135,922
	Austral-Asia	515.1	9,608	16,674	132,088	158,370	148,762
	North America	935.2	41,893	12,146	112,410	166,449	124,556
	Latin America	179.5	3,931	7,705	64,181	75,816	71,886
ECONOMIC COUNTRY GRP.	OPEC 2009	682.3	11,504	95,149	91,394	198,048	186,543
	OPEC-Gulf	520.0	7,263	78,177	48,474	133,914	126,651
	OECD 2010	1,251.7	54,321	19,670	166,410	240,400	186,080
	EU-28	148.3	10,280	1,672	16,915	28,868	18,587

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

Table 24: Natural gas resources 2014 [bcm]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional	non-conventional		
				tight gas	shale gas	CBM
1	Russia	152,050	110,000	20,000	9,500	12,550
2	China	67,980	20,000	12,000	25,080	10,900
3	USA	53,246	23,000	8,500	17,276	4,470
4	Canada	37,493	10,110	7,500	16,230	3,653
5	Australia	32,430	5,400	8,000	12,380	6,650
6	Algeria	26,720	1,200	5,500	20,020	–
7	Saudi Arabia	24,664	19,000	–	5,664	–
8	Argentina	23,710	1,000	–	22,710	–
9	Brazil	18,446	11,500	–	6,940	6
10	Mexico	17,770	2,300	–	15,440	30
11	Turkmenistan	15,000	15,000	–	–	–
12	South Africa	12,620	1,000	–	11,050	570
13	Egypt	10,830	8,000	–	2,830	–
14	Iran	10,000	10,000	–	–	–
15	Indonesia	9,980	5,500	–	1,300	3,180
16	U. Arab Emirates	7,310	1,500	–	5,810	–
17	Venezuela	7,130	2,400	–	4,730	–
	Ukraine	7,130	500	–	3,630	3,000
19	India	7,020	2,000	–	2,720	2,300
20	Mozambique	5,500	5,500	–	–	–
	...					
40	Germany	1,860	20	90	1,300	450
	...					
	other countries [122]	101,103	65,126	1,182	30,885	3,910
	World	**649,992**	**320,056**	**62,772**	**215,495**	**51,669**
	Europe	20,203	5,461	312	13,257	1,174
	CIS	181,742	130,880	20,000	13,910	16,952
	Africa	83,325	35,595	5,500	40,820	1,410
	Middle East	56,044	42,250	750	13,044	–
	Austral-Asia	132,088	43,425	20,200	44,700	23,763
	North America	112,410	39,310	16,000	48,946	8,153
	Latin America	64,181	23,135	10	40,818	218
	OPEC 2009	91,394	46,220	5,500	39,674	–
	OPEC-Gulf	48,474	37,000	–	11,474	–
	OECD 2010	166,410	52,151	24,312	74,023	15,924
	EU-28	16,915	3,126	312	12,587	891

– no resources / not specified

Table 25: Natural gas reserves 2014 [bcm]
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Total	conventional [1]	non-conventional [2] shale gas	CBM
1	Russia	47,768	47,724	–	44
2	Iran	34,020	34,020	–	–
3	Qatar	24,528	24,528	–	–
4	Turkmenistan	9,934	9,934	–	–
5	USA	9,769	4,912	4,506	351
6	Saudi Arabia	8,167	8,167	–	–
7	U. Arab Emirates	6,091	6,091	–	–
8	Venezuela	5,581	5,581	–	–
9	Nigeria	5,100	5,100	–	–
10	Algeria	4,504	4,504	–	–
11	Australia	3,738	2,633	n. s.	1,105
12	Iraq	3,588	3,588	–	–
13	China	3,459	2,828	500	131
14	Indonesia	2,908	2,908	–	–
15	Malaysia	2,351	2,351	–	–
16	Egypt	2,167	2,167	–	–
17	Canada	2,030	1,982	n. s.	48
18	Kazakhstan	1,929	1,929	–	–
19	Norway	1,922	1,922	–	–
20	Kuwait	1,784	1,784	–	–
	...				
53	Germany	89	89	–	–
	...				
	other countries [83]	16,415	16,314	–	101
	World	**197,841**	**191,055**	**5,006**	**1,779**
	Europe	3,622	3,622	–	–
	CIS	63,404	63,360	–	44
	Africa	14,412	14,412	–	–
	Middle East	79,878	79,878	–	–
	Austral-Asia	16,674	14,838	500	1,337
	North America	12,146	7,241	4,506	399
	Latin America	7,705	7,705	–	–
	OPEC 2009	95,149	95,149	–	–
	OPEC-Gulf	78,177	78,177	–	–
	OECD 2010	19,670	13,660	4,506	1,504
	EU-28	1,672	1,672	–	–

n. s. not specified
– no reserves
[1] including tight gas
[2] partly data status 2013

Table 26: Natural gas production 2009 – 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country/Region	2009	2010	2011	2012	2013	2014	Share [%] country	Share [%] cumulative
				bcm					
1	USA	593.4	611.0	650.9	681.5	687.2	729.1	20.9	20.9
2	Russia	584.0	610.6	629.5	609.7	627.6	610.1	17.5	38.4
3	Iran	131.2	138.5	151.8	158.2	159.1	172.6	5.0	43.4
4	Canada	161.4	159.8	160.5	156.5	154.8	161.3	4.6	48.0
5	Qatar	89.3	116.7	146.8	157.0	158.5	160.0	4.6	52.6
6	China	82.0	96.8	103.1	110.7	119.3	132.8	3.8	56.4
7	Norway	102.7	106.4	101.4	114.8	107.1	108.8	3.1	59.6
8	Saudi Arabia	77.5	83.9	92.3	95.2	103.0	108.2	3.1	62.7
9	Algeria	81.4	83.9	78.0	81.5	79.6	79.7	2.3	64.9
10	Indonesia	71.9	82.8	91.7	76.7	70.4	71.8	2.1	67.0
11	Turkmenistan	36.4	42.4	59.5	64.4	62.3	69.3	2.0	69.0
12	Malaysia	62.7	63.9	61.8	63.0	69.1	66.4	1.9	70.9
13	Netherlands	73.7	82.9	80.6	80.1	84.5	66.3	1.9	72.8
14	Uzbekistan	64.4	64.7	58.8	57.7	58.7	59.3	1.7	74.5
15	U. Arab Emirates	48.8	51.0	51.7	51.7	56.0	55.6	1.6	76.1
16	Australia	52.6	50.4	45.4	48.8	50.1	55.3	1.6	77.7
17	Egypt	62.7	61.3	61.3	60.9	56.1	48.7	1.4	79.1
18	Mexico	48.3	55.3	52.5	47.0	45.8	44.8	1.3	80.4
19	Thailand	30.9	36.3	37.0	41.4	41.8	42.1	1.2	81.6
20	Trinidad and Tobago	40.6	42.4	42.8	42.2	42.8	42.1	1.2	82.8
	...								
42	Germany	15.5	14.2	13.3	12.1	11.1	10.5	0.3	97.2
	...								
	other countries [69]	530.6	584.7	566.0	577.4	576.1	589.1	16.9	100.0
	World	**3,042.0**	**3,239.8**	**3,336.7**	**3,388.5**	**3,421.0**	**3,483.9**	**100.0**	
	Europe	289.3	299.8	278.2	286.8	276.3	258.2	7.4	
	CIS	758.6	790.3	811.4	795.9	817.1	807.6	23.2	
	Africa	202.7	214.9	197.6	210.5	202.2	200.9	5.8	
	Middle East	407.2	461.0	523.5	541.1	566.8	587.6	16.9	
	Austral-Asia	439.3	486.0	492.1	491.9	492.5	515.1	14.8	
	North America	803.1	826.1	863.9	885.0	887.8	935.2	26.8	
	Latin America	141.8	161.6	170.1	177.3	178.3	179.5	5.2	
	OPEC 2009	501.4	565.5	611.1	648.2	655.6	682.3	19.6	
	OPEC-Gulf	360.4	403.4	460.9	482.5	498.0	520.0	14.9	
	OECD 2010	1,144.5 [1]	1,175.5	1,187.1	1,218.7	1,216.3	1,251.7	35.9	
	EU-28	185.6 [2]	192.5 [2]	175.6 [2]	170.8 [2]	168.0	148.3	4.3	

[1] including Estonia (cf. economic country groupings)
[2] including Croatia (cf. economic country groupings)

Table 27: Natural gas consumption 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	bcm	Share [%]	
			country	cumulative
1	USA	759.4	21.8	21.8
2	Russia	452.7	13.0	34.8
3	China	184.5	5.3	40.1
4	Iran	170.2	4.9	45.0
5	Japan	118.2	3.4	48.4
6	Saudi Arabia	108.2	3.1	51.5
7	Canada	104.2	3.0	54.5
8	Germany	84.7	2.4	56.9
9	Mexico	72.0	2.1	59.0
10	United Kingdom	70.2	2.0	61.0
11	U. Arab Emirates	67.7	1.9	62.9
12	Italy	56.8	1.6	64.6
13	Thailand	52.7	1.5	66.1
14	Korea, Rep.	51.5	1.5	67.6
15	India	50.6	1.5	69.0
16	Uzbekistan	48.8	1.4	70.4
17	Turkey	48.6	1.4	71.8
18	Egypt	48.0	1.4	73.2
19	Argentina	47.2	1.4	74.5
20	Qatar	42.8	1.2	75.8
	...			
	other countries [90]	844.0	24.2	100.0
	World	**3,483.1**	**100.0**	
	Europe	472.1	13.6	
	CIS	627.1	18.0	
	Africa	124.5	3.6	
	Middle East	468.2	13.4	
	Austral-Asia	684.7	19.7	
	North America	935.6	26.9	
	Latin America	170.9	4.9	
	OPEC 2009	503.9	14.5	
	OPEC-Gulf	416.2	11.9	
	OECD 2010	1,600.8	46.0	
	EU-28	412.8	11.9	

