6th edition
with insights

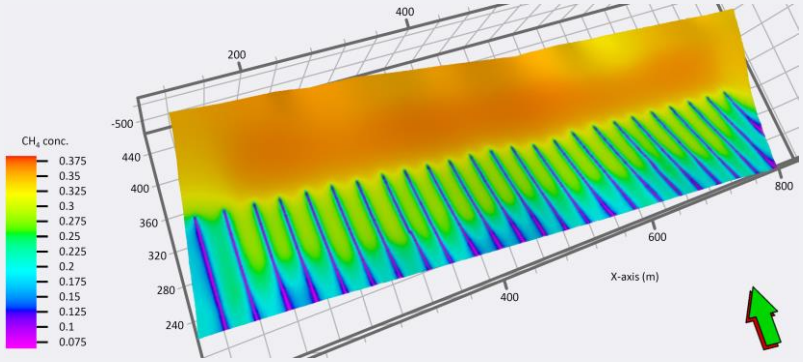
Coal industry across Europe

Cover photo: Stanari power plant in Bosnia and Herzegovina (see page 62). The plume forming the map of Europe is not pollution, just water vapour.

Contents

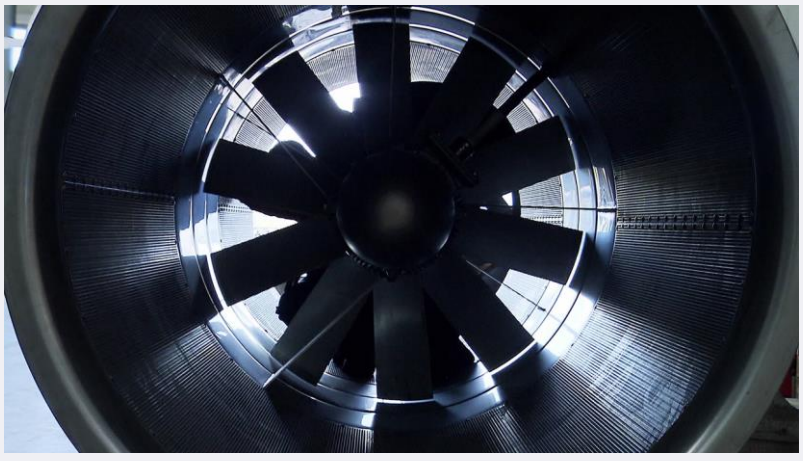
Energy efficiency initiatives at coal mines

INSIGHT 1



A model of a pre-mining methane drainage pattern

High-pressure mine dewatering pump



Mine ventilation fan

The LOWCARB project, funded by the EU Research Fund for Coal and Steel, has partners from Poland, Slovenia, Spain and the UK. The project links a number of different investigations under the theme of energy efficiency and reduced carbon emissions.

Numerical modelling of pre-mining methane drainage in Poland was accompanied by the drilling of boreholes to test the concept. A fire on the longwall initially identified for this work was a significant setback, but intensive efforts by the project team achieved results in time and the knowledge gained has fed into a subsequent project on how pre-fracturing can improve methane drainage and hence mine safety.

Probably the most immediate and practical outcome was the simulation and refinement of the micro-electronic application of a technique to assess the efficiency of water pumps and ventilation air fans. This enables the focussed and timely refurbishment of equipment with demonstrable cost savings in most cases. The technique is now being marketed by a UK-based SME.

LOWCARB •••

Foreword

I have the pleasure of introducing this report, the sixth edition of *Coal industry across Europe*. Some may be surprised by the facts and figures on coal contained within the report's pages; they reflect the activities of a significant industry.

The European Union is the world's fourth largest coal-consuming region, after China, India and North America. We mine around one hundred million tonnes of hard coal each year and import a further two hundred million tonnes, making us the world's largest importer by value. At around four hundred million tonnes, our lignite production far exceeds that from any other region, Germany being the world's largest producer.

Let me highlight one simple statistic. Although the European Union is currently implementing the strictest climate policies in the world, coal still accounts for around one quarter of the electricity consumed in the Union, it being our most reliable source of power with 178 GW of coal-fired capacity available at all times and whatever the weather.

Competitive electricity from coal allows industry to prosper in the European Union. This can continue so long as member states do not place additional burdens on coal use, such as the UK's carbon price floor – effectively a unilateral carbon tax. Society benefits from industries that create economic growth, provide jobs and invest for the future. In this respect, the European coal industry was disappointed by the UNFCCC Paris Agreement, not because it is too strict or too soft, but simply because it may limit the competitiveness of European industry. For example, the European coal industry invests in health, safety and environmental improvements, while coal users pay for carbon emissions under the EU emissions trading system. This market-based solution is a necessary tool in response to the climate challenge. Other regions of the world are less demanding, not because they do not care, but because economic growth takes priority over issues that do not directly affect their citizens' immediate daily lives.

The European Union leads an ambitious coalition that is determined to tackle climate change. We need others to follow, so must take care to base climate and energy policy on solid evidence. The current focus on point-source emissions of carbon dioxide needs to be balanced by a full life-cycle analysis of all energy supplies. Natural gas from Siberia is a convenient fuel for an energy user in Luxembourg, but what are the real environmental impacts in a power system that demands power plants are ramped up and down quickly, and often run at part load for extended periods when the efficiency of gas turbines is rather low? The latest coal-fired plants have been designed with sliding pressure controls so that they can and do operate efficiently under the operating regimes needed to balance intermittent renewables.

Wolfgang Cieslik, President of EURACOAL

Coal is abundant, available and affordable. In Europe, the coal sector has delivered large reductions in greenhouse gas emissions since 1990. In terms of the *Energiewende* or "energy transition" that is widely discussed at the EU level, coal fits well as a backup for renewables, making the best use of domestic coal mines and power plant assets while enjoying the diversity, security and low prices of imported coal from many coal-exporting countries. A vision for the future of energy supply is welcomed by EURACOAL, but it is prudent to base that vision on the realities of today's energy supply and not forget what the "old industries" still have to offer.

Many pollution control technologies have been deployed at coal-fired power plants, *e.g.* wet and dry flue gas desulphurisation, primary and secondary NOx reduction systems and many dust control techniques. The tangible result is that between 1990 and 2012 the EU coal-fired power sector reduced its sulphur dioxide (SO_2) emissions by 85%, NOx emissions by 55% and dust emissions by 70%. In the case of SO_2, atmospheric concentrations are now well below the limits for health protection. Unfortunately, NOx

emissions remain too high because of emissions from transport. The gradual introduction of electric vehicles will see NOx emissions fall.

Today, we look for new solutions. We work with the European Commission on the Large Combustion Plants Best Available Techniques Reference Document (LCP BREF) and continue to improve land restoration with innovative projects that lead the way in term of land-use planning and development. Energy Union implies a move away from an economy driven by fossil fuels and EURACOAL promotes a three-step strategy that will allow fossil fuels to play an important role in a low-emission economy. EURACOAL has always believed in free and competitive markets, with a balance between the three priorities of a sound energy policy: economic growth, security of supply and environmental protection.

This publication, prepared by EURACOAL's thirty-two members and updated every few years, shows what coal delivers for society. It covers not only the European Union, but all countries that participate in the Energy Community. Within its pages, there are many examples that show how modern technologies have enhanced productivity at coal mines, improved efficiency at coal-fired power plants and limited the negative impacts on the environment of coal use. With clear laws and regulations, and with a stable energy policy framework for the future, we can look forward to further investments in new technologies. Such a responsible approach would be good for energy consumers, employees in the coal industry and society as a whole.

Coal will continue to be used for many decades to come, although volumes will likely decline in Europe to meet politically agreed objectives. Our hope is that the close to four hundred thousand men and women working in the industry will continue to enjoy respect for their hard work during the "energy transition". To that end, we call for an Energy Union that values the contributions of all energy sources,

INSIGHT 2

Coal power in the Netherlands

The Uniper Maasvlakte MPP is a 1 100 MW ultra-supercritical coal-fired power plant at Rotterdam that also supplies heat to nearby industrial enterprises.

The 800 MW coal-fired ENGIE Rotterdam power plant can burn biomass as well as coal to further reduce CO_2 emissions over its expected 40-year life.

In its latest energy strategy, the Dutch government recognises that the country's comparative advantages allow wind energy and large, conventional generation to play important roles. Its flat, open landscapes and long coastline offer the Netherlands many good sites for wind turbines and coal-fired power plants. The latter need plenty of cooling water, access to coal terminals at deep-water ports and strong grid connections to link with the European internal energy market.

Three new, state-of-the-art plants are visible evidence of this strategy and will see CO_2 emissions reduce. Older coal-fired plants are being replaced with new ones which are flexible enough to balance the ups and downs of wind energy and so secure electricity supplies in north-west Europe. Looking to the future, there are plans to retrofit CO_2 capture and storage technologies, making use of depleted offshore gas reservoirs.

The latest ultra-supercritical steam technology reduces CO_2 emissions by around one quarter at the 1 600 MW RWE-Essent Eemshaven power plant.

Covered coal storage in Italy

INSIGHT 3

Coal storage domes under construction

Completed coal storage domes

Inside dome showing the wood structure

Lying twelve kilometres from the Italian city of Brindisi on the Adriatic coast, the ENEL Federico II coal-fired power plant is one of Europe's largest, with four 660 MW units totalling 2 640 MW. The power plant has benefited from an extensive retrofit programme, including upgraded coal mills and replacement of the flue gas clean-up system to significantly reduce emissions to air.

In 2012, work started on a €120 million fully automated coal storage facility to reduce fugitive dust emissions. Constructed largely from laminated wood, the two domed structures are part of a €500 million investment to improve the power plant's efficiency and environmental performance. Importantly for the region, this investment secures the one thousand permanent jobs that depend on the Federico plant.

The geodesic domes are 145 metres in diameter and 50 metres high, with a total storage capacity of around 360 000 tonnes, being the largest of their type in Europe and each requiring 22 000 m^2 of cross-laminated timber covering. The domes are similar to those at the ENEL Torrevaldaliga Nord power plant which are tubular aluminium structures covered in corrugated aluminium sheeting. Around 6.5 million tonnes of imported coal are unloaded each year from bulk cargo ships at Brindisi port. The coal is transported via a 13-kilometre conveyor belt to the coal storage domes from where it is conveyed to the power plant boilers, without exposure to the outside atmosphere.

The socio-economic value of coal during the energy transition

In the EU, coal mining is a large and mature industry that employs almost two hundred thousand people in well-paid jobs and many more at suppliers of equipment and materials. Coal remains one of the EU's most important energy sources, meeting 17% of EU primary energy demand in 2014; at 214 million tonnes of coal equivalent (Mtce), EU indigenous coal and lignite production exceeded indigenous natural gas production by 28% and indigenous oil production by 78%. Ample reserves of coal and lignite are found in many member states.

Power generation from coal – indigenous and imported – is second only to nuclear power: 26.4% of EU electricity came from coal in 2014. With advances in technology, notably by European power plant suppliers, coal-fired power plants are increasingly clean and efficient. In most markets, coal-fired power generation is the most cost competitive source of electricity. With the growth of intermittent renewable power generation from wind and solar, the flexibility of conventional plants matters more and more. Coal-fired power plants respond as quickly as gas-fired plants to changes in supply and demand, helping to keep electricity networks in balance and our lights on, whatever the time of day, whatever the weather and whatever the season.

