

HEAL Briefing

Lignite coal - health effects and recommendations from the health sector



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Notes on methodology

Our “countries in the European region” referred to in this publication, e.g. in data on coal consumption and production include: Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Iceland, Italy, 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 and Vatican City State.

Western Balkan countries referred to in this publication include: Albania, Bosnia & Herzegovina, Kosovo, Macedonia, Montenegro and Serbia.

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Lignite - the most polluting and health-harming form of coal

Coal is still the main source for electricity production globally although it is one of the main sources for health harming air pollution and climate changing greenhouse gases.

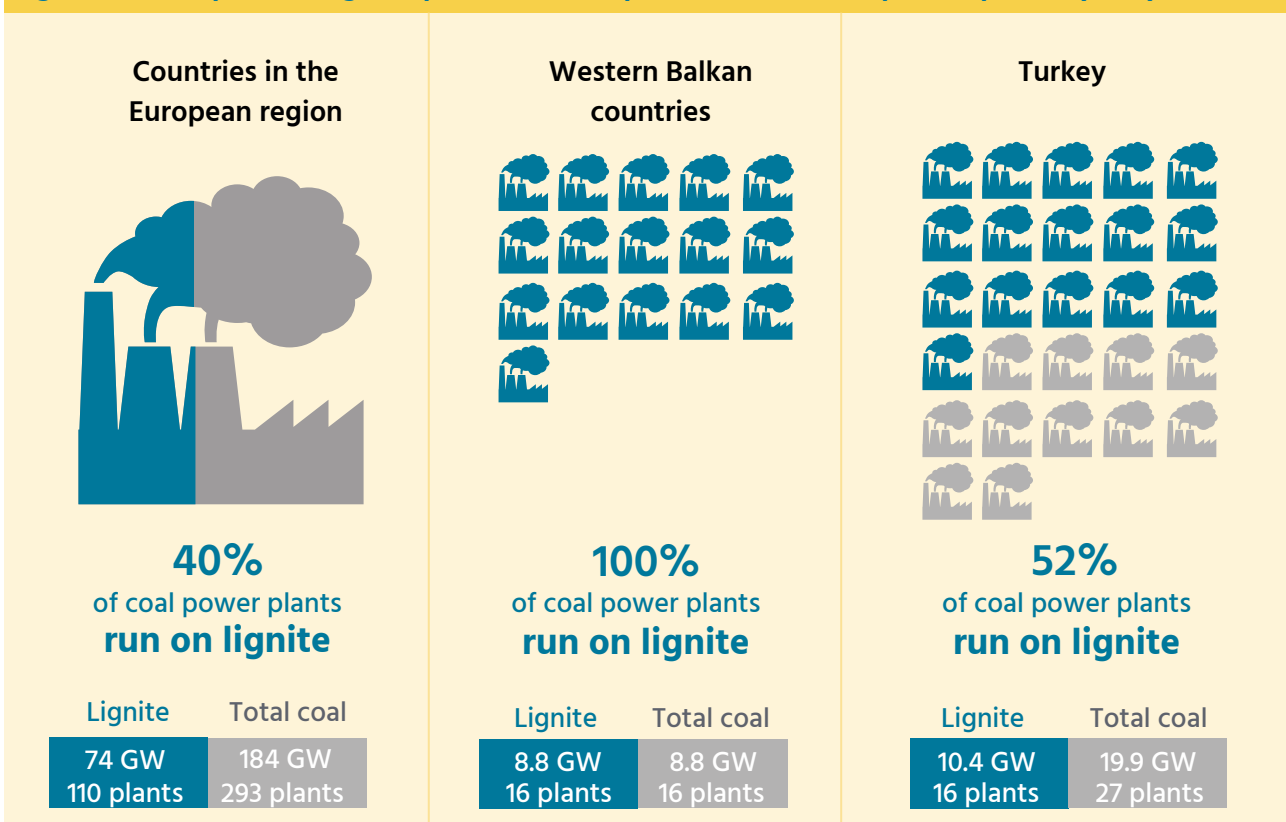
In 2016, 65% of the global electricity was generated by burning of fossil fuels, with 38% coming from hard coal and lignite¹. Lignite, also called brown coal, is the most health harming type of coal. European countries are major contributors in terms of both production and consumption of lignite coal despite governments' commitments on tackling climate change and improving air quality. In Europe, every year 50% of all global lignite is produced and consumed².

Much of this is needed to fuel Europe's own coal and lignite addiction: in the wider European Region 293 coal power plants are still operating with 184 GW installed capacity, when 110 of these plants (a capacity of 74 GW) using lignite. That means that in

the wider European Region, 40% of the coal power plants are fuelled by lignite³. The situation is even worse in South-Eastern Europe, in the Western Balkans countries (Albania, Bosnia & Herzegovina, Kosovo, Macedonia, Montenegro and Serbia), where all of the existing 16 coal power plants run on lignite. In Turkey, 16 coal power plants out of 27 plants in operation are lignite based⁴.

This HEAL briefing provides an overview of the features of lignite and hard coal, and what their health impacts are. It also puts a spotlight on individual, particularly polluting coal power plants in Turkey, Germany, Poland and Bosnia and Herzegovina. In addition, the briefing gives recommendations for policy-makers, health professionals and the public on how to overcome Europe's addiction to this health-harming fossil fuel and achieve a healthy energy future.

Figure 1 - Comparison lignite powered coal plants / total coal power plants (2018)



2.

Lignite and hard coal – the differences in a snapshot



Lignite

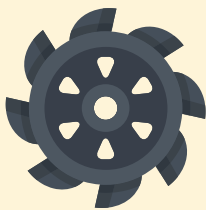


Hard coal

Photos: Geography in Action website

Lignite is also known as brown coal and is an intermediate stage between peat, which is partially decayed vegetation or organic matter, and hard coal. The sample in the visual on the left is part of a core (hence its shape) drilled from the Ballymoney area of Northern Ireland. This lignite was formed about 50 million years ago. Coal like on the right is carboniferous in age i.e. between 290 and 354 million years old⁵.

Mining



Both hard coal and lignite are mined all over the world. However, while hard coal is extracted in underground (deep) mines, most of the lignite is mined in open cast (surface) mines. This means that the mining process of lignite is comparatively cheaper than for hard coal. But open mining of lignite creates new burdens (and costs) due to its social and environmental impacts such as rehabilitation of open mines or forced resettlement of the population living around the mining area.