Table 28: Natural gas export 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	bcm	Share [%]	
			country	cumulative
1	Russia	181.1	17.9	17.9
2	Qatar	123.4	12.2	30.1
3	Norway	106.4	10.5	40.6
4	Canada	78.0	7.7	48.3
5	Netherlands	55.4	5.5	53.8
6	Algeria	44.2	4.4	58.1
7	USA	42.7	4.2	62.4
8	Turkmenistan	41.6	4.1	66.5
9	Malaysia	33.5	3.3	69.8
10	Indonesia	32.1	3.2	73.0
11	Australia	31.6	3.1	76.1
12	Nigeria	25.3	2.5	78.6
13	Germany	21.4	2.1	80.7
14	Trinidad and Tobago	19.3	1.9	82.6
15	Bolivia	17.9	1.8	84.4
16	Myanmar	12.7	1.2	85.6
17	Belgium	12.5	1.2	86.9
18	Uzbekistan	11.9	1.2	88.0
19	Kazakhstan	11.5	1.1	89.2
20	United Kingdom	10.6	1.0	90.2
	...			
	other countries [33]	99.1	9.8	100.0
	World	**1,012.1**	**100.0**	
	Europe	224.5	22.2	
	CIS	254.9	25.2	
	Africa	85.5	8.4	
	Middle East	160.1	15.8	
	Austral-Asia	121.2	12.0	
	North America	120.8	11.9	
	Latin America	45.0	4.4	
	OPEC 2009	216.9	21.4	
	OPEC-Gulf	141.0	13.9	
	OECD 2010	376.6	37.2	
	EU-28	117.5	11.6	

Table 29: Natural gas import 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	bcm	Share [%]	
			country	cumulative
1	Japan	115.4	11.4	11.4
2	Germany	96.3	9.5	20.9
3	USA	76.3	7.5	28.4
4	China	58.4	5.8	34.2
5	Italy	51.5	5.1	39.2
6	Korea, Rep.	51.1	5.0	44.3
7	Turkey	48.4	4.8	49.1
8	United Kingdom	42.8	4.2	53.3
9	France	41.2	4.1	57.3
10	Spain	30.9	3.0	60.4
11	Belgium	28.5	2.8	63.2
12	Mexico	27.4	2.7	65.9
13	Netherlands	27.4	2.7	68.6
14	Russia	24.2	2.4	71.0
15	Canada	21.9	2.2	73.1
16	U. Arab Emirates	20.1	2.0	75.1
17	Ukraine	19.2	1.9	77.0
18	India	18.9	1.9	78.9
19	Belarus	17.9	1.8	80.7
20	Brazil	17.3	1.7	82.4
	...			
	other countries [55]	178.8	17.6	100.0
	World	**1,014.0**	**100.0**	
	Europe	436.1	43.0	
	CIS	75.2	7.4	
	Africa	9.2	0.9	
	Middle East	34.1	3.4	
	Austral-Asia	297.0	29.3	
	North America	125.6	12.4	
	Latin America	36.8	3.6	
	OPEC 2009	32.4	3.2	
	OPEC-Gulf	30.5	3.0	
	OECD 2010	726.9	71.7	
	EU-28	382.3	37.7	

Table 30: Hard coal 2014 [Mt]

	Country / Region	Production	Reserves	Resources	Total Resources
EUROPE	Belgium	–	–	4,100	4,100
	Bulgaria	–	192	3,920	4,112
	Czech Republic	8.3	1,107	15,419	16,526
	France	0.3	–	160	160
	Germany	8.3	21	82,961	82,982
	Hungary	–	276	5,075	5,351
	Ireland	–	14	26	40
	Italy	0.1	10	600	610
	Montenegro	–	142	195	337
	Netherlands	–	497	2,750	3,247
	Norway	1.7	2	90	93
	Poland	73.0	16,203	162,709	178,913
	Portugal	–	3	n. s.	3
	Romania	–	11	2,435	2,446
	Serbia	0.2	402	453	855
	Slovakia	–	–	19	19
	Slovenia	–	56	39	95
	Spain	3.9	868	3,363	4,231
	Sweden	–	1	4	5
	Turkey	1.8	380	802	1,182
	United Kingdom	11.6	70	186,700	186,770
CIS	Armenia	–	163	154	317
	Georgia	0.4	201	700	901
	Kazakhstan	109.0	25,605	123,090	148,695
	Kyrgyzstan	0.3	971	27,528	28,499
	Russia	287.0	69,634	2,658,281	2,727,915
	Tajikistan	0.6	375	3,700	4,075
	Turkmenistan	–	–	800	800
	Ukraine	65.0	32,039	49,006	81,045
	Uzbekistan	< 0.05	1,375	9,477	10,852
AFRICA	Algeria	–	59	164	223
	Botswana	0.8	40	21,200	21,240
	Congo, DR	0.1	88	900	988
	Egypt	0.3	16	166	182
	Madagascar	–	–	150	150
	Malawi	0.1	2	800	802
	Morocco	–	14	82	96
	Mozambique	6.1	1,792	21,844	23,636
	Namibia	–	–	350	350
	Niger	0.3	–	90	90
	Nigeria	< 0.05	287	1,857	2,144
	South Africa	253.2	9,893	203,667	213,560
	Swaziland	0.2	144	4,500	4,644
	Tanzania	0.2	269	1,141	1,410
	Uganda	–	–	800	800
	Zambia	0.4	45	900	945
	Zimbabwe	4.0	502	25,000	25,502
ME	Iran	2.8	1,203	40,000	41,203

continuation of table 30
[Mt]

	Country / Region	Production	Reserves	Resources	Total Resources
AUSTRAL-ASIA	Afghanistan	0.7	66	n. s.	66
	Australia	441.3	62,095	1,536,666	1,598,761
	Bangladesh	0.9	293	2,967	3,260
	Bhutan	0.1	n. s.	n. s.	n. s.
	China	3,725.0	124,059	5,338,613	5,462,672
	India	612.4	85,562	174,981	260,544
	Indonesia	410.8	17,394	92,431	109,825
	Japan	1.3	340	13,543	13,883
	Korea, DPR	33.0	600	10,000	10,600
	Korea, Rep.	1.7	326	1,360	1,686
	Laos	0.2	4	58	62
	Malaysia	2.5	141	1,068	1,209
	Mongolia	18.1	1,170	39,854	41,024
	Myanmar	0.5	3	248	252
	Nepal	< 0.05	1	7	8
	New Caledonia	–	2	n. s.	2
	New Zealand	3.7	825	2,350	3,175
	Pakistan	1.9	207	5,789	5,996
	Philippines	8.1	211	1,012	1,223
	Taiwan	–	1	101	102
	Viet Nam	41.7	3,116	3,519	6,635
NORTH-AMERICA	Canada	60.5	4,346	183,260	187,606
	Greenland	–	183	200	383
	Mexico	14.0	1,160	3,000	4,160
	USA	835.1	222,641	6,457,688	6,680,329
LATIN AMERICA	Argentina	0.1	500	300	800
	Bolivia	–	1	n. s.	1
	Brazil	4.5	1,547	4,665	6,212
	Chile	4.0	1,181	4,135	5,316
	Colombia	88.6	4,881	9,928	14,809
	Costa Rica	–	–	17	17
	Peru	0.2	102	1,465	1,567
	Venezuela	2.0	731	5,981	6,712
	World	**7,153.0**	**698,660**	**17,713,376**	**18,412,036**
COUNTRY GROUPS	Europe	109.2	20,255	471,821	492,077
	CIS	462.2	130,362	2,872,737	3,003,098
	Africa	265.8	13,150	283,611	296,761
	Middle East	2.8	1,203	40,000	41,203
	Austral-Asia	5,304.0	296,417	7,224,568	7,520,985
	North America	909.6	228,330	6,644,148	6,872,478
	Latin America	99.4	8,943	26,491	35,434
	Antarctica	–	–	150,000	150,000
ECONOMIC COUNTRY GRP.	OPEC 2009	4.8	2,279	48,002	50,281
	OPEC-Gulf	2.8	1,203	40,000	41,203
	OECD 2010	1,470.6	312,606	8,667,020	8,979,626
	EU-28	105.6	19,329	470,281	489,610

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

Table 31: Hard coal resources 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country/Region	Mt	Share [%] country	Share [%] cumulative
1	USA	6,457,688	36.5	36.5
2	China	5,338,613	30.1	66.6
3	Russia[1]	2,658,281	15.0	81.6
4	Australia	1,536,666	8.7	90.3
5	South Africa	203,667	1.1	91.4
6	United Kingdom	186,700	1.1	92.5
7	Canada	183,260	1.0	93.5
8	India	174,981	1.0	94.5
9	Poland	162,709	0.9	95.4
10	Kazakhstan	123,090	0.7	96.1
11	Indonesia	92,431	0.5	96.6
12	Germany	82,961	0.5	97.1
13	Ukraine[1]	49,006	0.3	97.4
14	Iran	40,000	0.2	97.6
15	Mongolia[1]	39,854	0.2	97.8
16	Kyrgyzstan	27,528	0.2	98.0
17	Zimbabwe	25,000	0.1	98.1
18	Mozambique	21,844	0.1	98.3
19	Botswana	21,200	0.1	98.4
20	Czech Republic[1]	15,419	0.1	98.5
	...			
	other countries [57]	272,477	1.5	100.0
	World	**17,713,376**	**100.0**	
	Europe	471,821	2.7	
	CIS	2,872,737	16.2	
	Africa	283,611	1.6	
	Middle East	40,000	0.2	
	Austral-Asia	7,224,568	40.8	
	North America	6,644,148	37.5	
	Latin America	26,491	0.1	
	Antarctica	150,000	0.8	
	OPEC 2009	48,002	0.3	
	OPEC-Gulf	40,000	0.2	
	OECD 2010	8,667,020	48.9	
	EU-28	470,281	2.7	