Security of energy supply

In these uncertain times, Europe needs energy security. That was the main idea behind President Donald Tusk's call to create an Energy Union, made back in April 2014 when he was Prime Minister of Poland. He believed in making full use of indigenous fossil fuels, including coal. It is instructive to see how his forward-thinking ideas were grasped in Brussels and turned into a project that neglects coal, despite its indisputable role in economic development and energy security.

The European Commission is implementing one of the most radical strategies for Europe: a shift away from fossil fuels in what is called the "energy transition". The strategic vision is evolving, but it envisages the EU becoming ever-more dependent on imported gas. The question then is whether European energy security can be achieved without coal? Should Europe rely on imported gas, which will become more expensive if there is no competition from coal?

Box 1
Energy Union

A communication on Energy Union was published by the European Commission in February 2015. It heralds a fundamental transformation of Europe's energy system, promising a sustainable, low-carbon and climate-friendly economy. To reach this goal means moving away from an economy driven by fossil fuels; this would not be favourable for coal, although a new strategy for imported natural gas is proposed. The Energy Union proposal consists of five main pillars:

- energy security, solidarity and trust;
- a fully integrated European energy market;
- energy efficiency contributing to moderation of demand;
- decarbonising the economy; and
- research, innovation and competitiveness.

The fourth pillar is based on an EU-wide carbon market under the EU emissions trading system (ETS), with the vision of making Europe the number one in renewable energy sources.

Coal during the energy transition

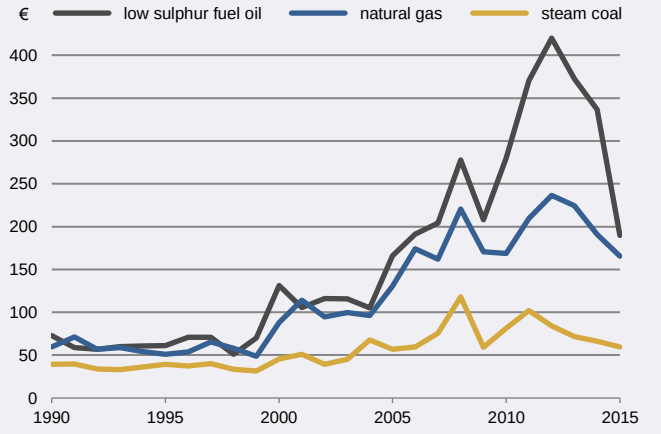
In terms of energy supply, Japan should be one of the world's least secure countries. It has virtually no indigenous energy reserves – coal mining stopped in 2002 and the abandoned coal mine on Hashima Island is seen now only in Bond movies. Nevertheless, following the terrible incident at Fukushima nuclear power plant in 2011, Japan has become more reliant on coal which now covers around one third of the country's electricity generation. Japan is building new coal-fired power plants, some within city limits, and expanding its coal imports, mostly from Australia, Indonesia and Russia. At the same time, it is investing in subsidised renewable energy sources and gas-fired generation based on the expansion of liquefied natural gas (LNG) imports.

Europe should take note of Japan's balanced approach because it shows that coal can be used cleanly and efficiently at state-of-the-art plants with public acceptance. During the energy transition in Europe, coal can play a similar role as in Japan – ensuring security and competition in the electricity sector. The EU ETS sets a cap on carbon emissions, providing space for coal within the politically agreed emission reduction targets. Looking out to 2050, coal consumption in Europe will decline. This should be seen as an opportunity. The flexibility and efficiency of modern coal-fired power plants mean that the services they provide in the market can be delivered with a lower coal burn, providing new investments are permitted to replace older plants – the average age of coal-fired plants in Europe is thirty-six years, compared with twenty-two years in Japan. The question for policymakers is whether, during the energy transition, coal will be viewed as an undesirable fuel and at best ignored, or whether the advantages of coal will be recognised in the EU as they are in Japan.

Competitive energy from coal

Coal is abundant, affordable and available – that is why it is a fuel of choice for electricity generation in many developed and developing countries. In Europe, coal ensures a truly competitive energy market. Without inter-fuel competition from coal, we would be faced with much higher energy prices for industrial and residential electricity consumers across Europe. Moreover, it is easy to forget that over 10% of EU citizens live in energy poverty and need affordable energy to stay warm and comfortable in the winter.

Figure 1
Oil, gas and coal prices in the EU since 1990 – compared on an energy basis, € per tonne of coal equivalent



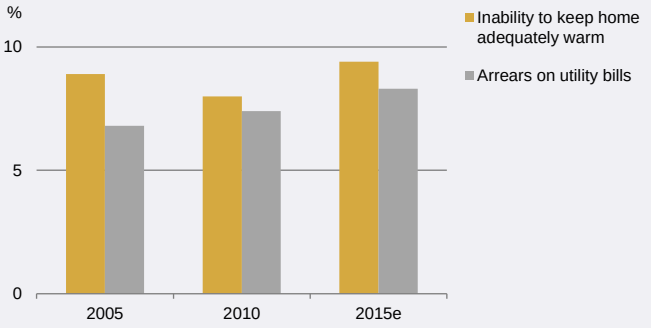
Sources: IEA databases, BAFA in BP, 2016 and IHS, 2016

Energy poverty

"Energy access" is about providing modern energy services to everyone around the world. At their most basic, these services are defined as household access to electricity and clean cooking facilities (*e.g.* fuels and stoves that do not cause indoor air pollution). Modern energy services are crucial to human well-being and to a country's economic development and yet globally over 1.3 billion people are without access to electricity and 2.6 billion people are without clean cooking facilities. More than 95% of these people are either in sub-Saharan Africa or developing Asia and 84% are in rural areas. For many, electricity from coal is the route out of grinding poverty: over the last twenty-five years, China has lifted 650 million people out of poverty by using coal.

The EU is not immune from the impacts of energy poverty. With rising energy prices and recessionary pressures, often coupled with poorly insulated homes, energy poverty is a problem across many member states. According to the EU Survey on Income and Living Conditions (EU-SILC), energy poverty in the EU is rising such that almost 10% of citizens are unable to heat their homes adequately and over 8% have fallen behind with payment of their utility bills. In total, an estimated 54 million European citizens (10.8% of the EU population) live in energy poverty.

Figure 2
Energy poverty in the EU, % of total population



Source: Eurostat (EU-SILC Survey Indicators) Statistics on income and living conditions

Added value from coal

The annual value of EU-wide coal and lignite use, based on its calorific value and on international hard coal prices during 2015, totals around €22 billion.[1] If the quantity of coal used in the EU were to be replaced by natural gas, then the annual cost would be over €70 billion.[2] The EU has insufficient indigenous natural gas production to meet its existing gas needs and is 67.4% dependent on imports, so this entire sum would leave the EU and severely weaken the region's economy.

According to analysis carried out by NERA, net government revenues and mandated transfers from the EU and Norwegian coal industry in 2011 amounted to €33 billion. This positive contribution to government revenues should be contrasted with the negative contributions of wind and solar, as shown in Table 1.

Table 1
EU-28 + Norway net government revenues and mandated transfers in 2011

Source	Government revenues (€ billion)	Government expenditures & mandated transfers (€ billion)	Total (€ billion)	Primary energy consumption (Mtoe)
Oil	333	-0.2	332	511
Gas	100	-0.4	100	390
Coal	36	-4	33	286
Wind	8	-9	-1	16
Solar	2	-17	-15	4

Source: NERA, 2014

Employment in the European coal industry

In 2015, across the EU, 191 million tonnes of hard coal and 399 million tonnes of lignite were mined. Mining this coal employed 185 000 people, some at integrated mine and power plants. In the greater Europe, including Turkey and Ukraine, this number rises to 380 000 people (Table 2). Adding the indirect jobs supported by coal mining leads to a total of over one million people whose livelihoods depend on the coal industry. Coal mining is often the main employer in regions which would otherwise be depressed and suffering from high unemployment. With youth unemployment across the EU now higher than 24%, new jobs are vital and the coal sector provides them.

Table 2
Manpower in the European coal industry, 2012 and 2015

	2012			2015		
	Hard Coal	Lignite	Total	Hard Coal	Lignite	Total
Bosnia and Herzegovina	-	15 000	15 000	-	14 382	14 382
Bulgaria	-	13 000	13 000	-	11 765	11 765
Czech Republic	12 900	9 100	22 000	10 131	7 869	18 000
Germany	17 600	16 600	34 200	9 640	15 428	25 068
Greece	-	7 500	7 500	-	4 919	4 919
Hungary	-	2 100	2 100	-	1 655	1 655
Norway	400		400	267	-	267
Poland	113 000	15 000	128 000	89 924	9 574	99 498
Romania	6 000	15 000	21 000	4 442	10 600	15 042
Serbia	3 900	12 300	16 200	1 600	12 360	13 960
Slovakia	-	3 700	3 700	-	2 190	2 190
Slovenia	-	1 600	1 600	-	1 274	1 274
Spain	3 400	-	3 400	3 324	-	3 324
Turkey	18 500	37 000	55 500	15 668	28 856	44 524
Ukraine	273 800	-	273 800	122 000	-	122 000
United Kingdom	5 800	-	5 800	1 975	-	1 975
Total	455 300	147 900	603 200	258 971	120 872	379 843

Source: EURACOAL members

A just and fair energy transition

The term “just transition” was popularised after the 2009 United Nations COP 15 climate conference in Copenhagen and has been embraced by trade unions and environmental NGOs. In 2010, the International Labour Organization published in its International Journal of Labour Research a series of articles on “Climate change and labour: the need for a just transition”. Thus, trade unions have accepted the supremacy of climate policy over the economic and social aspects of industrial policy, calling for the “fair” treatment of workers during what they see as the necessary and inevitable de-industrialisation of society in order to save the planet for future generations.

The Energy Union will bring social changes. The European Commission recognises this and proposes vocational and other training paths towards new or adapted job profiles, corresponding to the needs of new businesses and providing citizens with solid skills: *“An energy transition that is just and fair will therefore require retraining or up-skilling of employees in certain sectors and where needed, social measures at the appropriate level.”* (COM(2015) 80 final).

During the energy transition, some sectors are expected to shrink and hundreds of thousands of jobs will disappear.

The role of the European Commission is not only to present a vision for the EU, but also to secure this vision in an orderly process that avoids social unrest and the extinction of economic activity in those regions of Europe which depend on the energy sector and heavy industry. More generally, across Europe, there is a risk associated with rising energy prices. The issues of energy poverty and industrial competitiveness have to be addressed.

The coal industry is working with the European Commission as well as our social partners to diminish the negative outcomes of EU policy on its own employees and on society in general. Nobody should be left behind during the fight against climate change and the political establishment must consider all the implications of their policies. In the case of coal, this means recognising its benefits while managing its drawbacks.

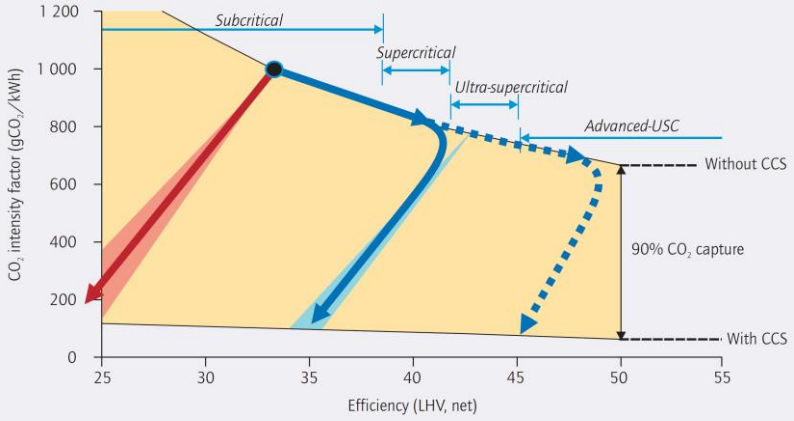
Notes

[1] Indigenous production of 206 Mtce or 240 Mt (6 000 kcal/kg) and imports of 191 Mt in 2015, all at a price of 57 US$/tonne (IHS, 2016).