Transport



Due to its relatively high water content (40% to 60%)⁶ it is difficult to transport lignite over long distances, unlike hard coal. That means lignite powered coal power plants are mostly located close to the mine, equipped with conveyor belts or short distance trains. Hard coal transportation results in additional air pollutant and greenhouse gas emissions.

Energy value



Lignite contains a lot more water than hard coal, meaning lignite typically has smaller energetic value per mass unit and is considered as “lower quality coal”. While the energy content of hard coal is between 16.5-32.5 megajule (MJ) per kilogram, typically lignite has energy content less than 16.5 MJ/kg⁷. As a result, compared to hard coal, a higher amount of lignite needs to be burnt to produce the same amount of energy. For example, in Turkey 3.4 times more lignite has to be burned for the same megawatt generated compared to hard coal (see Turkey chapter on 14 page of this briefing).

Pollution emissions



Combustion of both fuels equally releases particulate matter (PM), sulphur dioxide (SO₂), nitrogen oxides (NO_x), heavy metals and other pollutants⁸ to the air. This pollution can travel thousands of kilometres across borders and even oceans⁹. Burning coal for electricity generation is also one of the biggest industrial sources of CO₂ emissions, fuelling climate change.

However, the pollutant composition changes with type and content of the coal as well as with the combustion technology of the power plant. Lignite is likely to have more sulphur and ash content and less energetic value compared to hard coal, so burning lignite in coal power plants creates more air pollutant emissions per megawatt generated.

Waste

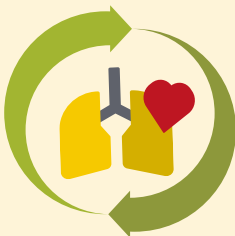


Coal waste is typically created at three steps in the electricity production; mine waste which typically contains mixed coal, soil and rock, liquid coal waste which is a leftover after preparation processes including coal washing and crushing, and fly ash as a residue after burning of the coal in the plant. In some countries such as Poland mine waste is often used for domestic heating¹⁰ despite the fact that it can contain hazardous materials such as heavy metals.

In Turkey, fly ash as a waste from coal power plants is often sold to cement factories as a raw material¹¹. Even though fly ash is not considered hazardous waste in many countries such as USA, fly ash can contain silica and other toxic metals cadmium, copper, chromium, nickel, lead, mercury, titanium, arsenic, and selenium¹². Storage of fly ash in open piles can result in increasing air pollutant emissions.

The disposal of liquid coal waste in landfills can lead to groundwater contamination. In 2008, an energy company was fined for drinking water contamination as a result of dumping billions tons of coal ash in Maryland USA¹³.

Life-Cycle



When the whole life-cycle process is considered, lignite results in relatively higher air pollutant emissions, resettlements and changes in the soil and water characteristics¹⁴ such as acidic mining lakes¹⁵ left after the mining¹⁶. For hard coal, the transportation process and the energy use during the heavily mechanised ground mining process are the main concerns.

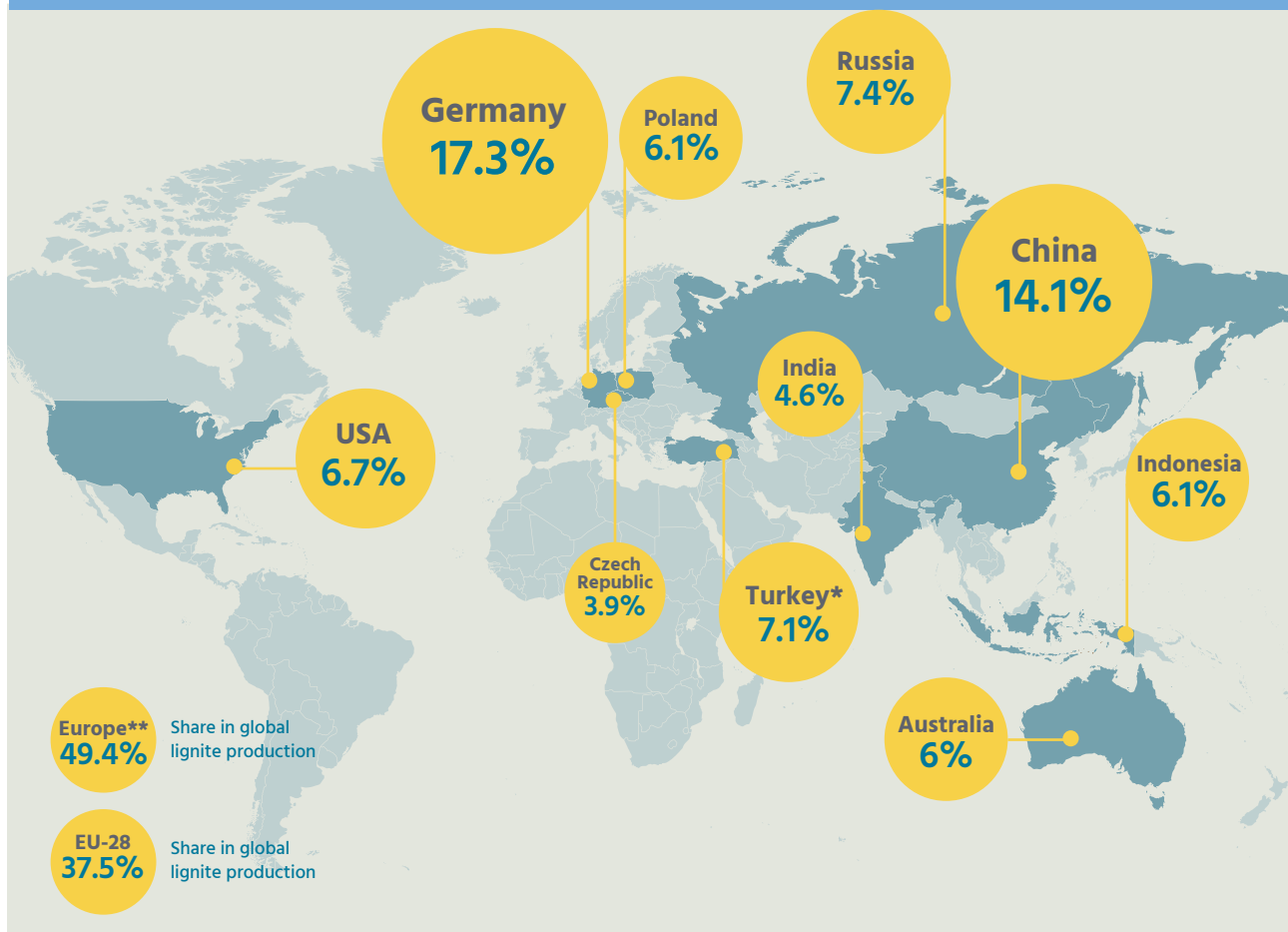
A 2013 study by The University of Manchester on the life cycle environmental impacts of electricity from fossil fuels in Turkey analysed all types of fossil fuelled plants based on eleven criteria and showed that lignite is the worst option overall with eight impacts higher than for hard coal, ranging from 11% higher fossil fuel depletion to six times greater fresh water ecotoxicity¹⁷.