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

Table 32: Hard coal reserves 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	USA	222,641	31.9	31.9
2	China	124,059	17.8	49.6
3	India	85,562	12.2	61.9
4	Russia [1]	69,634	10.0	71.8
5	Australia	62,095	8.9	80.7
6	Ukraine [1]	32,039	4.6	85.3
7	Kazakhstan	25,605	3.7	89.0
8	Indonesia	17,394	2.5	91.5
9	Poland	16,203	2.3	93.8
10	South Africa	9,893	1.4	95.2
11	Colombia	4,881	0.7	95.9
12	Canada	4,346	0.6	96.5
13	Viet Nam	3,116	0.4	97.0
14	Mozambique	1,792	0.3	97.2
15	Brazil	1,547	0.2	97.4
16	Uzbekistan	1,375	0.2	97.6
17	Iran	1,203	0.2	97.8
18	Chile	1,181	0.2	98.0
19	Mongolia [1]	1,170	0.2	98.2
20	Mexico	1,160	0.2	98.3
	...			
56	Germany [2]	21	< 0.05	100.0
	...			
	other countries [50]	11,743	1.7	100.0
	World	**698,660**	**100.0**	
	Europe	20,255	2.9	
	CIS	130,362	18.7	
	Africa	13,150	1.9	
	Middle East	1,203	0.2	
	Austral-Asia	296,417	42.4	
	North America	228,330	32.7	
	Latin America	8,943	1.3	
	OPEC 2009	2,279	0.3	
	OPEC-Gulf	1,203	0.2	
	OECD 2010	312,606	44.7	
	EU-28	19,329	2.8	

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

[2] Deviating from the BGR reserves definition, RAG AG refers to a „Technically extractable planned inventory“ of 2.5 billion t (status 2011)

Table 33: Hard coal production 2009 – 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2009	2010	2011	2012	2013	2014	Share [%] country	Share [%] cumulative
					Mt				
1	China	2,930.0	3,115.0	3,383.7	3,505.0	3,823.0	3,725.0	52.1	52.1
2	USA	907.4	918.2	920.4	850.5	823.4	835.1	11.7	63.8
3	India	532.0	532.7	539.9	557.7	565.6	612.4	8.6	72.3
4	Australia	348.0	355.4	345.2	374.1	412.3	441.3	6.2	78.5
5	Indonesia	256.2	285.0	364.5	406.3	430.0	410.8	5.7	84.2
6	Russia [1]	232.5	247.9	258.5	276.1	279.0	287.0	4.0	88.2
7	South Africa	250.5	257.2	252.8	258.6	256.3	253.2	3.5	91.8
8	Kazakhstan	95.8	103.6	108.1	112.8	114.6	109.0	1.5	93.3
9	Colombia	72.8	74.4	85.8	89.0	85.5	88.6	1.2	94.5
10	Poland	78.1	76.7	76.4	79.8	77.1	73.0	1.0	95.6
11	Ukraine [1]	72.0	75.0	81.7	85.6	83.4	65.0	0.9	96.5
12	Canada	52.4	57.9	57.4	57.0	59.9	60.5	0.8	97.3
13	Viet Nam	44.1	44.8	46.6	42.1	41.0	41.7	0.6	97.9
14	Korea, DPR	24.6	24.0	31.5	32.2	31.6	33.0	0.5	98.4
15	Mongolia [1]	8.3	18.3	26.1	23.6	27.0	18.1	0.3	98.6
16	Mexico	9.5	11.2	21.0	16.3	15.7	14.0	0.2	98.8
17	United Kingdom	17.9	18.4	18.6	17.0	12.8	11.6	0.2	99.0
18	Czech Republic [1]	10.6	11.2	11.0	10.8	8.6	8.3	0.1	99.1
19	Germany	15.0	14.1	13.0	11.6	8.3	8.3	0.1	99.2
20	Philippines	5.2	7.3	7.6	8.2	7.8	8.1	0.1	99.3
	...								
	other countries [40]	42.7	42.7	39.7	42.8	45.1	48.9	0.7	100.0
	World	**6,005.6**	**6,291.1**	**6,689.3**	**6,856.9**	**7,207.9**	**7,153.0**	**100.0**	
	Europe	139.1	136.5	132.5	131.7	117.6	109.2	1.5	
	CIS	400.8	427.3	449.0	475.7	478.2	462.2	6.5	
	Africa	253.6	261.7	257.7	267.2	267.7	265.8	3.7	
	Middle East	2.2	2.5	2.5	2.8	2.8	2.8	0.0	
	Austral-Asia	4,164.1	4,398.5	4,760.0	4,964.4	5,352.1	5,304.0	74.2	
	North America	969.3	987.3	998.7	923.8	899.0	909.6	12.7	
	Latin America	76.5	77.3	88.9	91.3	90.5	99.4	1.4	
	OPEC 2009	5.5	5.2	5.1	4.6	5.1	4.8	0.1	
	OPEC-Gulf	2.2	2.5	2.5	2.8	2.8	2.8	0.0	
	OECD 2010	1,462.2 [3]	1,485.0	1,481.7	1,434.9	1,436.2	1,470.6	20.6	
	EU-28	133.5 [4]	131.8 [4]	128.2 [4]	128.0 [4]	113.6	105.6	1.5	

[1] Hard coal production contains only bituminous coal and anthracite according to national classification
[2] preliminary
[3] including Estonia (cf. economic country groupings)
[4] including Croatia (cf. economic country groupings)

Table 34: Hard coal consumption 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country/Region	Mt	Share [%] country	Share [%] cumulative
1	China	4,010.3	56.1	56.1
2	India	826.4	11.6	67.6
3	USA	757.0	10.6	78.2
4	Japan	189.7	2.7	80.9
5	South Africa	178.1	2.5	83.4
6	Russia[1]	160.3	2.2	85.6
7	Korea, Rep.	133.4	1.9	87.5
8	Kazakhstan	84.8	1.2	88.7
9	Poland	74.4	1.0	89.7
10	Ukraine[1]	74.3	1.0	90.7
11	Taiwan	63.9	0.9	91.6
12	Germany	61.8	0.9	92.5
13	Australia	53.9	0.8	93.2
14	United Kingdom	48.5	0.7	93.9
15	Viet Nam	34.8	0.5	94.4
16	Canada	34.3	0.5	94.9
17	Turkey	31.8	0.4	95.3
18	Malaysia	26.1	0.4	95.7
19	Brazil	24.9	0.3	96.0
20	Mexico	21.3	0.3	96.3
	...			
	other countries [83]	261.4	3.7	100.0
	World	**7,151.2**	**100.0**	
	Europe	328.2	4.6	
	CIS	320.6	4.5	
	Africa	195.4	2.7	
	Middle East	17.1	0.2	
	Austral-Asia	5,425.4	75.9	
	North America	812.6	11.4	
	Latin America	52.0	0.7	
	OPEC 2009	6.0	0.1	
	OPEC-Gulf	5.8	0.1	
	OECD 2010	1,537.6	21.5	
	EU-28	293.6	4.1	

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

Table 35: Hard coal export 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	Indonesia	408.2	30.5	30.5
2	Australia	387.4	28.9	59.4
3	Russia	151.9	11.3	70.7
4	USA	88.3	6.6	77.3
5	Colombia	80.1	6.0	83.3
6	South Africa	76.4	5.7	89.0
7	Canada	34.0	2.5	91.6
8	Kazakhstan	24.4	1.8	93.4
9	Mongolia	19.5	1.5	94.8
10	Korea, DPR	15.6	1.2	96.0
11	Viet Nam	9.9	0.7	96.7
12	Poland	9.1	0.7	97.4
13	China	5.7	0.4	97.8
14	Philippines	5.2	0.4	98.2
15	Ukraine	5.0	0.4	98.6
16	Czech Republic	4.3	0.3	98.9
17	Mozambique	3.8	0.3	99.2
18	Venezuela	2.0	0.1	99.4
19	Chile	1.9	0.1	99.5
20	New Zealand	1.7	0.1	99.6
	...			
27	Germany	0.2	< 0.05	100.0
	...			
	other countries [6]	4.8	0.4	100.0
	World	**1,339.5**	**100.0**	
	Europe	17.1	1.3	
	CIS	181.3	13.5	
	Africa	80.4	6.0	
	Austral-Asia	854.3	63.8	
	North America	122.3	9.1	
	Latin America	84.0	6.3	
	OPEC 2009	2.0	0.1	
	OECD 2010	530.5	39.6	
	EU-28	15.5	1.2	

Table 36: Hard coal import 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	China	291.0	21.7	21.7
2	India	215.0	16.0	37.7
3	Japan	188.4	14.0	51.7
4	Korea, Rep.	130.8	9.7	61.4
5	Taiwan	65.8	4.9	66.3
6	Germany	53.7	4.0	70.3
7	United Kingdom	41.8	3.1	73.4
8	Turkey	30.0	2.2	75.7
9	Russia	25.2	1.9	77.5
10	Malaysia	23.6	1.8	79.3
11	Thailand	20.8	1.5	80.8
12	Brazil	20.4	1.5	82.4
13	Italy	19.9	1.5	83.8
14	Spain	16.2	1.2	85.0
15	Philippines	15.2	1.1	86.2
16	Netherlands	14.5	1.1	87.3
17	Ukraine	14.3	1.1	88.3
18	Hong Kong	13.9	1.0	89.4
19	France	13.3	1.0	90.3
20	Israel	10.9	0.8	91.2
	...			
	other countries [60]	118.7	8.8	100.0
	World	**1,343.4**	**100.0**	
	Europe	242.1	18.0	
	CIS	39.7	3.0	
	Africa	10.0	0.7	
	Middle East	14.3	1.1	
	Austral-Asia	975.4	72.6	
	North America	25.3	1.9	
	Latin America	36.6	2.7	
	OPEC 2009	3.2	0.2	
	OPEC-Gulf	3.0	0.2	
	OECD 2010	602.7	44.9	
	EU-28	209.6	15.6	

Table 37: Lignite 2014 [Mt]