[2] In 2015, the cost of importing natural gas into Germany was 6.61 US$/mmBtu (BAFA, 2016) which is equivalent to 166 €/tce. The annual cost of replacing coal with imported natural gas would therefore be €72 billion.

High-efficiency, low-emissions (HELE) coal power generation

INSIGHT 4



Reducing CO_2 emissions from coal-fired power generation (Source: *Technology Roadmap: High-Efficiency, Low-Emissions Coal-Fired Power Generation*, IEA, 2012)

Attaching blades to a large steam turbine

J-POWER 600 MW ultra-supercritical Isogo power plant in Japan

According to the International Energy Agency, about 75% of operating coal-fired power plants worldwide do not use the latest high-efficiency, low-emissions (HELE) technologies; more than half of current capacity is over twenty-five years with many "subcritical" units smaller than 300 MW. Modern coal technologies reduce CO_2 emissions by around 30% and protect the environment.

For conventional pulverised coal combustion (PC) technology – the most commonly used technique – powdered coal is injected into the boiler and burned to raise steam for subsequent expansion in a steam turbine generator. The most efficient HELE technology is currently ultra-supercritical (USC) pulverised coal combustion with an efficiency of 45% (LHV, net), significantly higher than the average 33% efficiency of the exiting coal-fired power plant fleet. Reducing conventional pollutant emissions remains a priority and with today's commercially available flue gas treatment systems it is possible to reduce emissions of sulphur dioxide, NOx and dust to below the most stringent levels demanded anywhere in the world.

The higher capital costs of supercritical technology are due largely to the alloys used and the welding techniques required for operation at higher steam pressures (250 to 290 bar) and temperatures (up to 620°C); however, the higher costs may be partially or wholly offset by fuel cost savings. Further development of new high-temperature, nickel-based alloys will allow advanced USC power plants to operate at over 700°C with efficiencies in excess of 50% and will mean more electricity from less coal in the future.

In Europe, marrying the continued use of coal with the need to reduce emissions can be achieved by improving the efficiency of Europe's older coal-fired power plants to reduce CO_2 emissions by 30% or more. EURACOAL estimates that the total annual investment needed is between €5 and €10 billion across the EU, vastly lower than any alternative and with no hike in energy prices.

International coal market and global energy trends

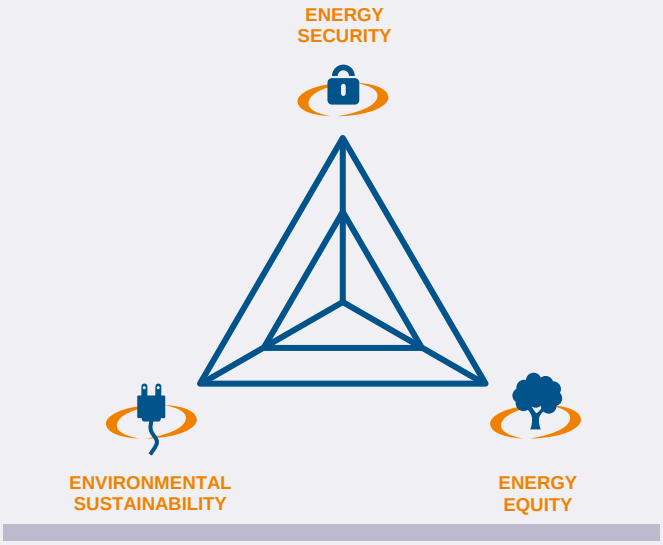
In today's uncertain world, coal makes a crucial contribution to the security of our energy supply. Add to this the positive impacts of coal use on energy prices and added economic value and it is clear that coal should be included in many policy decisions. For example, a diverse energy mix with coal should be part of any strategy that aims to reduce risks and underpin sustainable economic growth.

The aim of this section is to give an overview of how coal production and use in the European Union fit with the wider global picture of expanding coal consumption. Although it is impossible to forecast the future, it is instructive to look at current energy trends and examine how climate and energy policies may influence these trends.

Coal and sustainability

The European coal industry believes that the three energy sustainability objectives – security of supply, competitiveness and environmental compatibility – must be pursued with equal effort. Europe's energy sector faces considerable challenges to ensure security of energy supplies and investment in new energy infrastructure. Conventional thermal power generation, including nuclear power plants and, to an even greater extent, coal-, lignite- and gas-fired power plants, will continue to form the backbone of Europe's electricity supply. So, they need to be sustainable.

Figure 3
The energy trilemma according to the World Energy Council



Source: World Energy Council, 2015

One of the key requirements for the development of sustainable energy supplies in Europe is competitiveness. An energy supply at affordable and equitable prices is a must at all times; it helps to maintain the competitiveness of European industry as a whole. The risks for energy supply in the EU have increased significantly in recent years according to the European Commission in its framework strategy for a resilient Energy Union published in 2015.

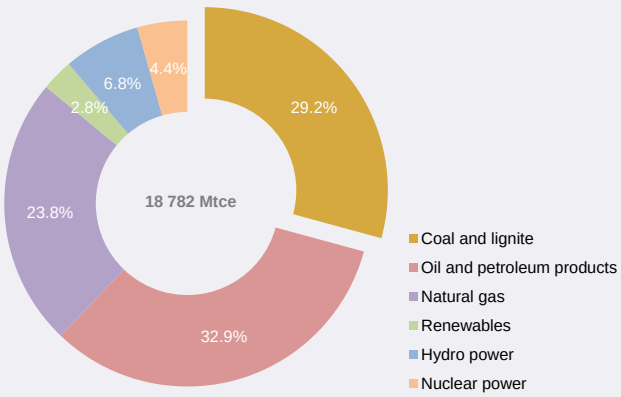
Two essential elements of a secure energy system are a diversity of energy sources and a diversity of energy technologies. A diverse energy mix, comprising in particular of indigenous energy sources including hard coal and lignite, helps to limit the high level of import dependency seen in the EU of 53.5% in the case of fossil energy sources in 2014.

Renewable energy sources and energy efficiency alone cannot overcome the challenges facing us; nor will power be generated in the future using only coal, natural gas and nuclear energy as in the past. New renewable energy sources such as wind power and solar power require reliable backup from conventional thermal energy sources. The more conventional energy that can be used flexibly within an energy mix that is environmentally acceptable and affordable, the greater will be the scope for developing and implementing renewable energy sources. The key to Europe's future power generation lies in a broad mix of all energy sources, so that supply risks can be minimised, reliability maximised, low-cost power generation ensured and further progress made in environmental protection. Efficient coal- and lignite-fired power plants play a crucial role here.

Global energy mix and coal

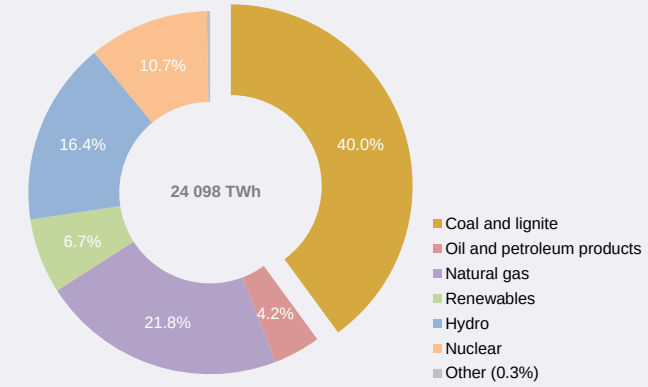
World total primary energy supply in 2015 was 18.8 billion tonnes of coal equivalent (Gtce) of which 29.2% came from coal. Coal is of particular significance for electricity generation. Some 40.8% of global power generation and 26.4% of EU power generation in 2014 was based on coal.

Figure 4
World total primary energy supply by fuel, 2015



Source: BP, 2016 (excludes non-commercial biofuels)

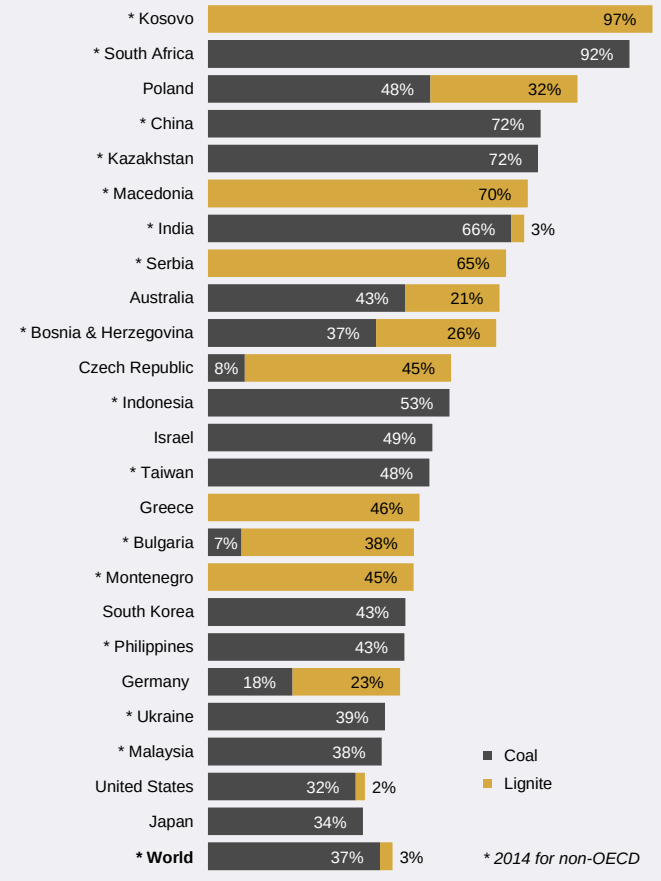
Figure 5
World electricity generation by fuel, 2015



Sources: IEA databases, BP, 2016 and own estimates

In the EU, 841 TWh of electricity were produced from solid fuels in 2014 (474 TWh from hard coal, 318 TWh from lignite and the remainder from coke ovens, oil shale and peat). Power plant capacities total 123 GW for hard coal-fired power plants and a further 55 GW for lignite-fired power plants. Individual countries have very different energy mixes for power generation, with coal being indispensable for many EU member states (Figure 6 and table on page 75).

Figure 6
Share of coal- and lignite-fired power generation in selected countries, 2014 and 2015

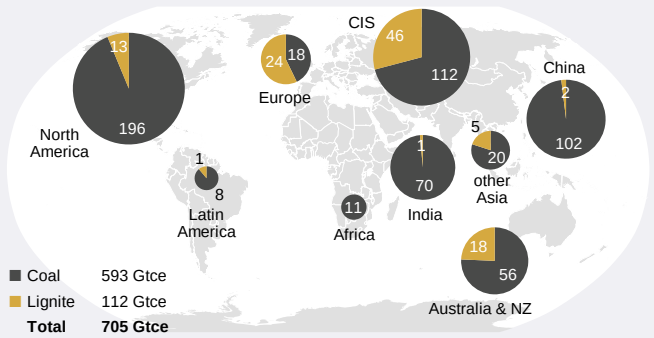


Source: IEA databases (including coal gases and coal products)

World coal resources

Reserves of coal and lignite are abundant; total resources are estimated at 17 449 billion tonnes of coal equivalent (Gtce) of which only 1.2% have been extracted so far. Reserves amount to 705 Gtce and are substantially greater than those of either oil or natural gas, even if one includes non-conventional oil and gas reserves. In fact, coal reserves account for more than one half of all non-renewable energy reserves and are distributed more favourably than those of natural gas and oil. The world coal market is a free commodity market, which – in contrast to oil and natural gas markets – is not influenced by geopolitics or the formation of cartels.