3.

Mining and consumption of lignite and hard coal around the world

Around 13.5% of the world's coal production comes from lignite. Globally, Germany is the biggest lignite producer and consumer, with European countries together being responsible for 50% of global lignite production and consumption.

Figure 2 - The 10 largest lignite mining countries in the world with their share in global lignite production¹⁸



Data from 2016; full list of countries can be found in Annex 1 and 2

*Numbers for Turkey is retrieved from Turkish General Directorate of Energy Affairs, 2017, "Hard coal imports in Turkey in 2002-2016" datasets, <http://www.eigm.gov.tr/tr-TR/Denge-Tablolari/Denge-Tablolari> & IEA 2018, "Electricity Information", <https://webstore.iea.org/electricity-information-2018>

The biggest open-pit lignite mine in Europe is Belchatow mine in Poland that powers the most health-harming European coal power plant, the Belchatow Lignite Coal Power Plant. The mine is 12 km long and 200 m deep²⁴. The Belchatow Coal Power Plant has a 5.4 GW capacity and its pollution results in 1,270 premature deaths, 359,200 lost working days, 630 new cases of chronic bronchitis and 1,310 hospital admissions annually¹⁹.

China is the worldwide biggest producer and consumer of hard coal as well as it is also for total coal amount (lignite + hard coal). It produces 49% of global hard coal followed by India and USA¹⁸. In the European Region Poland, is the biggest hard coal consumer followed by Germany and Turkey (for a detailed list of countries please see annex 3).

How air pollution from coal power plants may harm your health

Brain



- Increased cerebrovascular ischemia
- Dementia

Blood



- Altered rheology
- Increased coagulability
- Translocated particles
- Peripheral thrombosis
- Reduced oxygen saturation

Cells



- Bladder cancer
- Skin cancer
- Obesity
- Diabetes

Lungs



- Inflammation
- Oxidative stress
- Accelerated progression and exacerbation of COPD
- Increased respiratory symptoms
- Effected pulmonary reflexes
- Reduced lung function
- Higher lung cancer risk

Heart



- Altered cardiac autonomic function
- Oxidative stress
- Increased dysrhythmic susceptibility
- Altered cardiac repolarisation
- Increased myocardial ischemia

Children



- Pre-eclampsia of the pregnant mother
- Pre-term birth
- Reduced birth weight
- Pollutants can reach the placenta
- Increased asthma risk, and increased frequency of attacks for already asthmatic children
- ADHD

Vasculature



- Atherosclerosis, accelerated progression and destabilisation of plaques
- Endothelial dysfunction
- Vasoconstriction and hypertension

Health impacts result from both short and long-term, repeated exposure to air pollution. A recent review by the World Health Organisation (WHO) found that impacts can already occur at concentrations even lower than previously considered, and that the range of health impacts is larger than previously thought. For particulate matter there is no safe threshold.

The health effect of coal power plants mostly stems from the release of harmful air pollutants, which contribute to poor air quality, impacting heart and lung health in particular. These health impacts are not only felt in the proximity of the plants but because of the transboundary nature of pollution, coal power generation can lead to health impacts or costs far away from the source of combustion.

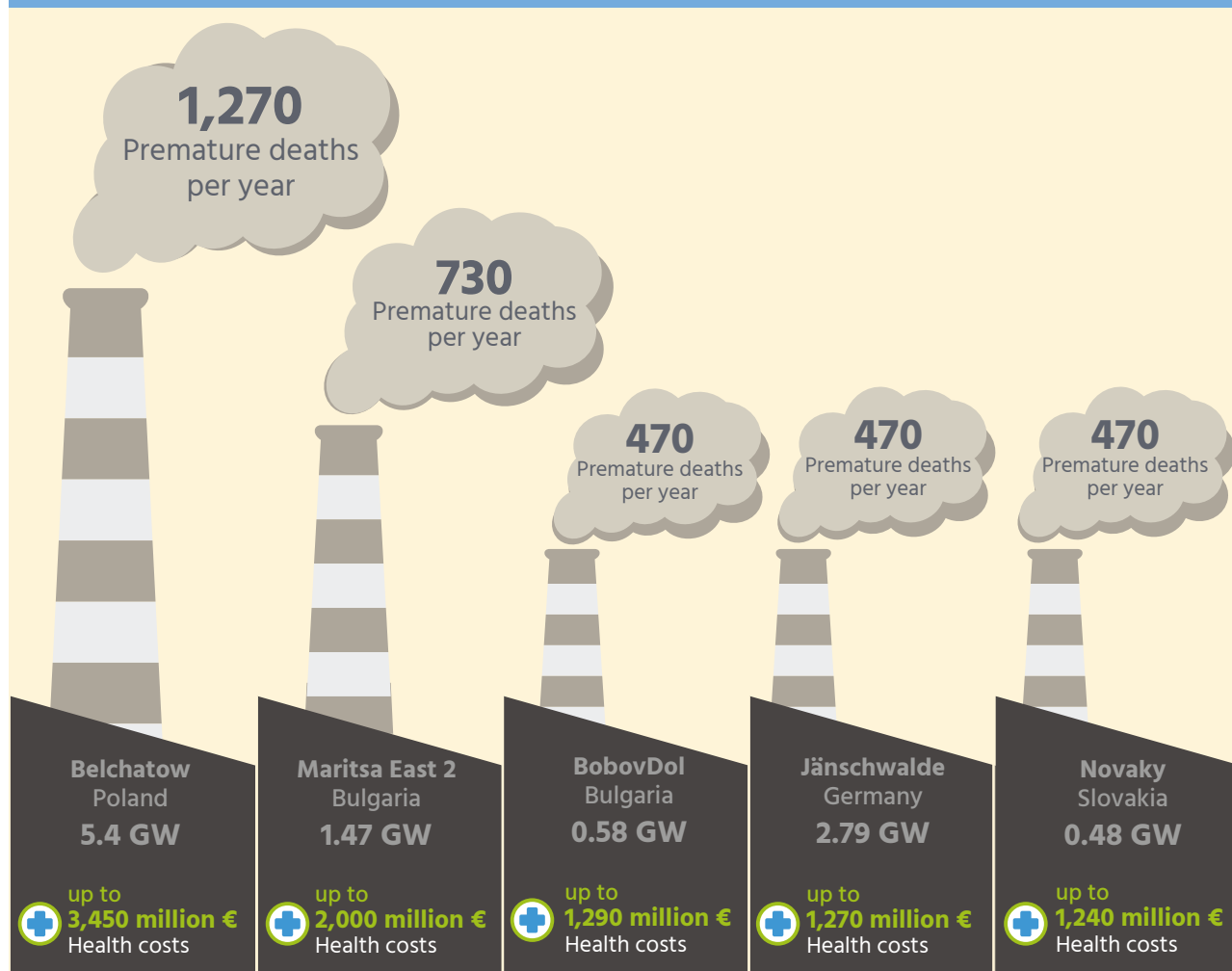
According to the World Health Organization (WHO), air pollution is one of the major health risks; in 2016, the WHO estimates that 7 million people died prematurely worldwide as a result of diseases attributed to outdoor and household air pollution²⁰.