	Country / Region	Production	Reserves	Resources	Total Resources
EUROPE	Albania	< 0.05	522	205	727
	Austria	–	–	333	333
	Bosnia & Herzegovina	6.3	2,264	3,010	5,274
	Bulgaria	31.3	2,174	2,400	4,574
	Croatia	–	n. s.	300	300
	Czech Republic	38.3	2,604	7,163	9,767
	France	–	n. s.	114	114
	Germany	178.2	36,300	40,500	76,800
	Greece	48.0	2,876	3,554	6,430
	Hungary	9.6	2,633	2,704	5,337
	Italy	–	7	22	29
	Kosovo	7.2	1,564	9,262	10,826
	Macedonia	6.5	332	300	632
	Montenegro	1.6	n. s.	n. s.	n. s.
	Poland	63.9	5,429	222,458	227,886
	Portugal	–	33	33	66
	Romania	23.6	280	9,640	9,920
	Serbia	29.9	7,112	13,074	20,186
	Slovakia	2.2	135	938	1,073
	Slovenia	3.0	315	341	656
	Spain	–	319	n. s.	319
	Turkey	60.0	12,466	362	12,828
	United Kingdom	–	–	1,000	1,000
CIS	Belarus	–	–	1,500	1,500
	Kazakhstan	6.6	n. s.	n. s.	n. s.
	Kyrgyzstan	1.3	n. s.	n. s.	n. s.
	Russia	70.0	90,730	1,288,894	1,379,623
	Ukraine	0.2	2,336	5,381	7,717
	Uzbekistan	4.4	n. s.	n. s.	n. s.
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
	Australia	62.0	44,164	399,267	443,431
	Bangladesh	–	–	3	3
	China	145.0	7,555	325,097	332,652
	India	47.2	4,714	37,932	42,645

continuation of table 37
[Mt]

	Country / Region	Production	Reserves	Resources	Total Resources
AUSTRAL-ASIA	Indonesia	60.0	8,274	32,365	40,639
	Japan	–	10	1,026	1,036
	Korea, DPR	7.0	n. s.	n. s.	n. s.
	Laos	0.5	499	22	521
	Malaysia	–	39	412	451
	Mongolia	6.3	1,350	119,426	120,776
	Myanmar	< 0.05	3	2	5
	New Zealand	0.3	6,750	4,600	11,350
	Pakistan	1.2	2,857	176,739	179,596
	Philippines	–	105	912	1,017
	Thailand	18.0	1,063	826	1,889
	Viet Nam	–	244	199,876	200,120
NORTH AMERICA	Canada	8.5	2,236	118,270	120,506
	Mexico	–	51	n. s.	51
	USA	71.8	30,483	1,367,877	1,398,360
LATIN AMERICA	Argentina	–	–	7,300	7,300
	Brazil	3.4	5,049	12,587	17,636
	Chile	0.2	n. s.	7	7
	Dominican Rep.	–	–	84	84
	Ecuador	–	24	n. s.	24
	Haiti	–	–	40	40
	Peru	–	–	100	100
	World	**1.023.4**	**285,964**	**4,418,658**	**4,704,622**
COUNTRY GROUPS	Europe	509.5	77,365	317,711	395,077
	CIS	82.4	93,065	1,295,775	1,388,840
	Africa	< 0.05	66	402	468
	Middle East	–	–	–	–
	Austral-Asia	347.5	77,625	1,298,506	1,376,131
	North America	80.3	32,770	1,486,147	1,518,917
	Latin America	3.6	5,073	20,118	25,191
ECONOMIC COUNTRY GRP.	OPEC 2009	–	81	320	401
	OPEC-Gulf	546.0	146,811	2,170,568	2,317,379
	OECD 2010	397.9	53,105	291,499	344,604
	EU-28				

n. s. not specified

– no production, reserves or resources

Table 38: Lignite resources 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	USA	1,367,877	31.0	31.0
2	Russia [1]	1,288,894	29.2	60.1
3	Australia	399,267	9.0	69.2
4	China	325,097	7.4	76.5
5	Poland	222,458	5.0	81.6
6	Viet Nam	199,876	4.5	86.1
7	Pakistan	176,739	4.0	90.1
8	Mongolia [1]	119,426	2.7	92.8
9	Canada	118,270	2.7	95.5
10	Germany	40,500	0.9	96.4
11	India	37,932	0.9	97.2
12	Indonesia	32,365	0.7	98.0
13	Serbia	13,074	0.3	98.3
14	Brazil	12,587	0.3	98.5
15	Romania	9,640	0.2	98.8
16	Kosovo	9,262	0.2	99.0
17	Argentina	7,300	0.2	99.1
18	Czech Republic [1]	7,163	0.2	99.3
19	Ukraine [1]	5,381	0.1	99.4
20	New Zealand	4,600	0.1	99.5
	...			
	other countries [32]	20,951	0.5	100.0
	World	**4,418,658**	**100.0**	
	Europe	317,711	7.2	
	CIS	1,295,775	29.3	
	Africa	402	0.0	
	Austral-Asia	1,298,506	29.4	
	North America	1,486,147	33.6	
	Latin America	20,118	0.5	
	OPEC 2009	320	0.0	
	OECD 2010	2,170,568	49.1	
	EU-28	291,499	6.6	

[1] Lignite resources contains subbituminous coal

Table 39: Lignite reserves 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	Mt	Share [%] country	Share [%] cumulative
1	Russia [1]	90,730	31.7	31.7
2	Australia	44,164	15.4	47.2
3	Germany	36,300	12.7	59.9
4	USA	30,483	10.7	70.5
5	Turkey	12,466	4.4	74.9
6	Indonesia	8,274	2.9	77.8
7	China	7,555	2.6	80.4
8	Serbia	7,112	2.5	82.9
9	New Zealand	6,750	2.4	85.3
10	Poland	5,429	1.9	87.2
11	Brazil	5,049	1.8	88.9
12	India	4,714	1.6	90.6
13	Greece	2,876	1.0	91.6
14	Pakistan	2,857	1.0	92.6
15	Hungary	2,633	0.9	93.5
16	Czech Republic [1]	2,604	0.9	94.4
17	Ukraine [1]	2,336	0.8	95.2
18	Bosnia & Herzegovina [1]	2,264	0.8	96.0
19	Canada	2,236	0.8	96.8
20	Bulgaria	2,174	0.8	97.6
	...			
	other countries [22]	6,960	2.4	100.0
	World	**285,964**	**100.0**	
	Europe	77,365	27.1	
	CIS	93,065	32.5	
	Africa	66	0.0	
	Austral-Asia	77,625	27.1	
	North America	32,770	11.5	
	Latin America	5,073	1.8	
	OPEC 2009	81	0.0	
	OECD 2010	146,811	51.3	
	EU-28	53,105	18.6	

[1] Lignite reserves contains subbituminous coal

Table 40: Lignite production 2009 – 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2009	2010	2011	2012	2013	2014	Share [%] country	Share [%] cumulative
					Mt				
1	Germany	169.9	169.4	176.5	185.4	183.0	178.2	17.4	17.4
2	China	115.5	125.3	136.3	145.0	147.0	145.0	14.2	31.6
3	USA	65.8	71.0	73.6	71.6	70.1	71.8	7.0	38.6
4	Russia [1]	68.2	76.0	77.6	77.9	73.0	70.0	6.8	45.4
5	Poland	57.1	56.5	62.8	64.3	65.8	63.9	6.2	51.7
6	Australia	68.3	68.8	66.7	69.1	59.9	62.0	6.1	57.7
7	Turkey	75.6	70.0	71.0	70.0	57.5	60.0	5.9	63.6
8	Indonesia [3]	38.2	40.0	51.3	60.0	65.0	60.0	5.9	69.5
9	Greece	61.8	53.6	58.4	62.4	54.0	48.0	4.7	74.1
10	India	34.1	37.7	42.3	46.5	44.3	47.2	4.6	78.8
11	Czech Republic [1]	45.6	43.9	46.8	43.7	40.6	38.3	3.7	82.5
12	Bulgaria [2]	27.3	27.1	34.5	31.0	26.5	31.3	3.1	85.6
13	Serbia	38.3	37.8	41.1	38.2	40.3	29.9	2.9	88.5
14	Romania [1]	28.4	27.7	32.9	34.1	24.7	23.6	2.3	90.8
15	Thailand	17.6	18.3	21.3	18.1	18.1	18.0	1.8	92.5
16	Hungary [1]	9.0	9.0	9.5	9.3	9.6	9.6	0.9	93.5
17	Canada	10.6	10.3	9.7	9.5	9.0	8.5	0.8	94.3
18	Kosovo	7.9	8.0	8.2	8.0	8.2	7.2	0.7	95.0
19	Korea, DPR [3]	9.0	7.0	7.6	7.0	7.0	7.0	0.7	95.7
20	Kazakhstan	5.1	7.3	8.4	7.7	6.5	6.6	0.6	96.3
	...								
	other countries [17]	44.2	43.5	43.8	42.7	43.6	37.5	3.7	100.0
	World	**997.1**	**1,008.0**	**1,080.4**	**1,101.5**	**1,053.6**	**1,023.4**	**100.0**	
	Europe	547.3	529.4	565.7	569.0	530.9	509.5	49.8	
	CIS	76.9	87.3	90.8	90.6	84.9	82.4	8.1	
	Africa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	Austral-Asia	290.3	304.1	334.6	353.6	349.6	347.5	34.0	
	North America	76.3	81.2	83.3	81.1	79.0	80.3	7.8	
	Latin America [4]	6.2	5.9	6.0	7.1	9.1	3.6	0.4	
	OECD 2010	570.9 [5]	560.1	582.8	592.7	556.3	546.0	53.3	
	EU-28	405.7 [6]	394.1 [6]	428.4 [6]	436.8 [6]	410.3	397.9	38.9	

[1] Lignite production contains subbituminous coal
[2] Lignite production contains subbituminous coal from 2014
[3] preliminary
[4] Lignite production in 2014 is not comparable with previous years due to changes in statistics
[5] including Estonia (cf. economic country groupings)
[6] including Croatia (cf. economic country groupings)