Figure 7
Global hard coal and lignite reserves



Source: BGR, 2015 and own calculations

EU coal resources

The availability of coal and lignite resources in Europe and around the world, combined with the high productivity of European coal and lignite producers and the diversity of coal exporters to Europe, guarantee a high degree of supply security and competitive prices. Indigenous energy production, diversified sources of import supply and the storage capacities available at mines, ports and consumers all help to ensure a stable supply chain. Unlike oil and natural gas, coal does not require strategic stocks to safeguard against political risks.

Table 3
Non-renewable energy reserves in the European Union

	Gtce	share
Hard coal	17.6	46.2%
Lignite	16.3	43.0%
Oil	1.6	4.1%
Natural gas	2.2	5.7%
Uranium	0.3	0.9%
Total	38.0	100.0%

Source: BGR, 2015

International coal market

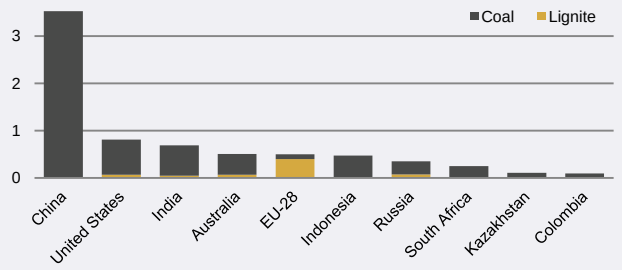
The largest coal producers in 2015 were China and the United States, followed by India and Australia. The European Union was the fifth largest producer, being the world's largest producer of lignite by a wide margin. Indonesia was the sixth largest coal producer, mostly of steam coal for export. The top-10 producers accounted for 95% of total world production.

Table 4
Largest coal producers, 2015

	Country	Coking coal (Mt)	Steam coal (Mt)	Lignite (Mt)	Total (Mt)
1	China	611.1	2916.1	-	3527.2
2	United States	57.4	691.3	64.1	812.8
3	India	54.5	593.5	43.2	691.3
4	Australia	191.1	252.3	65.4	508.7
5	EU-28	20.9	79.1	398.9	498.9
6	Indonesia	2.7	466.5	-	469.3
7	Russia	78.0	198.1	73.2	349.3
8	South Africa	3.2	248.9	-	252.1
9	Kazakhstan	16.0	85.0	6.2	107.2
10	Colombia	4.7	85.5	-	90.3
	others	50.3	195.1	156.4	401.6
	World	1089.9	5811.4	807.4	7708.7

Source: IEA Coal Information 2016 and EURACOAL members

Figure 8
Largest coal producers in 2015, billion tonnes



Source: IEA Coal Information 2016

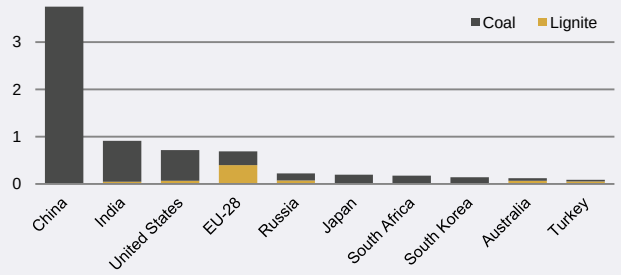
The largest coal consumers in 2015 were China and India, followed by the United States. The European Union was the fourth largest consumer, with steam coal for electricity generation being the main use of coal, accounting for 77% of all coal and lignite use on an energy basis. The top-10 consumers accounted for over 90% of total world consumption, with the European Union accounting for 8.9%. *Per-capita* coal consumption in the European Union is the same as the global average of 0.75 tonnes of coal equivalent per person.

Table 5
Largest coal users, 2015

	Country	Coking coal (Mt)	Steam coal (Mt)	Lignite (Mt)	Total (Mt)
1	China	658.1	3094.4	-	3752.5
2	India	105.6	763.5	43.2	912.3
3	United States	17.6	628.8	66.9	713.3
4	EU-28	59.9	228.1	398.9	686.9
5	Russia	59.7	88.3	70.9	218.9
6	Japan	50.3	141.2	-	191.5
7	South Africa	4.0	172.0	-	176.0
8	South Korea	38.9	100.4	-	139.3
9	Australia	3.9	52.6	65.7	122.2
10	Turkey	6.2	30.6	50.5	87.3
	others	67.3	527.7	110.7	705.7
	World	1071.5	5827.6	806.8	7705.9

Source: IEA Coal Information 2016 and EURACOAL members

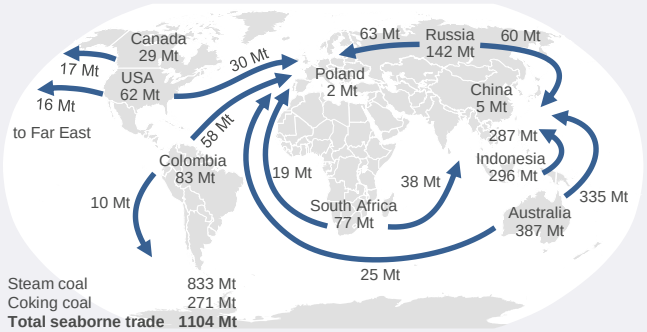
Figure 9
Largest coal users in 2015, billion tonnes



Source: IEA Coal Information 2016

Global seaborne hard coal trade is estimated at 1 104 million tonnes in 2015, of which 833 million tonnes were steam coal and 271 million tonnes were coking coal.

Figure 10
World traded coal flows in 2015



Source: VDKi, 2016

Important exporting countries for steam coal and coking coal are Australia, Indonesia, Russia, Colombia, South Africa and the United States who together accounted for 87% of all coal exports in 2015.

Table 6
Supply and demand of steam coal in 2015

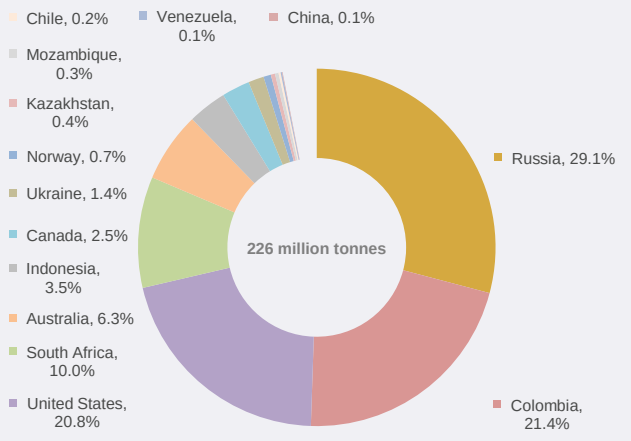
Atlantic Market: 217 Mt		Pacific Market: 616 Mt	
← 203 Mt ←		→ 561 Mt →	
Importers: 217 Mt	Exporters: 258 Mt	Exporters: 575 Mt	Importers: 616 Mt
EU-28	Colombia	Australia	Japan
Eastern Europe	South Africa	Indonesia	South Korea
Mediterranean	Russia	China	Taiwan
Americas	Poland	Russia	India
	Venezuela	Vietnam	China
	USA	South Africa	
Atlantic ← 14 Mt ← Pacific			
Atlantic → 55 Mt → Pacific			

Source: VDKi, 2016

Top coal importing countries are India, China, Japan, South Korea and Taiwan, together accounting for 62% of all coal trade in 2015. India surpassed China to become the world's largest coal importer in 2015. In the EU, Germany and the United Kingdom were the biggest coal importers in 2015, followed by Italy, Spain and France.

Seaborne coal trade can be divided into Pacific and Atlantic markets, each with different supply patterns (Table 6). Leading exporters to the EU are Russia, Colombia, USA, South Africa and Australia. In 2014, over 29% of all coal imports into the European Union came from Russia.

Figure 11
Coal imports into the EU by source country, 2014



Source: European Commission DG Energy, 2016

Global energy trends

Future world energy scenarios to 2040 and beyond from the International Energy Agency (IEA) and other respected bodies show a marked increase in world total primary energy consumption, with more or less similar proportions of oil, coal and gas in the energy supply mix.

In marked contrast to the global picture of growing fossil fuel use, EU leaders agreed at a European Council meeting in October 2009 to reduce greenhouse gas emissions by 80-95% by 2050 compared with 1990 levels. The European Commission presented its *Energy Roadmap 2050* in December 2011, accompanied by an impact assessment in which it details various scenarios to achieve an 80% reduction in greenhouse gas emissions by 2050. While all sectors are analysed, the power sector is seen as the one carrying most of the burden of emission reductions.

The IEA *World Energy Outlook* analyses future energy supply and demand to 2040. In its New Policies Scenario, the Agency assumes the cautious implementation of already announced policy measures. Figures 12 and 13 show that coal and lignite are expected to remain an important albeit smaller component of EU energy supply for many years.

Figure 12
EU production of coal and lignite

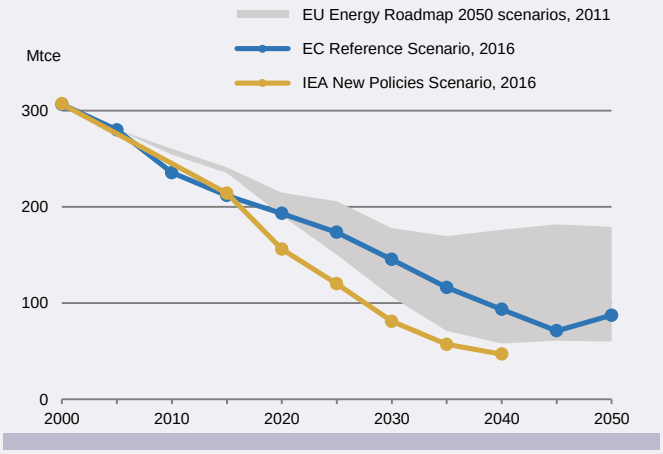
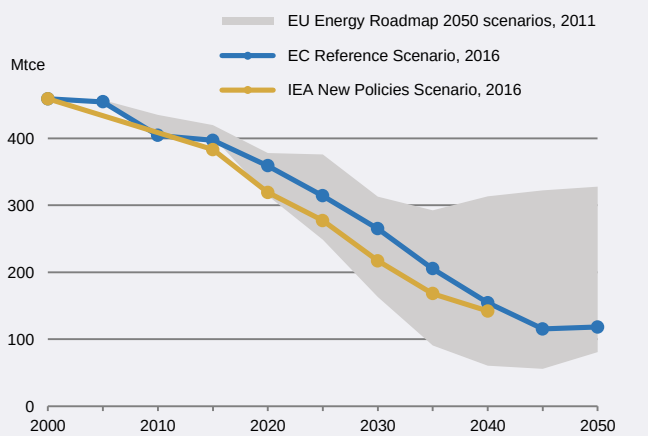