One of the recent studies, the 'Europe's Dark Cloud' report, estimates that the EU's 257 operational coal-fired power plants were responsible for about 22,900 premature deaths by air pollution emissions; this can be compared to 26,000 deaths in road traffic accidents in the EU the same year^{19,21}. These premature deaths resulted from the impacts of three main pollutants - particulate matter (by far

the most harmful), ground-level ozone and nitrogen dioxide - on the cardiovascular or respiratory system. According to the same report, 7 coal power plants out of the top 10 that cause the most premature deaths in Europe were using lignite, causing 4,290 premature deaths annually. In another study, the 'Unpaid Health Bill-Turkey' report based on datasets from 2014, around 3,000 premature deaths are attributed to air pollution caused by coal power plants in Turkey²² alone.

While particulate matter is the chief driver behind premature deaths, other pollutants also lead to adverse health and environmental impacts. Energy production releases more mercury than any other industrial source, almost twice as much as of all other sectors (metals, minerals, chemical, waste, paper & wood) combined¹⁹. 9 coal power plants out of the top 10 emitting hazardous amounts of mercury are fuelled with lignite - they are located in Germany and Poland²³, countries that produce and consume 17% and 6% of world total lignite coal respectively.

Figure 3 - Lignite power plants that are most harmful to Europeans' health¹⁹



Data taken from "Europe's Dark Cloud" report. Health impacts and costs are per year. Coal power plants in Western Balkans and Turkey are excluded in this statistics.



Summary

- Lignite is the most health-harming form of coal, given the higher amount of pollution resulting from its combustion.
- European countries are the biggest producers and consumers of lignite coal worldwide.
- Since 2010, lignite production has not decreased, despite all political commitments and efforts on mitigating climate change and reducing air pollutants.
- European countries also have a considerable share in hard coal imports. While China was the biggest importer of hard coal in 2016, it was followed by Germany and Turkey (6th and 7th coal importers globally)²⁶.
- The top 4 European lignite coal consumers are also the countries that cause the most harm to health due to air pollution emitted by coal power plants ^{2,19,42}.



HEAL's recommendations for policy-makers

- In order to protect our health and limit the worst impacts of climate change, end coal power generation in Europe by 2030 at the latest. This means shelving any new coal projects and phasing out existing coal plants as soon as possible, starting with those running on lignite, and investing instead into healthy and renewable energy forms.
- Phase out any awarding of public money for the production and use of health-harming fossil fuels.
- When deciding on which energy forms to choose, policy-makers should carry out an assessment of the health impacts, costs and benefits of each option, to ensure that those boosting health the most are prioritised.
- Involve the non-governmental health sector and health ministers into all negotiations and decisions on energy and climate policies.



HEAL's recommendations for Health professionals

- Should speak about the unpaid costs of coal.
- Health and medical professionals have a unique role to play in encouraging transition from polluting to healthy forms of energy in Europe and beyond. They should initiate debates on the healthy energy options with the ministry of health, ministry of energy and other governmental institutions, as well with the public. Making the true costs of coal power generation including lignite will help benefit public health.

5.

Case studies

Poland: Belchatow Power Plant

The Belchatow lignite power plant and Belchatow open-pit lignite mine are located in central Poland. Belchatow plant with a capacity of 5.4 GW and 13 units is the biggest coal power plant in the European Region, and the Belchatow open-pit mine is one of the largest mines in Europe - 12 km long and 200 m deep²⁴.