Table 41: Lignite consumption 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country/Region	Mt	Share [%] country	cumulative
1	Germany	178.2	17.4	17.4
2	China	145.0	14.2	31.6
3	USA	71.8	7.0	38.6
4	Russia [1]	70.0	6.8	45.4
5	Poland	63.9	6.2	51.7
6	Australia	62.0	6.1	57.7
7	Turkey	60.0	5.9	63.6
8	Indonesia	60.0	5.9	69.4
9	Greece	48.0	4.7	74.1
10	India	47.2	4.6	78.7
11	Czech Republic [1]	38.3	3.7	82.5
12	Bulgaria	31.3	3.1	85.5
13	Serbia	29.9	2.9	88.5
14	Romania [1]	23.6	2.3	90.8
15	Thailand	18.4	1.8	92.5
16	Hungary [1]	9.6	0.9	93.5
17	Canada	8.5	0.8	94.3
18	Kosovo	7.2	0.7	95.0
19	Korea, DPR	7.0	0.7	95.7
20	Kazakhstan	6.6	0.6	96.3
	...			
	other countries [17]	37.5	3.7	100.0
	World	**1,023.8**	**100.0**	
	Europe	509.5	49.8	
	CIS	82.4	8.1	
	Austral-Asia	347.9	34.0	
	North America	80.3	7.8	
	Latin America	3.6	0.4	
	OECD 2010	546.0	53.3	
	EU-28	398.0	38.9	

[1] Lignite consumption contains subbituminous coal

Table 42: Uranium 2014 [kt]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
EUROPE	Bulgaria	–	–	–	25	25	25
	Czech Republic	0.2	112	–	342	454	342
	Finland	n. s.	< 0.5	–	24	24	24
	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	4	12	9
	Romania	0.1	19	–	13	32	13
	Slovakia	n. s.	–	9	18	26	26
	Slovenia	n. s.	–	2	9	10	10
	Spain	–	5	–	14	19	14
	Sweden	n. s.	< 0.5	–	10	10	10
	Turkey	–	–	7	2	9	9
CIS	Kazakhstan	23.1	246	236	1,407	1,890	1,644
	Russia	3.0	159	12	789	960	801
	Ukraine	0.9	20	50	313	383	364
	Uzbekistan	2.4	50	42	74	166	116
AFRICA	Algeria	–	–	–	20	20	20
	Botswana	–	–	–	69	69	69
	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	0.4	4	–	15	19	15
	Mali	–	–	–	13	13	13
	Namibia	3.3	121	–	513	634	513
	Niger	4.1	136	15	455	606	470
	Somalia	–	–	–	8	8	8
	South Africa	0.6	160	113	448	721	561
	Tanzania	–	–	38	20	58	58
	Zambia	–	< 0.5	–	54	54	54
	Zimbabwe	–	–	–	26	26	26
MIDDLE EAST	Iran	–	< 0.5	–	17	17	17
	Jordan	–	–	–	90	90	90
	Australia	5.0	194	–	1,791	1,985	1,791
	China	1.5	39	94	113	246	207
	India	0.4	11	–	205	216	205

continuation of table 42
[kt]

	Country / Region	Production	Cum. Production	Reserves	Resources	EUR	Remaining Potential
AUSTRAL-ASIA	Indonesia	–	–	2	32	34	34
	Japan	n. s.	< 0.5	–	7	7	7
	Mongolia	–	1	108	1,444	1,553	1,553
	Pakistan	< 0.05	1	–	–	1	–
	Viet Nam	–	–	–	84	84	84
NORTH AMERICA	Canada	9.1	484	275	1,243	2,002	1,518
	Greenland	–	–	–	271	271	271
	Mexico	n. s.	< 0.5	–	6	6	6
	USA	1.9	374	39	2,564	2,977	2,603
LATIN AMERICA	Argentina	–	3	5	85	92	90
	Brazil	0.2	4	155	421	580	576
	Chile	–	–	–	4	4	4
	Colombia	–	–	–	228	228	228
	Peru	–	–	1	41	43	43
	World	**56.2**	**2,513**	**1,213**	**13,444**	**17,170**	**14,657**
COUNTRY GROUPS	Europe	0.3	457	27	529	1,012	555
	CIS	29.4	474	340	2,585	3,399	2,925
	Africa	8.3	472	166	1,685	2,323	1,851
	Middle East	–	< 0.5	–	107	107	107
	Austral-Asia	6.9	246	204	3,676	4,126	3,880
	North America	11.1	858	315	4,084	5,256	4,398
	Latin America	0.2	7	162	779	947	940
ECONOMIC COUNTRY GRP.	OPEC 2009	–	< 0.5	–	36	36	36
	OPEC-Gulf	–	< 0.5	–	17	17	17
	OECD 2010	16.3	1,489	341	6,377	8,207	6,718
	EU-28	0.3	457	20	527	1,003	547

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

Table 43: Uranium resources (>20 kt U) [kt]
The most important countries 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
USA	433	n. s.	433	1,273	858	2,564	19.1	19.1
Australia	1,201	590	1,791	n. s.	n. s.	1,791	13.3	32.4
Mongolia	–	33	33	21	1,390	1,444	10.7	43.1
Kazakhstan	171	575	746	361	300	1,407	10.5	53.6
Canada	191	201	393	150	700	1,243	9.2	62.9
Russia	250	427	677	112	n. s.	789	5.9	68.7
Namibia	297	159	456	57	n. s	513	3.8	72.5
Niger	310	80	390	14	51	455	3.4	75.9
South Africa	121	217	338	110	n. s	448	3.3	79.3
Brazil	–	121	121	300	n. s	421	3.1	82.4
Czech Republic	51	68	119	223	–	342	2.5	84.9
Ukraine	117	54	171	23	120	313	2.3	87.3
Greenland	–	221	221	n. s.	50	271	2.0	89.3
Colombia	–	n. s.	–	11	217	228	1.7	91.0
India	98	22	120	85	n. s	205	1.5	92.5
China	26	79	105	4	4	113	0.8	93.3
Jordan	–	40	40	–	50	90	0.7	94.0
Argentina	3	11	14	14	56	85	0.6	94.6
Viet Nam	1	2	3	81	n. s	84	0.6	95.3
Uzbekistan	18	32	50	25	–	74	0.6	95.8
Botswana	13	56	69	n. s.	n. s	69	0.5	96.3
Zambia	10	15	25	30	n. s	54	0.4	96.7
Peru	–	2	2	20	20	41	0.3	97.0
Indonesia	6	2	9	23	n. s	32	0.2	97.3
Central African Rep.	32	n. s.	32	n. s.	n. s	32	0.2	97.5
Hungary	–	14	14	13	n. s	27	0.2	97.7
Zimbabwe	1	n. s.	1	–	25	26	0.2	97.9
Bulgaria	–	–	–	25	n. s	25	0.2	98.1
Finland	2	22	24	–	–	24	0.2	98.3
...								
Germany	3	4	7	–	–	7	0.1	99.7

continuation of table 43
[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*
World	**3,453**	**3,122**	**6,575**	**3,014**	**3,855**	**13,444**	**100.0**	**–**
Europe	91	141	232	284	13	529	3.9	–
CIS	555	1,089	1,644	520	420	2,585	19.2	–
Africa	835	563	1,398	210	76	1,685	12.5	–
Middle East	1	43	44	12	50	107	0.8	–
Austral-Asia	1,339	729	2,068	214	1,394	3,676	27.3	–
North America	627	423	1,050	1,426	1,608	4,084	30.4	–
Latin America	4	134	138	347	293	779	5.8	–
OPEC 2009	21	3	24	12	–	36	0.3	–
OPEC-Gulf	1	3	4	12	–	17	0.1	–
OECD 2010	1,924	1,151	3,075	1,684	1,618	6,377	47.4	–
EU-28	91	139	230	284	13	527	3.9	–

n. s. not specified
– no resources

Table 44: Uranium reserves 2014 (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	Share [%] cumulative
1	Canada	275	22.7	22.7
2	Kazakhstan	236	19.5	42.2
3	Brazil	155	12.8	55.0
4	South Africa	113	9.3	64.3
5	Mongolia	108	8.9	73.2
6	China	94	7.7	80.9
7	Ukraine	50	4.2	85.1
8	Uzbekistan	42	3.4	88.5
9	USA	39	3.2	91.8
10	Tanzania	38	3.2	94.9
11	Niger	15	1.2	96.1
12	Russia	12	1.0	97.1
13	Slovakia	9	0.7	97.8
14	Turkey	7	0.6	98.4
15	Argentina	5	0.4	98.8
16	Italy	5	0.4	99.2
17	Portugal	5	0.4	99.6
18	Indonesia	2	0.2	99.7
19	Slovenia	2	0.1	99.9
20	Peru	1	0.1	100.0
	World	**1,213**	**100.0**	
	Europe	27	2.2	
	CIS	340	28.0	
	Africa	166	13.7	
	Austral-Asia	204	16.8	
	North America	315	25.9	
	Latin America	162	13.3	
	OECD 2010	341	28.1	
	EU-28	20	1.6	

Table 45: Uranium resources 2014 (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	1,167.0	31.1	31.1
2	Canada	366.8	9.8	40.8
3	Niger	325.0	8.7	49.5
4	Kazakhstan	323.6	8.6	58.1
5	Namibia	248.2	6.6	64.7
6	Russia	216.5	5.8	70.5
7	USA	207.4	5.5	76.0
8	South Africa	175.3	4.7	80.6
9	Brazil	155.1	4.1	84.8
10	China	120.0	3.2	88.0
11	Mongolia	108.1	2.9	90.8
12	Ukraine	100.1	2.7	93.5
13	Uzbekistan	59.4	1.6	95.1
14	Tanzania	40.4	1.1	96.2
15	Central African Rep.	32.0	0.9	97.0
16	Botswana	12.8	0.3	97.4
17	Zambia	9.9	0.3	97.6
18	Slovakia	8.8	0.2	97.9
19	Argentina	8.6	0.2	98.1
20	Mali	8.5	0.2	98.3
	...			
	other countries [15]	63.3	1.7	100.0
	World	**3,756.8**	**100.0**	
	Europe	38.8	1.0	
	CIS	699.6	18.6	
	Africa	865.1	23.0	
	Middle East	1.0	0.0	
	Austral-Asia	1,410.1	37.5	
	North America	577.1	15.4	
	Latin America	165.1	4.4	
	OPEC 2009	1.0	0.0	
	OPEC-Gulf	1.0	0.0	
	OECD 2010	1,786.4	47.6	
	EU-28	32.0	0.9	