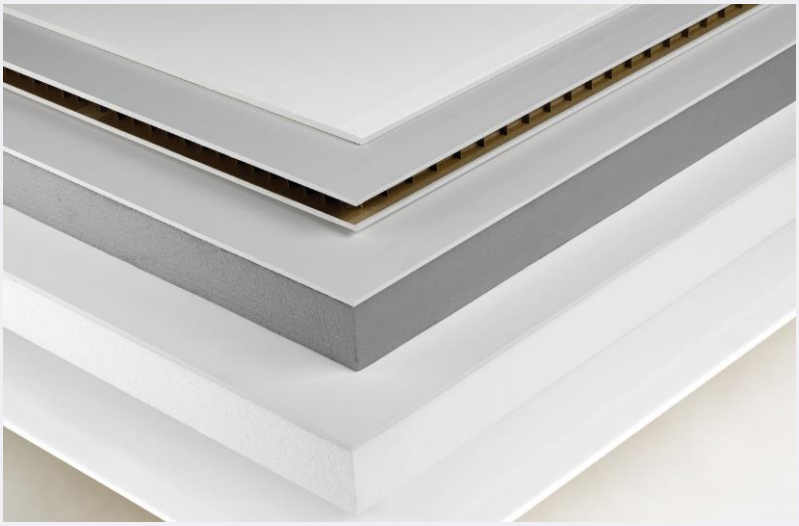
Figure 13
EU consumption of coal and lignite



Sources: European Commission, 2011 & 2016 and IEA, 2016b

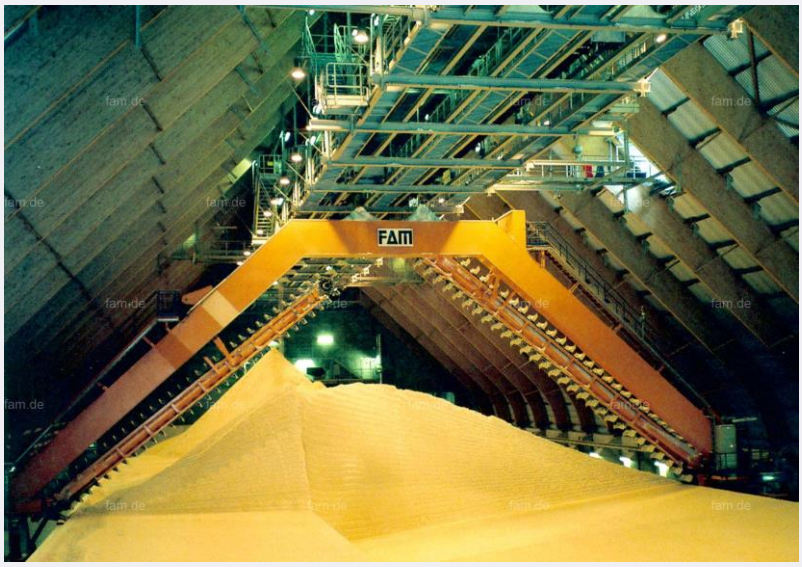
INSIGHT 5

A step towards a circular economy with FGD gypsum



Plasterboard made from flue gas desulphurisation (FGD) gypsum

A hydro-cyclone separates particles of solid gypsum, a by-product of the wet limestone slurry FGD process at the Šoštanj coal power plant in Slovenia



FGD gypsum store and reclaimer at the LEAG/EnBW Lippendorf lignite-fired power plant in Germany

Gypsum plasterboard is a widely used construction material that can be easily joined to the internal walls of buildings to provide a space or cavity for thermal insulation and thus contribute to energy efficiency. Plasterboard is also a solution for sound insulation and absorption, in cinemas for example, and one of the best materials to use as a fire barrier. Overall, 1.7 billion square metres of gypsum plasterboard are used each year, significantly contributing to EU energy efficiency objectives. The Guggenheim museum in Bilbao and the Bundestag in Berlin used several thousand square metres.

Less well known is that much of the gypsum needed for plasterboard comes from flue gas desulphurisation (FGD) at coal-fired power plants, while the rest is extracted from quarries. About 8 kilogrammes of synthetic or natural gypsum are required for every square metre of plasterboard. In Europe, over one half of the raw material needed for plasterboard is a by-product of coal-fired power generation.

Supplies of high-purity FGD or synthetic gypsum have also become increasingly attractive to those cement companies who produce gypsum concrete. It is generally cheaper and more practical to use FGD gypsum than gypsum from quarries. Cement companies have traditionally used other combustion products from coal burning, including fly ash, while block manufacturers use the coarser bottom ash, after grading. All these useful by-products put the coal industry a step closer towards a circular economy.

Chemical-looping coal combustion for zero CO_2

INSIGHT 6

Ilmenite from Åmdalsmoen, Froland, Aust-Agder, Norway (4.1 x 4.1 x 3.8 cm)

A pilot-scale 100 kW chemical-looping combustion unit at the Chalmers University of Technology: a 3D diagram (left) and the actual unit with oven enclosure (right)

The key objective for the ACCLAIM project, funded by the EU Research Fund for Coal and Steel, is to find ways to improve the performance of the chemical-looping process as applied to solid fuels so that coal can be combusted without emitting CO_2 to the atmosphere. The primary focus is on improving gas conversion rates in the fuel reactor.

The mineral ilmenite – a titanium-iron oxide – has been the dominant oxygen carrier in solid-fuel chemical looping, primarily due to its low cost and mechanical stability. However, it is difficult to reach very high conversion rates in the fuel reactor using ilmenite. Hence, it would be an advantage to find oxygen carriers with a higher gas conversion capacity. The ACCLAIM project aims to find more reactive oxygen carriers, in terms of their oxygen-releasing capacity, but also seeks to improve the reactor design with configurations that enable greater gas-solid contact. Qualification of oxygen carriers is being conducted in continuous test units ranging from 0.5 kW to 10 kW. The best-performing materials will be selected for operation in larger, pilot-scale, 100 kW and 1 MW chemical-looping combustors. Design optimisation is being investigated using various numerical modelling approaches.

Research Fund for Coal & Steel

Bulgaria

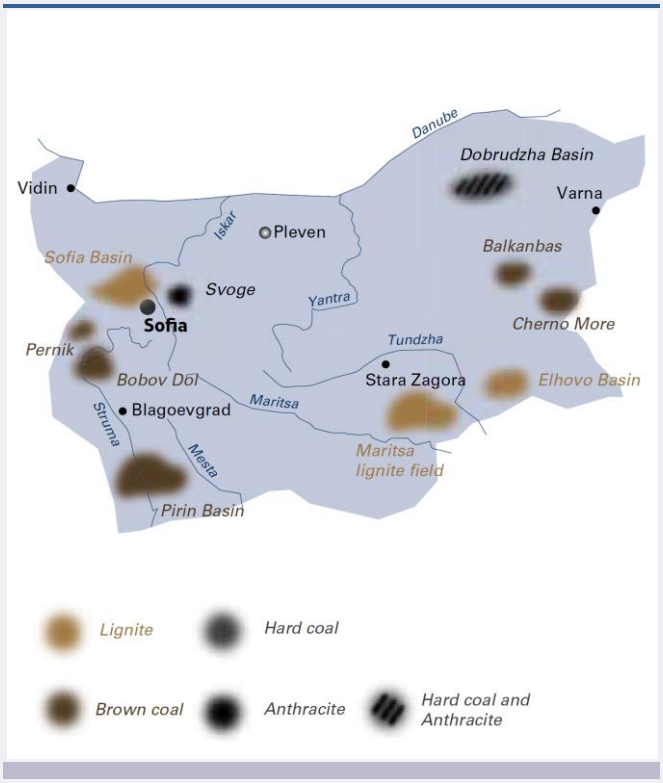
With its great resource potential, the mining sector is of outstanding importance to Bulgaria and has developed strongly over the last few years, considerably surpassing the labour productivity of other sectors and almost reaching the EU average. Over the last few years, the mining sector has attracted considerable local and foreign investment with several companies investing in world-class exploration, extraction and processing.

Bulgaria has an *Energy Strategy to 2020* and there are on-going discussions on a new medium- to long-term energy strategy post 2020. After finalising its new energy strategy, the government intends to develop a national low-carbon development strategy, continuing on from the *Third National Action Plan on Climate Change for the period 2013-2020* that was published in 2012.

Due to its domestic production of coal and nuclear electricity, Bulgaria had an import dependency in 2014 of just 34.5%, this being far below the EU average of 53.5% when all energy products are considered together. At 35.7%, the share of coal in total primary energy supply is twice the EU average while the 23.2% share of nuclear power is around 50% greater than the EU average. Power prices are correspondingly low – among the lowest in the EU. In 2012, eight years early, Bulgaria reached its 2020 target of 16% renewable energy in final energy consumption, but at a high economic and political cost.

The Bulgarian energy sector is relatively small on a global scale, although it is of great significance to the country`s energy-intensive industrial base and accounts for above EU-average shares in total employment and value added. It includes oil and gas transport to the European market. The sector is of strategic importance to the economic development of the country and to national energy security, which to some extent explains the large investments in new capacity, rehabilitation of old power plants and expansion of the power supply grid made over recent years. New projects will see more gas and electricity interconnectors with Greece, Romania, Serbia and Turkey. However, the regulated end-consumer tariffs are not sufficient to match the investment costs borne by electricity utilities, a situation exacerbated by the high number of consumers in arrears.

The liberalisation of the electricity and gas markets in Bulgaria is being carried out in line with the requirements of EU legislation. In practice, this is a step-by-step process with the aim of creating the necessary conditions for competition, such as giving consumers the opportunity to choose their supplier.



General data		2015
Population	million	7.2
GDP	€ billion	45.3

By providing jobs to highly qualified and experienced specialists, the mining sector contributes to the social and economic development and welfare of the mining municipalities. Unfortunately, the long permitting procedures from an initial investment assessment to exploration and the lack of clear regulations on extraction and planning are impeding the industry's development. Nevertheless, there are good prospects for the introduction of the best new technologies from Europe and around the world in order to further enhance efficiency in the fields of extraction and processing.

The major tasks of the Bulgarian mining industry are the sustainable development of the mining regions, environmental protection and land restoration, improvement of work safety standards and enhanced vocational training.

Lignite

Opencast lignite mining is mainly carried out in the mines of MINI MARITSA IZTOK EAD (MMI) whose production accounted for 90% of the country's total in 2015. Its mines cover an area of some 240 square kilometres, being the largest mining site in South East Europe. MMI is also the biggest employer in Bulgaria. The company supplies four power plants with its own lignite: the state-owned Maritsa East 2 thermal power plant (TPP) (1 620 MW) and the privately owned CONTOURGLOBAL Maritsa Iztok East 3 TPP (908 MW), AES Galabovo TPP (670 MW) and BRIKELL TPP (200 MW). MMI also supplies lignite to the 120 MW Maritsa 3 TPP in Dimitrovgrad.

As a subsidiary of BULGARIAN ENERGY HOLDING, MMI plays an important role in ensuring national energy security and guaranteeing Bulgaria's energy independence; 40% of the country's electricity is generated from lignite supplied by MMI.

Other smaller lignite mining companies operate Beli Bryag mine (1.9% of national lignite production in 2015), Stanyantsi mine (2.4%) and Chukurovo mine (0.2%).

Brown coal

Bulgaria's brown coal deposits are mostly located in the western part of the country (Bobov Dol, Pernik and Pirin coalfields and the Katrishte deposit) and near the Black Sea (Cherno More coalfield). In 2015, the production of brown coal from both underground and surface mines totalled 2.1 million tonnes.

VAGLEDOBIV BOBOV DOL EOOD mines in the Bobov Dol coalfield, being the largest deposit of brown coal in the country with reserves and resources amounting to some 100 million tonnes. Coal from the single opencast mine and two underground mines is supplied mainly to the nearby 210 MW Bobov Dol TPP. In 2015, a total of 1.0 million tonnes of brown coal was produced from the three mines. About 10% to 12% of the coal mined by VAGLEDOBIV BOBOV DOL is used by households.