Belchatow is responsible for 1,270 premature deaths annually¹⁹. Although Belchatow burned only 12% more lignite than Germany's Neurath plant (which is responsible for 410 premature deaths), it almost tripled the health impacts because its abatement equipment for NO_x and particularly for SO₂ was less effective. The plant also emits the most SO₂, NO_x and

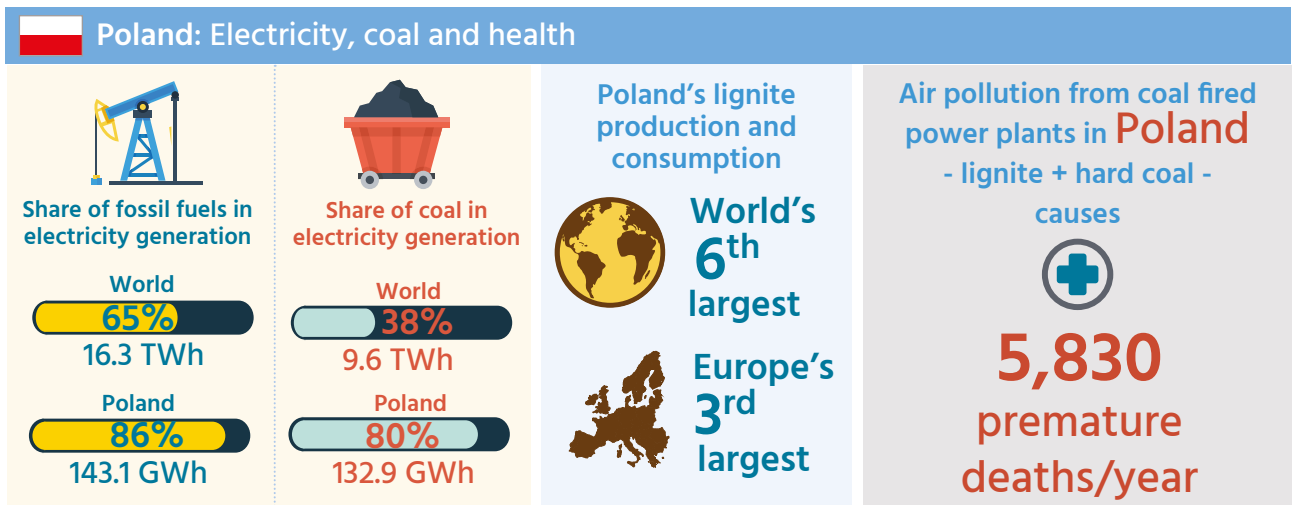


Belchatow Power Plant

© Bogusz Bilewski, Greenpeace Poland

CO₂ to the atmosphere and, according to latest EU data mercury emissions from the Belchatow plant were eighteen times higher in 2016 than the previous year²⁵.

Other health effects caused by the plant are 630 new cases of chronic bronchitis, 1,310 hospital admissions, 359,200 lost working days and 27,830 asthma attacks in children annually¹⁹.



The share of fossil fuels and coal in the electricity production of Poland was 86% and 80% respectively in 2016¹. Poland, as the 3rd European and 6th global largest lignite coal producer and consumer¹⁸ accounts for 6.1% of global lignite production with 60.2 million tons in 2016. According to a recent study, 5,830 premature deaths were caused by air pollution from coal power plants in Poland¹⁹.

TWh: Terawatt hours GWh: Gigawatt hours

Germany: Niederaussem Power Plant

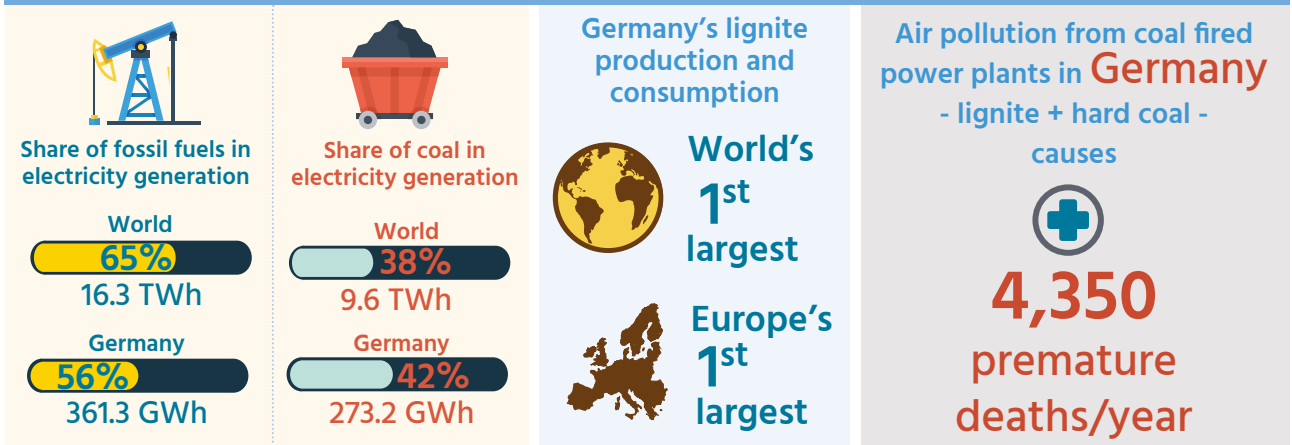


Niederaussem Power Plant

© Leon Liesener

The Niederaussem lignite plant located at 15 km northwest of Cologne is the second largest coal power plant in Germany with a capacity of 3.4 GW. It's estimated that the plant is responsible for 450 premature deaths, 190 new cases of chronic bronchitis, 340 hospital admissions, 125,320 lost working days and 8,500 asthma attacks in children¹⁹. Niederaussem is also the second biggest emitter of mercury among all European coal power plants.

Germany: Electricity, coal and health



The share of fossil fuels and coal in electricity production was 56% and 42% respectively in 2016¹. Germany, as the 1st global and European largest lignite coal producer and consumer¹⁸ accounts for 17.3% of global lignite production with 171.5 millions tons of lignite production in 2016. It was also the 6th biggest coal importer in 2016 globally²⁶.

According to a recent study, air pollution from German coal power plants caused 4,350 premature deaths in Germany and across Europe¹⁹.

TWh: Terawatt hours GWh: Gigawatt hours

Turkey: Afşin Elbistan, Soma, Can-1, Yatağan, Yeniköy, Kemerköy and Alpu Coal Power Plants

Yatağan, Yeniköy and Kemerköy Coal Power Plants

Yatağan, Kemerköy and Yeniköy coal power plants are operating with their 685 MW, 685 MW and 457 MW installed capacities respectively in Muğla city of Turkey¹⁸. Although these three coal power plants are nearing their retirement age, rehabilitation and capacity increase plans for 2019 were designed after they were privatized in 2014³². It is estimated that these three coal power plants caused 45,000 premature deaths due to air pollution since 1983, with the planned rehabilitation an additional 5,270 premature deaths would be caused in the next 10 years³³.