Table 46: Natural uranium production 2009 – 2014
The most important countries and distribution by regions and economic country groupings

Rank	Country / Region	2009	2010	2011	2012	2013	2014	Share [%] country	Share [%] cumulative
		kt							
1	Kazakhstan	14.0	17.8	19.5	21.3	22.6	23.1	41.1	41.1
2	Canada	10.2	9.8	9.1	9.0	9.3	9.1	16.2	57.4
3	Australia	8.0	5.9	6.0	7.0	6.4	5.0	8.9	66.3
4	Niger	3.2	4.2	4.4	4.7	4.5	4.1	7.2	73.5
5	Namibia	4.6	4.5	3.3	4.5	4.3	3.3	5.8	79.3
6	Russia	3.6	3.6	3.0	2.9	3.1	3.0	5.3	84.6
7	Uzbekistan	2.4	2.4	3.0	2.4	2.4	2.4	4.3	88.9
8	USA	1.5	1.7	1.5	1.6	1.8	1.9	3.4	92.3
9	China	0.8	0.8	1.5	1.5	1.5	1.5	2.7	95.0
10	Ukraine	0.8	0.9	0.9	1.0	1.1	0.9	1.6	96.6
11	South Africa	0.6	0.6	0.6	0.5	0.5	0.6	1.0	97.6
12	India	0.3	0.4	0.4	0.4	0.4	0.4	0.7	98.3
13	Malawi	0.1	0.7	0.8	1.1	1.1	0.4	0.7	99.0
14	Brazil	0.3	0.1	0.3	0.2	0.2	0.2	0.4	99.4
15	Czech Republic	0.3	0.3	0.2	0.2	0.2	0.2	0.3	99.7
16	Romania	0.1	0.1	0.1	0.1	0.1	0.1	0.1	99.9
17	Pakistan	0.1	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	99.9
18	Germany [1]	–	< 0.05	0.1	0.1	< 0.05	< 0.05	0.1	100.0
19	France	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	100.0
	World	**50.8**	**53.7**	**54.6**	**58.4**	**59.6**	**56.2**	**100.0**	
	Europe	0.3	0.3	0.4	0.4	0.3	0.3	0.5	
	CIS	20.9	24.6	26.3	27.5	29.2	29.4	52.4	
	Africa	8.5	9.9	9.0	10.7	10.5	8.3	14.7	
	Austral-Asia	9.1	7.2	7.9	8.9	8.2	6.9	12.3	
	North America	11.6	11.4	10.7	10.6	11.2	11.1	19.7	
	Latin America	0.3	0.1	0.3	0.2	0.2	0.2	0.4	
	OECD 2010	19.9 [2]	17.6	17.0	17.9	17.8	16.3	29.0	
	EU-28	0.3 [3]	0.3 [3]	0.4 [3]	0.4 [3]	0.3	0.3	0.5	

[1] only in the form of uranium concentrate as part of the remediation of production sites
[2] including Estonia (cf. economic country groupings)
[3] including Croatia (cf. economic country groupings)

Table 47: Uranium consumption 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	kt	Share [%]	
			country	cumulative
1	USA	18.82	28.5	28.5
2	France	9.93	15.1	43.6
3	China	6.30	9.6	53.2
4	Russia	5.46	8.3	61.4
5	Korea, Rep.	5.02	7.6	69.1
6	Ukraine	2.36	3.6	72.6
7	Japan	2.12	3.2	75.9
8	Germany	1.89	2.9	78.7
9	Canada	1.78	2.7	81.4
10	United Kingdom	1.74	2.6	84.1
11	Sweden	1.52	2.3	86.4
12	Spain	1.27	1.9	88.3
13	Taiwan	1.25	1.9	90.2
14	Belgium	1.02	1.5	91.7
15	India	0.91	1.4	93.1
16	Czech Republic	0.56	0.9	94.0
17	Switzerland	0.52	0.8	94.8
18	Finland	0.48	0.7	95.5
19	Slovakia	0.39	0.6	96.1
20	Hungary	0.36	0.5	96.6
	...			
	other countries [11]	2.22	3.4	100.0
	World	**65.91**	**100.0**	
	Europe	20.41	31.0	
	CIS	7.90	12.0	
	Africa	0.31	0.5	
	Middle East	0.17	0.3	
	Austral-Asia	15.70	23.8	
	North America	20.88	31.7	
	Latin America	0.54	0.8	
	OPEC 2009	0.17	0.3	
	OPEC-Gulf	0.17	0.3	
	OECD 2010	47.93	72.7	
	EU-28	19.89	30.2	

Table 48: Geothermal energy 2014[1]

	Region	El. Power [MW_e]	El. Energy Consumption [GWh]	Therm. Power [MW_{th}]	Therm. Energy Consumption [GWh]	Total Power [MW]	Total Energy Consumption [GWh]
EUROPE	Albania	–	–	16	29.9	16.2	29.9
	Austria	1	2.2	903	1,816.3	904.6	1,818.5
	Belgium	–	–	206	24.0	206.1	24.0
	Bosnia & Herzegovina	–	–	24	70.1	23.9	70.1
	Bulgaria	–	–	93	340.1	93.1	340.1
	Croatia	–	–	80	190.2	79.9	190.2
	Czech Republic	–	–	305	497.3	304.5	497.3
	Denmark	–	–	353	1,043.1	353.0	1,043.1
	Estonia	–	–	63	98.9	63.0	98.9
	Finland	–	–	1,560	5,000.4	1,560.0	5,000.4
	France	16	115.0	2,347	4,407.9	2,362.9	4,522.9
	Germany	27	35.0	2,849	5,425.8	2,875.6	5,460.8
	Greece	–	–	222	368.5	221.9	368.5
	Hungary	–	–	906	2,852.5	905.6	2,852.5
	Iceland	665	5,245.0	2,040	7,422.0	2,705.0	12,667.0
	Ireland	–	–	266	344.6	265.5	344.6
	Italy	916	5,660.0	1,014	2,411.9	1,930.0	8,071.9
	Latvia	–	–	2	8.8	1.6	8.8
	Lithuania	–	–	95	198.0	94.6	198.0
	Macedonia	–	–	49	167.0	48.7	167.0
	Netherlands	–	–	790	1,785.1	790.0	1,785.1
	Norway	–	–	1,300	2,294.6	1,300.0	2,294.6
	Poland	–	–	489	761.9	488.8	761.9
	Portugal	29	196.0	35	132.8	64.2	328.8
	Romania	< 0.5	0.4	245	529.3	245.2	529.7
	Serbia	–	–	116	500.7	115.6	500.7
	Slovakia	–	–	149	686.1	149.4	686.1
	Slovenia	–	–	153	315.9	152.8	315.9
	Spain	–	–	64	95.8	64.1	95.8
	Sweden	–	–	5,600	14,423.4	5,600.0	14,423.4
	Switzerland	–	–	1,733	3,288.3	1,733.1	3,288.3
	Turkey	397	3,127.0	2,886	12,536.0	3,283.3	15,663.0
	United Kingdom	–	–	284	529.6	283.8	529.6
CIS	Armenia	–	–	2	6.3	1.5	6.3
	Belarus	–	–	5	31.5	4.7	31.5
	Georgia	–	–	73	193.1	73.4	193.1
	Russia	82	441.0	308	1,706.7	390.2	2,147.7
	Tajikistan	–	–	3	15.4	2.9	15.4
	Ukraine	–	–	11	33.0	10.9	33.0

continuation of table 48

	Region	El. Power [MW_e]	El. Energy Consumption [GWh]	Therm. Power [MW_{th}]	Therm. Energy Consumption [GWh]	Total Power [MW]	Total Energy Consumption [GWh]
AFRICA	Algeria	–	–	55	472.3	54.6	472.3
	Egypt	–	–	7	24.5	6.8	24.5
	Ethiopia	7	10.0	2	11.6	9.5	21.6
	Kenya	594	2,848.0	22	50.7	616.4	2,898.7
	Madagascar	–	–	3	21.0	2.8	21.0
	Morocco	–	–	5	13.9	5.0	13.9
	South Africa	–	–	2	10.3	2.3	10.3
	Tunisia	–	–	44	101.1	43.8	101.1
MIDDLE EAST	Iran	–	–	82	306.5	81.5	306.5
	Israel	–	–	82	609.2	82.4	609.2
	Jordan	–	–	153	427.8	153.3	427.8
	Saudi Arabia	–	–	44	42.5	44.0	42.5
	Yemen	–	–	1	4.2	1.0	4.2
AUSTRAL-ASIA	Australia	1	0.5	16	54.0	17.2	54.5
	China	27	150.0	17,870	48,435.0	17,897.0	48,585.0
	India	–	–	986	1,195.1	986.0	1,195.1
	Indonesia	1,340	9,600.0	2	11.8	1,342.3	9,611.8
	Japan	519	2,687.0	2,186	7,258.9	2,705.2	9,945.9
	Korea, Rep.	–	–	836	745.2	835.8	745.2
	Mongolia	–	–	20	94.6	20.2	94.6
	Nepal	–	–	3	22.5	3.3	22.5
	New Zealand	1,005	7,000.0	487	2,394.9	1,492.5	9,394.9
	Pakistan	–	–	1	0.7	0.5	0.7
	Papua New Guinea	50	432.0	< 0.5	0.3	50.1	432.3
	Philippines	1,870	9,646.0	3	11.0	1,873.3	9,657.0
	Taiwan	< 0.5	–	–	–	0.1	–
	Thailand	< 0.5	1.2	129	328.1	128.8	329.3
	Viet Nam	–	–	31	25.7	31.2	25.7
NORTH AMERICA	Canada	–	–	1,467	3,226.7	1,466.8	3,226.7
	Greenland	–	–	1	5.8	1.0	5.8
	Mexico	1,017	6,071.0	156	1,158.7	1,172.8	7,229.7
	USA	3,450	16,600.0	17,416	21,074.5	20,865.9	37,674.5
LATIN AMERICA	Costa Rica	207	1,511.0	1	5.8	208.0	1,516.8
	El Salvador	204	1,442.0	3	15.6	207.4	1,457.6
	Guatemala	52	237.0	2	15.7	54.3	252.7
	Nicaragua	159	492.0	–	–	159.0	492.0
	Peru	–	–	3	17.0	3.0	17.0
	Venezuela	–	–	1	3.9	0.7	3.9