OTKRIT VAGLEDOBIV MINES EAD, another private company, owns two opencast mines in the Pernik coalfield where it extracted 1.0 million tonnes of brown coal in 2015.

BALKAN MK OOD carries out underground coal mining in the Oranovo coalfield with some 30 million tonnes of brown coal reserves and a production capacity of 0.7 million tonnes per year. The brown coal is supplied mainly to Bobov Dol TPP.

Other small privately owned mines are the Vitren mine located in the Katrishte deposit, with an annual capacity of around 0.1 million tonnes, and Cherno More mine in the Black Sea coalfield, with an annual capacity of 0.25-0.3 million tonnes.

Coal resources and reserves		
Resources brown coal	Mt	320
Resources lignite	Mt	4 300
Reserves brown coal	Mt	190
Reserves lignite	Mt	950

Primary energy production		2015
Total primary energy production*	Mtce	15.6
Brown coal and lignite (saleable)	Mt / Mtce	35.9 / 8.4

Saleable coal quality		
Brown coal calorific value	kJ/kg	12 140-13 400
Lignite calorific value	kJ/kg	5 652-7 746
Brown coal ash content	% a.r.	<26
Lignite ash content	% a.r.	17-45
Brown coal moisture content	% a.r.	<16
Lignite moisture content	% a.r.	51-60
Brown coal sulphur content	% a.r.	<2.7
Lignite sulphur content	% a.r.	2.2-2.8

Coal imports / exports		2015
Hard coal imports	Mt	1.1

Primary energy consumption		2015
Total primary energy consumption*	Mtce	25.4
Coal consumption	Mtce	9.8

Power supply		2015
Total gross power generation	TWh	48.4
Net power imports (exports)	TWh	(10.4)
Total power consumption	TWh	38.0
Power generation from lignite	TWh	18.8
Power generation from hard coal	TWh	1.0
Lignite and brown coal power generation capacity	MW	4 199
Hard coal generation capacity	MW	708

Employment		2015
Direct in brown coal & lignite mining	thousand	11.765
Other brown coal- & lignite-related**	thousand	46.851

** 2014 data*
**** e.g. *in power generation, equipment supply, services and R&D*

Hard coal

Hard coal output is not significant (35 thousand tonnes) and its extraction is carried out by MINA BALKAN 2000 EAD.

Czech Republic

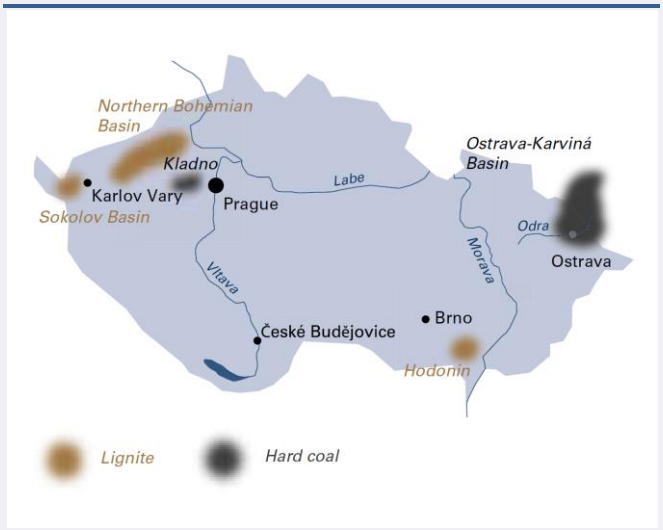
Coal is the only significant indigenous energy resource in the Czech Republic. The country's proven coal reserves have been estimated at some 880 million tonnes. Brown coal, which accounts for more than 90% of these reserves, is mainly produced in north-western Bohemia, while hard coal is mined in northern Moravia. Significant quantities of hard coal are exported to Poland, Slovakia, Austria, Germany and Hungary.

Primary energy consumption, which amounted to 58.4 Mtce in 2015, was supplied as follows: 39.2% coal (total 22.8 Mtce, of which 6.3 Mtce was hard coal and 16.5 Mtce was brown coal), 16.0% natural gas (9.3 Mtce) and 21.1% oil (12.3 Mtce). The primary energy mix is supplemented by nuclear energy with a 16.4% share (9.5 Mtce), as well as by solar, hydro and wind power, which together account for 1.0% (0.6 Mtce), with biofuels and waste accounting for a further 6.4% (3.8 Mtce).

The Czech Republic's dependence on energy imports has been quite modest to date; 30.4% of energy demand is met by imports. However, imports are structurally imbalanced. The country's dependence on oil and gas imports is 96% to 98%. A number of direct and indirect measures are being adopted to prevent any further increase in energy imports, including: increased energy efficiency, the promotion of renewable energy sources in areas where their use is effective in reaching a 13% share in final energy consumption by 2020, and the efficient use of indigenous solid fuel resources, mainly brown coal.

In 2015, approximately 51.4% of total gross electricity production (83.9 TWh) was generated from coal, 32.0% from nuclear energy and 7.0% from solar, hydro and wind. Conventional coal-fired power stations have a total capacity of approximately 10.8 GW. The Czech electricity market has been fully liberalised since 2006 and the gas market since 2007.

There are five coal mining companies in the Czech Republic: OSTRAVSKO-KARVINSKÉ DOLY, the only hard coal producer, and four brown coal mining companies, SEVEROČESKÉ DOLY, owned by ČEZ and the biggest producer of brown coal, VRŠANSKÁ UHELNÁ, with coal reserves to last until 2055, SEVERNÍ ENERGETICKÁ with the largest brown coal reserves in the Czech Republic, and SOKOLOVSKÁ UHELNÁ, the smallest brown coal mining company. All of these coal mining companies have been privatised. The majority state-owned utility company, ČEZ, is the largest coal consumer in the Czech Republic and the most important Czech supplier of electricity.



General data		2015
Population	million	10.5
GDP	€ billion	167.0

Hard coal

The Czech Republic has 42 million tonnes of economically recoverable hard coal reserves (as of 1 January 2016). The largest hard coal deposits are located in the Upper Silesian coal basin. With an area of 6 500 square kilometres, this coal basin ranks among the largest in Europe. A major part is located in Poland, while about one sixth (1 200 square kilometres) lies in the Czech Republic where it is called the Ostrava-Karviná basin (after the city of Ostrava and the town of Karviná). Here, OSTRAVSKO-KARVINSKÉ DOLY (OKD) extracts hard coal from deep mines. In 2015, saleable output was 8.2 million tonnes, with a workforce of around 10 131 own employees and 3 495 contractors. Coal is currently extracted at three deep mines: DZ 1 (Karviná and Darkov), DZ 2 (ČSM) and DZ 3 (Paskov). The worked seams at the Paskov colliery near Ostrava range in thickness from 0.8 to 1.6 metres. The thickness of the Karviná seams ranges from 1.5 to 6.5 metres. Longwall working with shearer loaders (90.2%) and ploughs (9.8%) is employed, combined with controlled caving. Mechanical supports (95.1%) and individual hydraulic props (4.9%) are used to support the coalfaces. OKD is trialling "room and pillar" mining as a potential new method in the DZ 2 mine. At each of the collieries, the extracted coal is processed in preparation plants where it is graded as coking coal or steam coal, based on its quality parameters.

Brown coal and lignite

The Czech Republic has 737 million tonnes of economically recoverable brown coal reserves (as of 1 January 2016). In addition to a coal basin in northern Bohemia and another basin near the town of Sokolov, there are coalfields in the south of the country, although they are not economically viable. Production of brown coal totalled 38.1 million tonnes in 2015, providing an important contribution to the country's energy supply.

The main brown coal deposit and the largest mining area, covering 1 400 square kilometres, is the Northern Bohemian brown coal basin, which is located at the foothills of the Krušné hory mountains, along the border with Germany (Saxony), in the vicinity of the towns of Kadaň, Chomutov, Most, Teplice and Ústí nad Labem. The coal seams in this area extend to depths of up to 400 metres and are between 15 and 30 metres thick.

Brown coal is extracted in the central part of the Northern Bohemian brown coal basin by two mining companies, VRŠANSKÁ UHELNÁ (VUAS) and SEVERNÍ ENERGETICKÁ (Sev.en).

Sev.en manages the country's largest brown coal deposit, the ČSA surface mine, which holds reserves of 750 million tonnes of good quality brown coal with an energy content of up to 17 500 kJ/kg. These reserves are sufficient to support extraction for the next one hundred years, subject to mining limits set in 1991. Within the current mining limits, extraction will last until 2024. A total of 3.6 million tonnes was produced in 2015.

In addition to the ČSA surface brown coal mine, Sev-en Group also operated the Centrum deep brown coal mine. Extraction from this mine ended on 1 April 2016 after 128 years of operation. Since this was the last deep brown coal mine in the country, the closure marked the end of deep brown coal mining in the Czech Republic.

In 2013, Sev.en acquired the 800 MW Chvaletice brown coal-fired power station to create a new vertically integrated company that has become a competitive player in the Czech energy market. After 2015, the power station will be retrofitted to meet the most stringent requirements for long-term environmentally friendly operation, thus extending its life to 2030. Sev.en had a total workforce of 924 in 2015.

VUAS, part of the CZECH COAL GROUP, extracts brown coal at the Vršany surface mine. Its coal reserves within existing mining limits have the longest remaining life of any in the Czech Republic. In 2013, the company entered into a fifty-year coal supply agreement with the ČEZ Počerady power station. This long-term contract secures the future of Vršany mine through to its depletion and brings economic stability to the northern Bohemian region. In 2015, VUAS extracted 6.7 million tonnes of brown coal with 706 employees.

The brown coal company SEVEROČESKÉ DOLY (SD) based in the town of Chomutov operates in the north-western part of the Northern Bohemian brown coal basin, to the east of the town of Most. SD extracts brown coal at two mine sites, namely Nástup Tušimice and Bílina. A total of 21 million tonnes was produced in 2015, decreasing SD's share in national brown coal production to 55%.

The Nástup Tušimice brown coal mining area is located between the towns of Chomutov and Kadaň and comprises one large surface mine with an average annual output of 11.5 million tonnes. After preparation at the Tušimice crushing plant, most of the product is supplied to power stations operated by ČEZ.

The Bílina brown coal mining area has one surface mine located between the towns of Bílina and Duchcov. More than 9.5 million tonnes of brown coal are produced each year and transported to the Ledvice preparation plant before being delivered to power stations, industries and households.

In 2015, the SD group had a total workforce of 4 901.

Located in western Bohemia, in the western part of the coalfield below the Krušné hory mountains, the brown coal basin around the town of Sokolov is mined by SOKOLOVSKÁ UHELNÁ (SU). The company operates one surface mine, the Jiří mine. In 2015, its output was 6.4 million tonnes. Brown coal from the Sokolov area is mainly used for power and heat generation, with chemical by-products from coal gasification also being important.

SU generates electricity and heat at two of its own plants: the Vřesová IGCC plant (2 x 200 MWe) and a CHP plant (5 x 270 MWt), which have a combined annual output of 3.5 TWh. Most of the heat produced is consumed by the company itself, although some is supplied to the towns of Karlovy Vary, Nejdek, Chodov and Nová Role. The company also pursues environmental activities, notably the reclamation of land affected by surface mining, and waste processing and disposal. SU's operations employed a total workforce of 3 334 in 2015.