Afşin Elbistan Coal Power Plant

The Afşin-Elbistan lignite mine in Manisa is currently the biggest operating lignite mine in Turkey²⁷. It is estimated to have at least 46% of the lignite reserve in Turkey²⁸. The open pit-mine fuels the biggest coal power plants in Turkey³; Afşin Elbistan-A and Afşin Elbistan-B coal power plants that have 1.5 and 1.6 GW electricity capacity respectively.

Soma B Coal Power and Soma Lignite Mine

Soma B Coal Power Plant with a capacity of 990 MW is the 3rd biggest lignite power plant in Turkey³, but more importantly, the lignite mine feeding the plant, Soma Lignite Coal Mine, saw one of the world's worst mining disasters on 13th May 2014 following an explosion. The total number of casualties from the incident was estimated at 301 coal miners and led to several protest of the coal miners²⁹. The coal mining area spreads 18,000 hectares²⁹. The mine, which began feeding the Soma B Coal Power Plant when it was state-owned, was privatized and the privatization is held responsible for the disaster²⁹. Despite the accident, the mine is still operational and the coal extracted is being used for the plant. According to the Union of Chambers of Turkish Engineers and Architects (UCTEA), the coal and lignite mining sector has the highest level of occupational accidents and the second highest level of occupational fatalities among all the sectors in Turkey³⁰.



Lignite Mine in Muğla Turkey

© Servet Dilber, costsofcoal.europa.org

Çan-1 Coal Power Plant

The Çan-1 Lignite Power Plant, with 330 MW installed capacity, is situated in Çan town of Çanakkale city, which is one of the cities where the most new coal power is being planned³. Çan-1 coal power plant is not one of the biggest one in terms of capacity but air pollution levels, especially SO₂ emission values in the town hosting the plant is alarming mostly due to high dust and sulphur content of the lignite mined in the same area³⁰. Even though the Turkish Ministry of Environment has banned the sales of lignite extracted by Turkish Coal Enterprises to households with the aim of improving the air quality³¹, a second coal power plant, Çan-2, started operation in July 2018. Recently on 5th November 2018, an explosion occurred in Çan-1 Lignite Power Plant resulted in the one workers injury and one workers death³².

Alpu Eskişehir Coal Power Plant

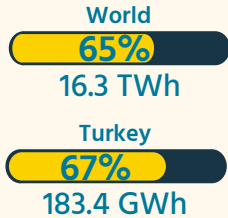
Eskişehir Alpu lignite basin is defined as the 3rd largest lignite reserve in Turkey that can be used in electricity production²⁷. Yunus Emre Coal Power Plant with 315 MW installed capacity on lignite has completed construction and is in the test phase³⁴ while another plant, Alpu Coal Power Plant is in the planning process. Local decision makers and health actors have presented several times their arguments against the planned coal power plants and the lignite mine. According to a recent study, if Alpu Lignite Power Plant is built and operates, it will cause 3,200 premature deaths in 35 years of its lifetime³⁵. Besides, the area where lignite mine and plant are planned to be built had been previously declared as agricultural site to be protected and not be used for any purpose except agriculture.



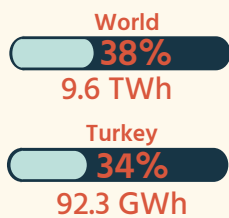
Turkey: Electricity, coal and health



Share of fossil fuels in electricity generation



Share of coal in electricity generation



Turkey's lignite production and consumption



World's 4th largest



Europe's 2nd largest

Air pollution from coal fired power plants in Turkey

- lignite + hard coal -

causes



2,876 premature deaths/year

The share of fossil fuels and coal in electricity production of Turkey was 67% and 34% respectively in 2016¹. Turkey, as the 2nd European and 4th global largest lignite coal producer and consumer¹⁸, accounts for 7.1% of global lignite production with 70.2 million tons in 2016¹⁸.

In Turkey, there are 27 coal power plants in operation, when 16 of them operate on lignite with 10.4 GW installed capacity, 11 plants operate on hard coal with 9.5 GW capacity (2018 September update). In addition to this, compare to other European countries Turkey has the largest amount of both lignite and hard coal fueled electricity plants in the pipeline; 0.8 GW of lignite is under construction when 18.4 GW of lignite and 15 GW of hard coal are planned (September 2018 update), which means that if these plans are realised Turkey will almost triple its lignite fueled coal power plant capacity³.

Turkey also aims to break the dependency on imported energy resources -particularly natural gas- and utilisation of national sources which is particularly lignite coal³⁶. When Turkey aims to decrease the share of natural gas in electricity production by 30% until 2030, it also aims to increase current coal power plant capacity to 30 GW from 18.6 GW (end-2017 statistics) until 2030³⁷.

However contrary to this aim, Turkey was also listed as the global 7th biggest coal importer in 2016²⁶. Amount of imported coal is steadily increasing; it increased nearly six times between 1990 and 2016 when almost doubled from 2006 to 2016²⁶.

According to the "Unpaid Health Bill" report by HEAL in 2015, air pollution from coal power plants in Turkey caused 2,875 premature deaths²¹. Moreover, HEAL analysed Turkey's 2016 data for a clearer analysis that would highlight lignite's comparably lower calorific value. Results showed that 3.4 times more lignite should be burned for the same megawatt generated compared to hard coal which would result in more air pollutant emissions. In 2016, 43.4 million tons of lignite was burned in coal power plants to produce 38.6 GWh electricity, at the same year 16.9 Mt of hard coal was burned to produce 50.8 GWh³⁹. For the last 5 years, lignite is primarily used in electricity production and then in industry, excluding iron and steel plants³⁹.