continuation of table 48

	Region	El. Power [MW_e]	El. Energy Consumption [GWh]	Therm. Power [MW_{th}]	Therm. Energy Consumption [GWh]	Total Power [MW]	Total Energy Consumption [GWh]
	World	**12,636**	**73,549.3**	**70,328**	**163,067.3**	**82,964.3**	**236,616.6**
COUNTRY GROUPS	Europe	2,051	14,380.6	27,235	70,596.8	29,286.1	84,977.4
	CIS	82	441.0	402	1,986.0	483.7	2,427.0
	Africa	601	2,858.0	140	705.3	741.3	3,563.3
	Middle East	–	–	362	1,390.1	362.2	1,390.1
	Austral-Asia	4,813	29,516.7	22,571	60,577.9	27,383.4	90,094.6
	North America	4,467	26,353.0	19,040	25,465.7	23,506.5	51,818.7
	Latin America	622	3,682.0	579	2,345.6	1,201.1	6,027.6
ECON. COUNTRY GROUPINGS	OPEC 2009	–	–	186	853.5	186.0	853.5
	OPEC-Gulf	–	–	126	348.9	125.5	348.9
	OECD 2010	8,043	46,738.7	49,183	105,142.4	57,226.6	151,881.1
	EU-28	989	6,008.6	19,071	44,288.2	20,060.3	50,296.8

[1] On the occasion of the World Geothermal Congress (WGC) taking place every five years, geothermal data are compiled and presented. Each time, the most recent data are provided by the individual country, hence, the data are nonuniform and varies in quality. Data employed in this report are based on the latest and most comprehensive documentation, status as of 2014, published by WGC 2015.

– no data available

Table 49: Geothermal energy resources 2014

Region	Theoretical Potential [EJ]	Technical Potential [EJ/year]		
	Total	Electricity	Heat	Total
Europe	2,342,000	37.1	3.5	40.6
CIS	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**

Table 50: Geothermal electricity installed power 2009 – 2014
The most important countries (top 20) and distribution by regions and economic country groupings

Rank	Country / Region	2009	2010	2011	2012 MW	2013	2014	Share [%] country	Share [%] cumulative
1	USA	3,093	3,102	3,389	3,442	3,525	3,450	27.3	27.3
2	Philippines	1,904	1,904	1,848	1,904	1,917	1,870	14.8	42.1
3	Indonesia	1,197	1,197	1,341	1,333	1,401	1,340	10.6	52.7
4	Mexico	958	887	1,017	1,017	834	1,017	8.0	60.8
5	New Zealand	628	792	843	895	971	1,005	8.0	68.7
6	Italy	843	772	876	876	916	916	7.2	76.0
7	Iceland	575	665	660	664	665	665	5.3	81.2
8	Kenya	167	169	249	249	590	594	4.7	85.9
9	Japan	536	538	537	537	539	519	4.1	90.0
10	Turkey	82	114	242	167	368	397	3.1	93.2
11	Costa Rica	166	166	207	207	208	207	1.6	94.8
12	El Salvador	204	204	204	204	204	204	1.6	96.4
13	Nicaragua	88	82	150	150	160	159	1.3	97.7
14	Russia	82	82	82	82	82	82	0.6	98.3
15	Guatemala	52	52	48	48	48	52	0.4	98.7
16	Papua New Guinea	56	56	56	56	56	50	0.4	99.1
17	Portugal	29	30	23	29	29	29	0.2	99.4
18	China	24	24	27	27	27	27	0.2	99.6
	Germany	7	7	29	24	27	27	0.2	99.8
20	France	16	18	17	17	17	16	0.1	99.9
	...								
	other countries [6]	10	40	49	11	10	10	0.1	100.0
	World	**10,717**	**10,901**	**11,893**	**11,938**	**12,594**	**12,636**	**100.0**	
	Europe	1,553	1,608	1,848	1,778	2,024	2,051	16.2	
	CIS	82	82	82	82	82	82	0.6	
	Africa	174	176	264	257	597	601	4.8	
	Austral-Asia	4,346	4,512	4,653	4,753	4,912	4,813	38.1	
	North America	4,051	3,988	4,406	4,459	5,100	4,467	35.4	
	Latin America	510	534	639	609	620	622	4.9	
	OECD 2010	6,769[1]	6,927	7,635	7,670	7,894	8,043	63.7	
	EU-28	896[2]	829[2]	946[2]	947[2]	991	989	7.8	

[1] including Estonia (cf. economic country groupings)
[2] including Croatia (cf. economic country groupings)

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World Energy Council – WEC
World Geothermal Congress – WGC
World Nuclear Association – WNA

GLOSSARY / LIST OF ABBREVIATIONS

AfDB	African Development Bank
AGEB	Arbeitsgemeinschaft Energiebilanzen e. V. (Energy Balance Joint Venture), headquarters in Berlin
AGEE-Stat	Arbeitsgruppe Erneuerbare Energien-Statistik (Working Group on Renewables Statistics, headquarters in Berlin
Aquifer gas	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
Associated gas	Natural gas dissolved in the crude oil in the reservoir which is released when the oil is produced
AU	African Union
AUC	African Union Commission
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
BMU	Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit (Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety), office in Berlin
BMWi	Bundesministerium für Wirtschaft und Energie (Federal Ministry of Economic Affairs and Energy), office 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
CBM	Coal-bed methane; gas contained in coal, including methane

ce	Coal equivalent; corresponds to the amount of energy released when burning 1 kg hard coal, cf.: Conversion factors
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.
CTL	Coal to liquid; synthetic fuel made from coal
Cumulative production	Total production since the start of production operations
dena	German Energy Agency; office in Berlin
Deposit	Part of the earth’s crust with a natural concentration of economically extractable mineral and/or energy commodities
DFID	UK-Department for International Development
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	Renewable Energy Sources Act in Germany
EEPCO	Ethiopian Electricity and Power Company
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
EOR	Enhanced oil recovery: processes used to improve the natural recovery rate of an oilfield
ESA	Euratom Supply Agency – European Commission
EU-AITF	European Union-Africa Infrastructure Trust Fund
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)
Geothermal energy	Geothermal energy is made up of the original heat from when the earth was formed, and the heat generated in the interior of the earth by the continuous decay of naturally occurring radioactive isotopes. A differentiation is generally made between shallow geothermal energy down to approximately 400 m depth, and deep geothermal energy from 400 m downwards. Both zones are used for producing heat (direct use), but only deeper zones can be used geothermally for the production of electrical power because of the required higher temperature differences. Geothermal energy is a renewable energy resource. *Hydrothermal geothermal energy* The energy which harnesses the heat energy stored in natural deep thermal-water-filled horizons (hydrothermal) .
Gas hydrate	Solid (snow-like) molecular compound consisting of gas and water which is stable under high pressures and low temperatures
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
GRMF	Geothermal Risk Mitigation Facility

GTL	Gas to liquid; using different methods to produce synthetic fuels from natural gas. Methods include Fischer-Tropsch synthesis
GWe	Gigawatt elektricity
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
IAEA	International Atomic Energy Agency; UN agency; headquarters in Vienna. cf. Economic country groupings
ICEIDA	Icelandic International Development Agency
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)
J	Joule; *cf. Units*
KenGen	Kenya Electricity Generating Company
LBEG	Landesamt für Bergbau, Energie und Geologie, headquarters in Hannover (State Office of Mining, Energy and Geology)
LEU	Low enriched uranium
LIAG	Leibniz-Institut für Angewandte Geopysik (Leibniz Institute for Applied Geopysics), headquarters 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)
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	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
NEA	Nuclear Energy Agency; part of OECD, headquarters in Paris
NGL	Natural gas liquids
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
OPEC	Organization of Petroleum Exporting Countries, headquarters in Vienna; cf. Economic country groupings