The Czech coal industry has always played and will continue to play a significant role in the national economy. In 2015, the share of coal in gross electricity production amounted to 51.4%. According to the National Energy Concept adopted in May 2015 the share of coal in electricity production should decrease to between 11% and 21% by 2040. To ensure the sustainable use of coal over this period, the Czech Republic is engaged in a comprehensive programme to renovate and renew coal-fired power stations in northern Bohemia. The 800 MW Tušimice II power station has been renovated, reducing its CO_2 emissions significantly and extending its life to 2035. Likewise, the life of the Prunéřov II power station has been extended by twenty-five years following renovation of three units (750 MW), successfully reducing CO_2 emissions by 40%. Finally, the new 660 MW Ledvice power station was commissioned in 2015 with a planned life of forty years.

Czech Republic

Coal resources and reserves		
Resources hard coal	Mt	563
Resources lignite	Mt	1 601
Reserves hard coal	Mt	42
Reserves lignite	Mt	737

Primary energy production		2015
Total primary energy production	Mtce	39.8
Hard coal (saleable output)	Mt / Mtce	8.3 / 7.6
Lignite (saleable output)	Mt / Mtce	38.1 / 16.0

Saleable coal quality		
Hard coal net calorific value	kJ/kg	25 490-32 070
Lignite net calorific value	kJ/kg	11 600-20 560
Hard coal ash content	% a.r.	4.3-18.9
Lignite ash content	% a.r.	6.0-37.8
Hard coal moisture content	% a.r.	3.5-9.9
Lignite moisture content	% a.r.	26.5-38.3
Hard coal sulphur content	% a.r.	0.42-0.43
Lignite sulphur content	% a.r.	0.78-1.44

Coal imports / exports		2015
Hard coal imports	Mt	2.9
Hard coal exports	Mt	3.6

Primary energy consumption		2015
Total primary energy consumption	Mtce	58.4
Hard coal consumption	Mtce	6.3
Lignite consumption	Mtce	16.5

Power supply		2015
Total gross power generation	TWh	83.9
Net power imports (exports)	TWh	(12.5)
Total power consumption	TWh	71.4
Power generation from hard coal	TWh	5.7
Power generation from lignite	TWh	37.5
Hard coal power generation capacity	MW	1 200
Lignite power generation capacity	MW	9 600

Employment		2015
Direct in hard coal mining	thousand	10.131
Direct in lignite mining	thousand	7.869

Investing to lower CO_2 emissions in the Czech Republic

INSIGHT 7

New supercritical unit at Ledvice power plant

Prunerov complex viewed from Hasištejn Castle in the Czech Republic

The refurbishment of the Prunerov II coal-fired power plant in the Czech Republic shows that significant efficiency gains and emission reductions can be made by investing in existing assets. The smaller, more flexible capacity at Prunerov will see an overall reduction in CO_2 emissions of around 40%, alongside reductions in the emissions of sulphur dioxide, oxides of nitrogen and dust in compliance with EU directives, as well as less noise.

Three 250 MW units have been rebuilt to operate for a further twenty-five years, replacing five old units as part of a €900 million project began in September 2012. Whilst the efficiency of power production has increased to 40%, the Prunerov complex also supplies heat, increasing overall efficiency to 43%. After decommissioning the old units, CO_2 emissions from the Prunerov complex will be lowered from 10 million tonnes per year to 4 million tonnes per year.

The most efficient brown coal-fired power plant in the Czech Republic is the new 660 MW unit at the Ledvice power plant, owned and operated by ČEZ. The unit, with a design life of forty years, is supplied with brown coal from the nearby Bílina mines. Completed by Škoda Praha and Alstom in 2015 under a contract signed in 2007, the net generation efficiency of the new unit is over 42% which means a considerable reduction of CO_2 and other emissions. To achieve this means high steam temperatures and pressures, so high heat-resistant steel alloys are used, such as P92, T24, Super 304H and VM12. At 135 metres, the boiler house is the tallest building in the Czech Republic.

Overall, ČEZ has invested over €3 billion in the upgrading and renewal of coal-fired power plants in the Czech Republic.

Germany

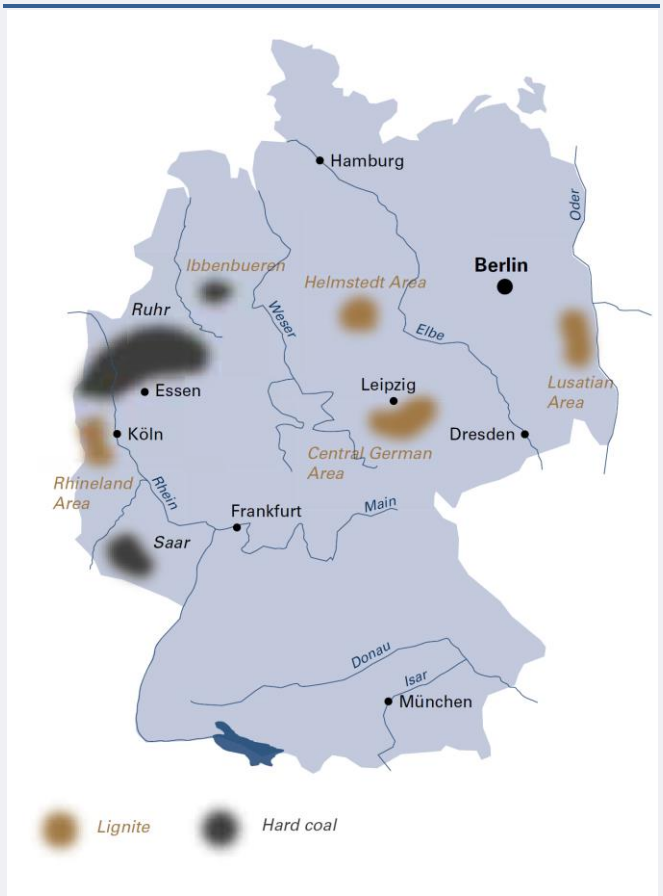
Germany has considerable reserves of hard coal and lignite, making these the country's most important indigenous sources of energy. However, in the case of hard coal, there remain only approximately 20 million tonnes to be extracted following the political decision to end subsidised German hard coal production in 2018. For lignite, there are long-term prospects for about 5 billion tonnes of mineable reserves in existing and approved surface mines.

In 2015, primary energy production totalled 139.6 Mtce, excluding nuclear power. With an output of 61.3 Mtce, coal and lignite had a share of 43.9%. The mix of indigenous primary energy production excluding nuclear power can be broken down as follows: 54.9 Mtce of lignite (39.3%), 6.4 Mtce of hard coal (4.6%), 8.9 Mtce of natural gas (6.4%), 3.5 Mtce of oil (2.5%) and 57.7 Mtce of renewable energy (41.3%) and other fuels 7.9 Mtce (5.6%).

Germany's primary energy consumption amounted to 453.6 Mtce in 2015. Oil accounted for the largest share (33.6%), followed by coal (24.7%), natural gas (21.1%) and nuclear energy (7.5%). Renewable energy sources grew to 12.5%. Within the figure for coal, hard coal accounted for 12.9% and lignite for 11.8% of total primary energy consumption. Germany is dependent on energy imports to a large extent, except in the cases of lignite and renewable energy. About 90% of hard coal was imported, in comparison with 98% import dependence for oil and 90% for natural gas.

The power generation structure is characterised by a widely diversified energy mix. In 2015, gross power generation output of 646.5 TWh was produced as follows: 42.1% from coal (of which 23.9% was from lignite and 18.2% from hard coal), 14.2% from nuclear, 9.5% from natural gas, 29.0% from renewable energy sources and 5.2% from other sources. Thus, hard coal and lignite, along with nuclear power, are still the mainstays of the German power industry.

The federal government adopted its *Energiekonzept* (energy plan) in October 2010. At this time, it assumed life extensions of German nuclear power plants up to the late 2030s. In 2011, after the Fukushima incident, it was decided to phase out nuclear power generation in Germany by the end of 2022. From the beginning, the focus has been on ambitious climate protection policies: a greenhouse gas emission reduction of 80% to 95% by 2050 with step-by-step objectives for each decade, including a 40% reduction by 2020 (compared with 1990); a massive increase in energy efficiency to yield total energy savings of 20% by 2020 and 50% by 2050; and the steady development of renewables to a 60% share of final energy consumption and 80% of power consumption by 2050. Thus, Germany's climate protection targets go beyond EU targets. In order to achieve the 2020 CO_2-reduction target, the German government decided in 2015 to implement a "Climate Action Programme 2020" (*Aktionsprogramm Klimaschutz 2020*)). This includes specific measures for the electricity sector which will have a direct impact on the use of lignite and hard coal. In November 2016, the German federal government also agreed upon a "Climate Protection Plan 2050" (*Klimaschutzplan 2050*) which sets out strategies to reduce greenhouse gas emissions by 61% to 62% by 2030 compared with 1990. The plan was presented at the UNFCCC COP 22 meeting in Marrakesh and means a move away from EU-wide efforts towards national climate action. However, up to now, there are no concrete actions concerning coal.



General data		2015
Population	million	81.2
GDP	€ billion	3 032.8

Since 2011, the German government and parliament have decided on a package of several new or amended energy laws and further political measures to foster change in the energy sector. This long-term and fundamental change is known as the *Energiewende* or "energy transition" to renewable energy.

In practice, coal-fired power plants will be needed to compensate for the phase out of nuclear power and, in the long term, to balance the ever-increasing power generation from renewables. Subsidised hard coal production is to be phased out by 2018, but imported hard coal will play a considerable role, because of a large and quite modern power plant portfolio. Coal – hard coal and lignite – is one of the pillars to ensure security during the transition process and is acknowledged as helpful by federal states and the German government.

In response to the rising cost of the *Energiewende*, a reform of the *Erneuerbare-Energien-Gesetz* (EEG – German Renewable Energy Act) was made in 2014 and a ten-point energy agenda outlined by the new Federal Ministry of Economic Affairs and Energy to ensure that the *Energiewende* becomes a success story. Currently, the main challenges are to control costs by introducing limits to the expansion of onshore and offshore wind power and solar PV, as well as a move to auctioning in place of fixed feed-in tariffs. A major question is grid expansion, which is far behind schedule and quite expensive. Electricity market design is also under discussion, taking into account regional co-operation within the EU and broader international markets. Due to the EEG subsidy for renewable power and the decline in coal and CO_2-certificate prices, wholesale electricity prices have fallen to very low levels in Germany and while coal is still needed to guarantee security of supply, more and more coal-fired power plants can no longer operate profitably. This has led to closure notifications being submitted to the grid agency (*Bundesnetzagentur*) covering a total capacity of 12.2 GW. Nineteen (2.9 GW) of the sixty-nine notified power plants cannot be closed for supply security reasons, thus underlining the importance of coal-fired power plants.

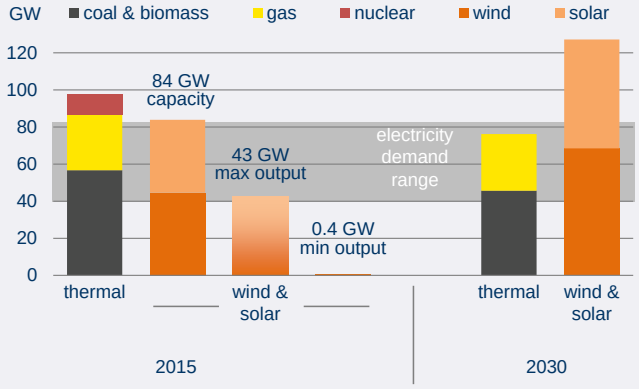
In the view of the coal industry, the transition process of the German power sector is a long-term task up to 2050. During these three to four decades, many steps have to be taken to maintain a secure and affordable power supply while reducing CO_2 emissions and introducing new, but currently unknown technologies. Comprehensive impact assessments as well as coherence with EU climate policy are indispensable when deciding on specific future climate actions at the national level.