Bosnia and Herzegovina: Ugljevik Power Plant

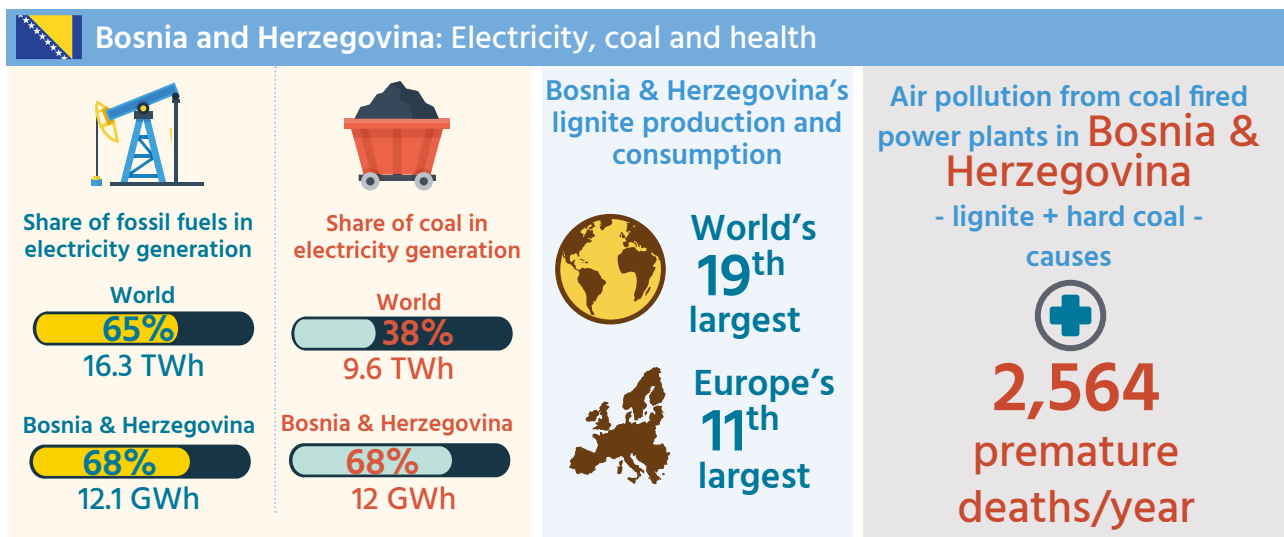


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Ugljevik Power Plant

Ugljevik lignite plant is located in the East of Bosnia and Herzegovina, near the Serbian border and is 33 years old⁴⁰. It is a unique case in Europe; the plant with a relatively small capacity of 300 MW emits as much SO₂ as all of Germany's plants together⁴⁰.

As of 1 January 2018, SO₂ emissions by the plant were expected to be cut down to 9,100 tonnes per year and yet the latest available data in 2016 shows that the emissions were 127,524 tonnes, no flue-gas desulphurisation system has been added to reduce the SO₂ emissions⁴⁰. If Ugljevik's operator plans to keep the plant running after January 2028, it would require bringing its SO₂ emissions even further down to around 2,100 tonnes per year⁴⁰. This is a 99% reduction from current values. Desulphurisation technologies that would support this kind of reduction have been implemented in most of EU's coal power plants, and in the case of Ugljevik it would save the lives of 1,165 people a year⁴¹.



The share of both fossil fuels and coal in electricity production of Bosnia and Herzegovina was 68% in 2016¹. Bosnia and Herzegovina, as the 11th European and 19th global largest lignite coal producer and consumer¹⁸ accounts for 0.7% of global lignite production with 7.3 million tons of lignite production in 2016.

According to "Health Impacts of Coal Fired Power Stations in the Western Balkans" report by HEAL in 2016, air pollution from coal power plants in Bosnia and Herzegovina caused 2,564 premature deaths⁴¹.

Annex 1: Lignite production 2010–2016

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

Global Rank	European Rank	Country/Region	2010 (in Mt)	2011 (in Mt)	2012 (in Mt)	2013 (in Mt)	2014 (in Mt)	2015 (in Mt)	2016 (in Mt)	Share [%]
1	1	Germany	169.4	176.5	185.4	183.0	178.2	178.1	171.5	17.3%
2		China	125.3	136.3	145.0	147.0	145.0	140.0	140.0	14.1%
3		Russia	76.0	77.6	77.9	73.0	70.0	73.2	73.7	7.4%
4	2	Turkey*	70.0	72.5	68.1	57.5	62.6	56.1	70.2	7.1%
5		USA	71.0	73.6	71.6	70.1	72.1	64.9	66.2	6.7%
6	3	Poland	56.5	62.8	64.3	65.8	63.9	63.1	60.2	6.1%
7		Indonesia	40.0	51.3	60.0	65.0	60.0	60.0	60.0	6.1%
8		Australia	68.8	66.7	69.1	59.9	58.0	61.0	59.7	6.0%
9		India	37.7	42.3	46.5	44.3	48.3	43.8	45.3	4.6%
10	4	Czech	43.9	46.8	43.7	40.6	38.3	38.3	38.6	3.9%
11	5	Serbia	37.8	40.6	38.0	40.1	29.7	37.7	38.0	3.8%
12	6	Greece	53.6	58.4	62.4	54.0	50.4	45.6	32.3	3.3%
13	7	Bulgaria	27.1	34.5	31.0	26.5	31.3	35.9	31.2	3.2%
14	8	Romania	27.7	32.9	34.1	24.7	23.6	25.5	23.0	2.3%
15		Thailand	18.3	21.3	18.1	18.1	18.0	15.2	17.0	1.7%
16		Canada	10.3	9.7	9.5	9.0	8.5	8.4	9.0	0.9%
17	9	Hungary	9.0	9.5	9.3	9.6	9.6	9.3	9.2	0.9%
18	10	Kosovo	8.0	8.2	8.0	8.2	7.2	8.2	8.8	0.9%
19	11	Bosnia & Herzegovina	11.0	7.1	7.0	6.2	6.2	6.5	7.3	0.7%
20		Mongolia	n.d.	7.6	7	6.3	6.3	5.8	7	0.7%
		Korea, DPR	7.0	7.6	7.0	7.0	7.0	7.0	7.0	0.7%
		Other countries	39.7	38.0	37.5	37.4	31.1	28.8	28.2	2.8%
		World Total	1,008.0	1,081.5	1,099.4	1,053.3	1,025.2	1,011.8	990.2	
		EU-28	394.1	428.4	436.8	410.3	398.0	401.1	371.4	37.5%
		Europe	529.4	566.7	566.9	530.7	511.8	511.3	488.8	49.4%

*2016 numbers for Turkey is retrieved from Turkish General Directorate of Energy Affairs, 2017, "Denge Tabloları" datasets, <http://www.eigm.gov.tr/tr-TR/Denge-Tabloları/Denge-Tabloları> & IEA 2018, "Electricity Information", <https://webstore.iea.org/electricityinformation-2018>