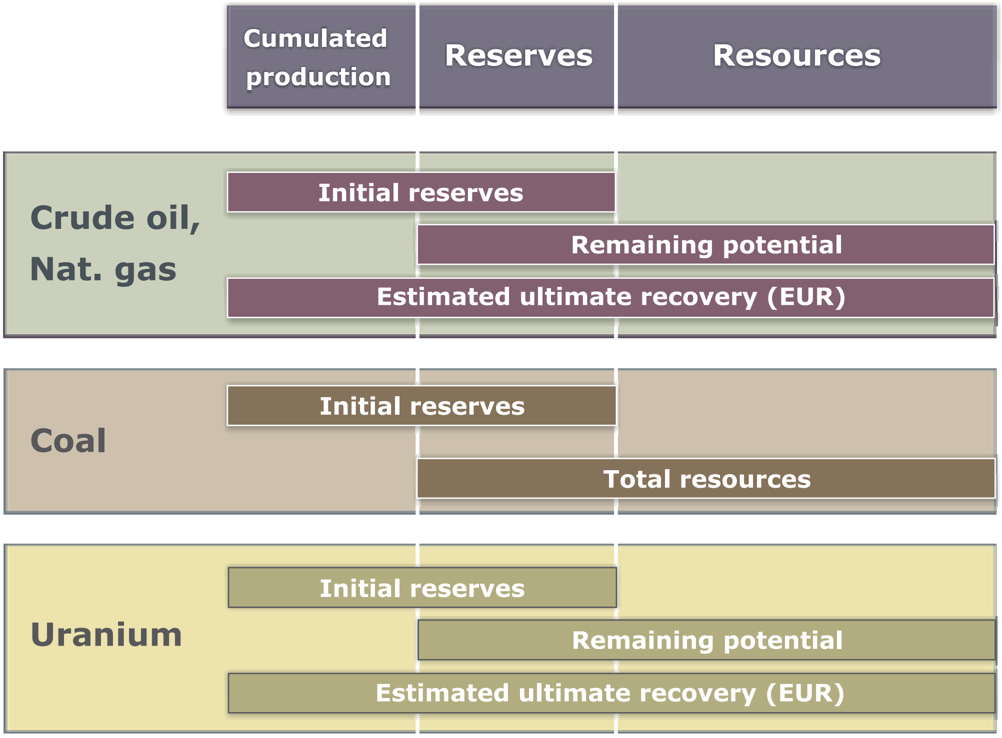
OPEC basket price	Average price of the different qualities of crude oil produced by OPEC members
Original reserves	Cumulative production plus remaining reserves
Peak Oil	Time when maximum crude oil production level is reached
PEC	Primary energy consumption; describes the total amount of energy required to supply an economy
Permeability	Measure of the hydraulic transmissivity of a rock; unit: Darcy [D]; symbol: k; cf.: Units
Petroleum	Crude oil and petroleum products produced in refineries
Porosity	Pore space in a rock: unit: [%]
Potential	Total potential: cumulative production plus reserves plus resources
Pure gas	Standardized natural gas with a calorific value of 9.7692 kWh / Nm³ in Germany
Raw gas	Untreated natural gas recovered during production
reamaining potential	reserves plus resources
Recovery rate	Amount of oil which can be recovered from an oilfield in per cent
REEGLE	Renewable Energy and Energy Efficiency Partnership
RGCU	Regional Geothermal Coordination Unit of the African Union Commission
reserve growth	(→ field growth)
Reserves	Proven volumes of energy resources economically exploitable at today's prices and using today's technology *Original reserves: cumulative production plus remaining reserves*
Ressources	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
SPE	Society of Petroleum Engineers
tce	Tons coal equivalent (→CE, here: in tonnes) 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
UNEP-ARGeo	United Nations Environment Programme – African Rift Geothermal Development Facility
UN-ESA	United Nations, Department of Economic and Social Affairs, Population Division
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, nonmetals, 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. (Organisation of Coal Importers); headquarters in Hamburg
WEC	World Energy Council, headquarters in London; organises the World Energy Congress

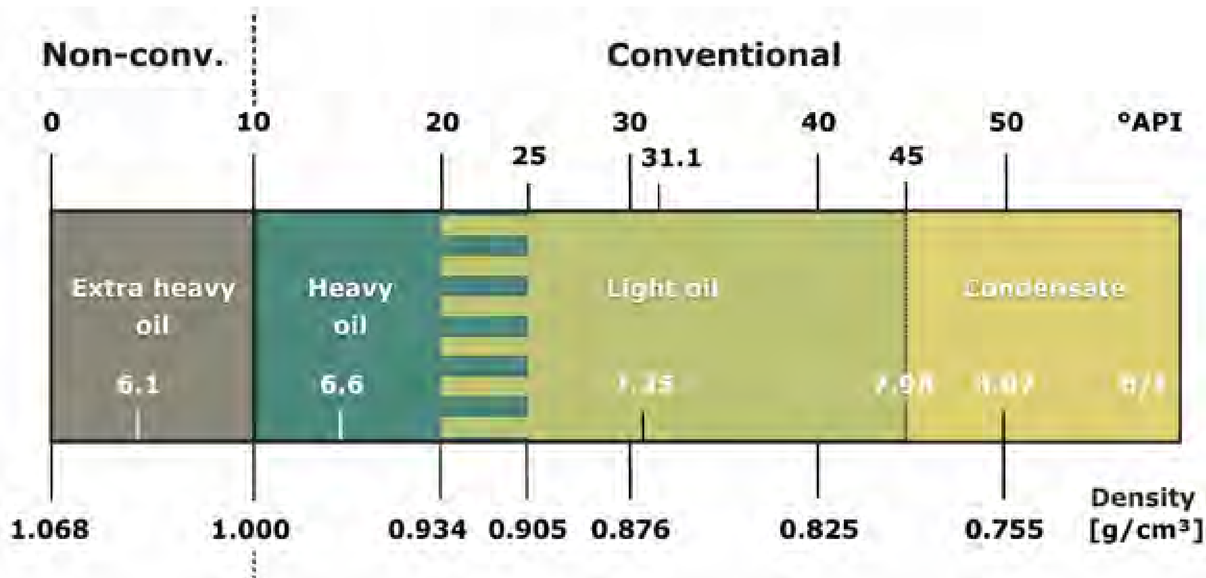
WGC	World Geothermal Congress: takes place every five years. Discussions on geothermal issues take place between global representatives from science, engineering, business, and society. In the run-up to the congress, comprehensive data is collected at a national level on the current situation regarding shallow and deep geothermal energy. This data is presented at the congress.
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



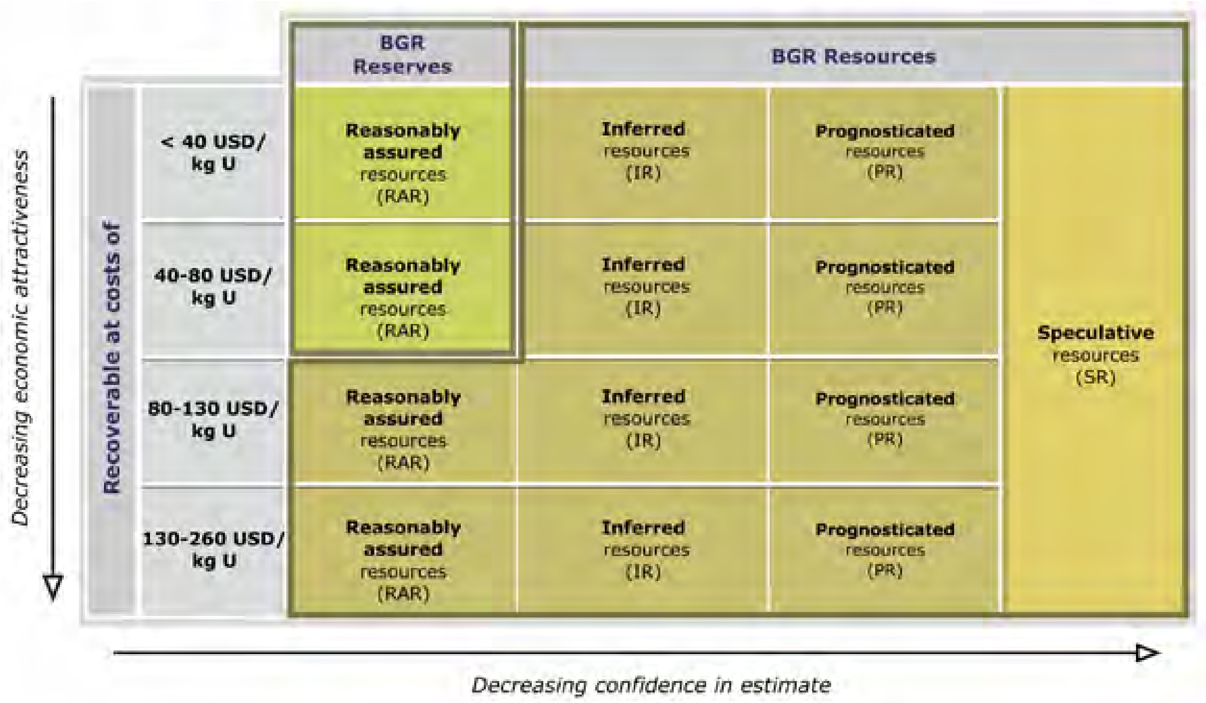
Classification of crude oil according to its density



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

Europe

Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, 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

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 Emirate, 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, Panama, Paraguay, Peru, Puerto Rico, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Turks and Caicos Islands, Uruguay, Venezuela (Bolivarian Republic), Virgin Islands (Brit.), Virgin Islands (Americ.)

ECONOMIC COUNTRY GROUPINGS *STATUS:2014*

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, Czech Republic, 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; 162 countries)

Afghanistan (Islamic Republic), Albania, Algeria, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, 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, Czech Republic, Denmark, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Estonia, Ethiopia, Fiji, Finland, France, Gabon, Georgia, Germany, Ghana, Greece, Guatemala, 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, San Marino, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, South Africa, South Sudan, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Tanzania (United Republic), Thailand, Togo, Trinidad and Tobago, Turkey, Tunisia, Uganda, Ukraine, United Arab Emirates, United Kingdom, United States, Uruguay, Uzbekistan, 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; 34 countries)

Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea (Republic), 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; 12 countries)

Algeria, Angola, Ecuador, 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	Joule	1 J = 0.2388 cal = 1 Ws (Watt second)
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
cm, m^3	cubic meter	
Nm^3	standard cubic meter	Volume of Gas in 1 m^3 at 0° C and 1,013 mbar
mcm	million cubic meter	1 mcm = 10^6 m^3
bcm	billion cubic meter	1 bcm = 10^9 m^3
tcm	trillion cubic meter	1 tcm = 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	ton(s) 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 kW = 3.6 kJ

CONVERSION FACTORS

1 t crude oil	1 toe = 7.35 bbl = 1.428 tce = 1,101 m^3 natural gas = 41.8 x 10^9 J
1 t LNG	1,380 m^3 natural gas = 1.06 toe = 1.52 tce = 44.4 x 10^9 J
1,000 Nm^3 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 m^3 natural gas = 29.3 x 10^9 J
1 EJ (10^{18} J)	34.1 Mtce = 23.9 Mtoe = 26.3 G. m^3 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

DISCLAIMER

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