Source: BGR, 2017, "BGR Energy Study" https://www.bgr.bund.de/EN/Themen/Energie/Downloads/energiestudie_2017_en.pdf?__blob=publicationFile&v=2
2010 datasets are delivered from BGR excel sheets in 2016, from https://www.bgr.bund.de/DE/Themen/Energie/Downloads/Energiestudie_2016_Tabellen.html on October 2018

Annex 2: Lignite consumption 2016

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

Rank	Country/Region	2016 (in Mt)	Share [%] country
1	Germany	168.2	17.0%
2	China	140.0	14.2%
3	Russia	73.7	7.5%
4	USA	66.2	6.7%
5	Poland	60.2	6.1%
6	Indonesia	60.0	6.1%
7	Australia	59.7	6.0%
8	Turkey*	56.9	5.8%
9	India	45.3	4.6%
10	Czech	38.6	3.9%
11	Serbia	38.0	3.9%
12	Greece	32.3	3.3%
13	Bulgaria	31.2	3.2%
14	Romania	23.0	2.3%
15	Thailand	16.9	1.7%
16	Hungary	9.2	0.9%
17	Canada	9.0	0.9%
18	Kosovo	8.8	0.9%
19	Bosnia & Herzegovina	7.3	0.7%
20	Mongolia	7	0.7%
	Korea Republic	7.0	0.7%
	Other countries	28.2	2.9%
	World Total	986.8	
	EU-28	368.0	37.3%
	Europe	485.4	49.2%

*2016 numbers for Turkey is retrieved from Turkish General Directorate of Energy Affairs, 2017, "Denge Tabloları" datasets, <http://www.eigm.gov.tr/tr-TR/Denge-Tabloları/Denge-Tabloları> & IEA 2018, "Electricity Information", <https://webstore.iea.org/electricityinformation-2018>

Source: BGR, 2017, "BGR Energy Study" https://www.bgr.bund.de/EN/Themen/Energie/Downloads/energiestudie_2017_en.pdf?__blob=publicationFile&v=2

Annex 3: Hard Coal production 2010–2016

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

Global Rank	Country/Region	2010 (in Mt)	2011 (in Mt)	2012 (in Mt)	2013 (in Mt)	2014 (in Mt)	2015 (in Mt)	2016 (in Mt)	Share [%]
1	China	3.115,0	3471,9	3532,6	3601,5	3495,2	3423,2	3102,5	49,3%
2	India	532,7	539,9	556,4	565,8	609,2	639,2	662,6	10,5%
3	USA	918,2	920,4	850,5	823,4	835,1	748,8	594,4	9,4%
4	Australia	355,4	352,0	381,0	411,3	441,5	441,1	443,9	7,1%
5	Indonesia	285,0	364,5	406,3	430,0	410,8	401,6	396,2	6,3%
6	Russia	247,9	258,5	276,1	279,0	287,0	300,1	312,0	5,0%
7	South Africa	257,2	252,8	258,6	256,3	260,5	252,1	254,0	4,0%
8	Kazakhstan	103,6	108,1	112,8	112,9	107,7	101,0	92,6	1,5%
9	Colombia	74,4	85,8	89,0	85,5	88,6	85,5	90,5	1,4%
10	Poland	76,7	76,4	79,8	77,1	73,3	72,7	70,6	1,1%
11	Canada	57,9	57,4	57,0	59,9	60,5	51,2	52,0	0,8%
12	Ukraine	75,0	81,7	85,6	83,4	65,0	39,7	40,9	0,7%
13	Vietnam	44,8	46,6	42,1	41,0	41,1	41,7	38,5	0,6%
14	Korea Republic	24,0	31,5	32,2	31,6	34,0	34,0	34,0	0,5%
15	Mongolia	18,3	26,1	23,6	27,0	18,1	18,2	28,1	0,4%
16	Philippines	7,3	7,6	8,2	7,2	8,4	8,2	12,1	0,2%
17	Mexico	18,4	21,0	16,3	15,7	15,9	15,7	11,6	0,2%
18	Mozambique	n.d.	0,6	5,0	5,9	6,3	6,6	6,8	0,1%
19	Czech Republic	11,2	11,0	10,8	8,6	8,3	7,6	6,1	0,1%
20	UK	18,4	18,6	17,0	12,8	11,6	8,6	4,2	0,1%
21	Germany	14,1	13,0	11,6	8,3	8,3	6,6	4,1	0,1%
...	other countries	41,2	38,3	36,7	39,7	46,9	39,6	33,1	0,5%
	World	6289,6	6783,5	6889,1	6983,8	6933,4	6743,1	6290,7	
	EU-28	131,8	128,2	128,0	113,6	105,9	98,7	86,8	1,4%
	Europe	136,5	132,5	131,7	117,6	109,5	101,4	89,0	1,4%

Source: BGR, 2017, "BGR Energy Study" https://www.bgr.bund.de/EN/Themen/Energie/Downloads/energiestudie_2017_en.pdf?__blob=publicationFile&v=2
2010 datasets are delivered from BGR excel sheets in 2016, from https://www.bgr.bund.de/DE/Themen/Energie/Downloads/Energiestudie_2016_Tabellen.html on October 2018

Annex 4: Hard coal consumption 2016

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

Rank	Country/Region	2016 (in Mt)	Share [%] country
1	China	3349.4	53.4%
2	India	852.9	13.6%
3	USA	548.7	8.7%
4	Japan	189.7	3.0%
5	South Africa	178.5	2.8%
6	Russia	168.7	2.7%
7	Korea Republic	136.2	2.2%
8	Poland	69.7	1.1%
9	Kazakhstan	69.0	1.1%
10	Taiwan	65.6	1.0%
11	Germany	56.9	0.9%
12	Ukraine	56.0	0.9%
13	Australia	51.8	0.8%
14	Vietnam	50.9	0.8%
15	Turkey	37.5	0.6%
16	Indonesia	30.5	0.5%
17	Malaysia	29.9	0.5%
18	Canada	28.1	0.4%
19	Brazil	23.0	0.4%
20	Thailand	21.8	0.3%
	Other countries	259.5	4.1%
	World	6,274.20	
	EU-28	239.3	3.8%
	Europe	279.8	4.5%

Source: BGR, 2017, "BGR Energy Study" https://www.bgr.bund.de/EN/Themen/Energie/Downloads/energiestudie_2017_en.pdf?__blob=publicationFile&v=

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