Flexible and ever-available power generation capacity is becoming short and even shorter because of the phase out of nuclear power and the policy-driven closures of old hard coal-, lignite- and gas-fired power plants. The forecast to 2035 of the German network regulatory authority shows that the power system will be based on fully available coal- and gas-fired capacities, on the one hand, and fast-growing wind and solar PV capacities on the other hand.

As long as there is no large-scale storage solution for electricity, a combination of power systems will be needed to match the ups and downs of wind and solar PV generation and so balance supply and demand, because renewable power can be close to zero at times and low for several months.

Figure 14
Two systems, one task: security of supply

In 2015, German electricity demand was met by two systems: a reliable thermal one mainly based on coal and a new renewables one with a widely varying output. Under an approved plan for electricity network development, Scenario A (2017 to 2030) shows the continued growth of renewable energy sources.



Coal-fired power plants can manage this task and contribute to a successful energy transition.

Hard coal

In 2015, the German hard coal market amounted to 57.7 Mtce, of which 38.8 Mtce were used for power and heat generation, while 17.6 Mtce were consumed by the steel industry. The remaining 1.3 Mtce were sold to the residential heating market.

At 55.5 million tonnes, Germany was the EU's largest hard coal importer in 2015 (43.2 million tonnes steam coal and 12.3 million tonnes coking coal). The most important sources of imported coal were Russia and other CIS countries with a market share of 29.0%, followed by Colombia, the United States, Australia, Poland and South Africa.

The German government is phasing out – in a socially acceptable manner – all state aid for coal production by 2018. Hence, restructuring of the hard coal industry continues such that there are only two operating mines, namely the Prosper-Haniel colliery located in the Ruhr area and another deep mine near Ibbenbüren, both owned by RAG DEUTSCHE STEINKOHLE (RAG), formerly RUHRKOHLE AG. In 2015, RAG produced 6.7 million tonnes of saleable hard coal.

Employment figures continue to fall steadily. The number of employees in the hard coal mining sector decreased during 2015 by 20.4% from 12 104 to 9 640.

In 2007 and 2008, the formal separation of RAG's so-called "white" business was completed and the new EVONIK INDUSTRIES AG was created. In April 2013, EVONIK, with its commercial activities in the fields of chemicals, energy and property, was listed on the Frankfurt and Luxembourg stock exchanges.

The core business of RAG remains hard coal mining with certain related activities, especially in the fields of real estate in mining areas (RAG MONTAN IMMOBILIEN), coal trading (RAG VERKAUF) and mining consultancy (RAG MINING SOLUTIONS).

The private RAG Foundation, created in July 2007, is the owner of RAG and majority owner of EVONIK. Continuing liabilities after the final phase-out of hard coal mining (*i.e.* mine water management) will be financed by the proceeds of the Foundation. Using its assets, the Foundation will also promote education, science and culture in the mining regions.

Brown coal and lignite

Lignite supply in 2015 totalled 55.0 Mtce of predominantly domestic production (lignite imports were an insignificant 47 thousand tonnes). Exports of pulverised lignite and briquettes amounted to 1.4 Mtce.

Lignite production, which totalled 178.1 million tonnes (54.9 Mtce) in 2015, was centred in four mining areas, namely the Rhenish mining area around Cologne, Aachen and Mönchengladbach, the Lusatian mining area in south-eastern Brandenburg and north-eastern Saxony, the Central German mining area in the south-east of Saxony-Anhalt and in north-west Saxony as well as the Helmstedt mining area in Lower Saxony. In these four mining areas, lignite is exclusively extracted at opencast mines. In 2015, a total of 887.8 m^3 of overburden were moved during mining – an average overburden-to-coal ratio of 5.0 cubic metres per tonne.

Nearly 90% of lignite production is used for power generation (159.3 million tonnes in 2015), accounting for 23.9% of total power generation in Germany. As a part of the "Climate Action Programme 2020", on 1 July 2015, national political leaders, trade unions and the power plant operators jointly agreed that 2 700 MW of lignite-fired power generation capacity would be gradually transferred into a security standby reserve, starting in October 2016 and ending in October 2023. These plants will remain on standby for a period of four years after which they will be closed. This will result in a reduction in lignite demand of about 21 million tonnes by 2019, reducing annual emissions by 21 $MtCO_2$.

In the Rhineland, RWE POWER AG produced a total of 95.2 million tonnes of lignite in 2015 from its three opencast mines: Hambach, Garzweiler and Inden. Almost 90% of the lignite was consumed at the company's own power stations, whilst some 10.6 million tonnes were used for processed products. At the end of 2015, the Rhenish mining area had a total workforce of 9 410.

The lignite mining plan for the third resettlement section of the Garzweiler mine was officially approved on 29 October 2015. This will be the last resettlement as declared by the state government of North Rhine Westphalia in its guideline decision on the future of the Rhenish lignite-mining area and Garzweiler II on 5 July 2016. According to this guideline decision, the planned further resettlements for Garzweiler in the 2030s are to be dropped. The stipulations made mean a significant downsizing of the already approved extraction field at the Garzweiler opencast mine, along with the loss of several hundred million tonnes of lignite. However, it is to be most welcome that the government also confirmed the need for the Garzweiler mine in the period after 2030 without time limitation and for the Inden and Hambach opencast mines within their approved mining boundaries. This gives general planning security for the Rhenish lignite mining area, although the Garzweiler mining plan has had to be scaled down.

The generation capacity of RWE POWER consists of lignite-fired power plants with a total capacity of 10 296 MW (net). At Neurath, two new lignite-fired units with optimised plant technology (BoA 2/3) were commissioned in August 2012 with a gross capacity of 2 200 MW to replace several old plants. Lignite-fired power output in the Rhenish lignite mining area amounted to some 78.4 TWh in 2015. The preparation of approval licenses for a new 1 100 MW BoA*plus* unit to replace four existing 300 MW units commenced in late March 2015 – after the municipal and regional planning procedures had been completed. This was followed later in the year by early public consultation meetings. With an efficiency of over 45%, BoA*plus* with optimised plant technology will set a new world record for lignite-based power generation, emitting about 30% less CO_2 compared with the existing 300 MW units which will be decommissioned.

Five of RWE's 300 MW units will be transferred to the security standby reserve. This will result in a CO_2 emission reduction of about 15% in the Rhineland. In the following decade from 2020 to 2030, there will be additional options for reducing CO_2 emissions by increasing efficiency and reducing load at all plants in times when enough renewable power production is available. By around 2030, the Weisweiler power plant will be decommissioned, because of the scheduled depletion of the Inden opencast mine. Total CO_2 emissions from lignite will thereby be reduced by 40% to 50% in total as early as about 2030. The use of lignite in the Rhineland is therefore in line with the overall climate protection targets. Depending on the further expansion of renewable energy after 2030, the power plant capacity can be further reduced until electricity is supplied exclusively by modern BoA units, at least until the Garzweiler and Hambach opencast mines are depleted around the middle of the century.

In the Lusatian mining region, the Czech-owned LAUSITZ ENERGIE BERGBAU AG (branded LEAG) is the only producer following the acquisition of VATTENFALL's assets in October 2016. With total lignite output of 62.5 million tonnes in 2015, LEAG extracts lignite at Jänschwalde and Welzow-Süd in Brandenburg, as well as at Nochten and Reichwalde in Saxony. The Cottbus Nord mine closed in late 2015.

Lignite sales to power plants in Lusatia amounted to 58.8 million tonnes in 2015. LAUSITZ ENERGIE KRAFTWERKE AG (also branded LEAG) is the main operator of lignite-fired power plants in the mining area with a total gross capacity of 7 175 MW (net), including Jänschwalde, Schwarze Pumpe and Boxberg power plants. In 2015, the gross power output from these plants totalled 55.6 TWh. At the end of 2015, the Lusatian mining area had a total workforce of 8 316.

The Central German mining area around Leipzig yielded a total lignite output of 18.9 million tonnes in 2015. The most important company in this area is MITTELDEUTSCHE BRAUNKOHLENGESELLSCHAFT mbH (MIBRAG), owner of two opencast mines at Profen in Saxony Anhalt and Schleenhain in Saxony. The company supplies lignite to its two combined heat and power plants at Deuben and Wählitz with a total capacity of 123 MW as well as to the larger LEAG/ENBW Lippendorf and UNIPER Schkopau power stations. With a total capacity of 2 900 MW (net), these plants generated 19.0 TWh in 2015. At the end of 2015, the Central German mining area had a total workforce of 2 565.

In January 2014, MIBRAG acquired HELMSTEDTER REVIER GmbH, owner and operator of the Schöningen opencast lignite mine in the Helmstedt mining area and the adjacent 352 MW (net) Buschhaus power plant which generated 2.5 TWh in 2015. The mine was closed in late 2016, because the power plant was transferred to the security standby reserve, HELMSTEDTER REVIER had a total workforce of 453.

Another opencast mine in the Central German mining area is operated by ROMONTA at Amsdorf in Saxony-Anhalt. A third of a million tonnes of lignite were mined in 2015 and processed to extract raw lignite wax. The wax-free fuel is used for power generation at Amsdorf.

It is clear that the coal industry, with its capital investments, operating expenditures and payment of salaries, makes a very substantial contribution to the German economy. A study by the EEFA research institute analysed the employment created by the German lignite industry. According to this study, for each direct job in the lignite industry, another 2.5 jobs are created at companies who supply equipment and services.

Extraction of lignite from opencast mines changes the natural landscape, so land reclamation is an integral part of any mining project. Mining activities are only complete following the transformation of a former "industrial" opencast mine into a vibrant landscape. For more than one hundred years, nature has inspired landscape restoration projects in Germany, including indigenous flora and fauna. Projects that return land to productive use, often with a high recreational and agricultural value, are most typical.

Germany

Coal resources and reserves		
Total resources hard coal	Mt	82 959
Total resources lignite	Mt	72 700
Reserves hard coal	Mt	2 500
Reserves lignite	Mt	36 200

Primary energy production		2015
Total primary energy production (including nuclear power)	Mtce	172.0
Hard coal (saleable output)	Mt / Mtce	6.7 / 6.4
Lignite (saleable output)	Mt / Mtce	178.1 / 54.9

Saleable coal quality		
Hard coal net calorific value	kJ/kg	30 264
Lignite net calorific value	kJ/kg	7 800-11 500
Hard coal ash content	% a.r.	3.3-21.0
Lignite ash content	% a.r.	2.5-20.0
Hard coal moisture content	% a.r.	2.5-13.0
Lignite moisture content	% a.r.	40.0-61.5
Hard coal sulphur content	% a.r.	0.45-1.8
Lignite sulphur content	% a.r.	0.12-2.5

Coal imports / exports		2015
Hard coal imports	Mt	55.5
Hard coal exports	Mt	0.1

Primary energy consumption		2015
Total primary energy consumption	Mtce	453.6
Hard coal consumption	Mtce	58.6
Lignite consumption	Mtce	53.4

Power supply		2015
Total gross power generation	TWh	646.5
Net power imports (exports)	TWh	(51.8)
Total power consumption	TWh	594.7
Power generation from hard coal	TWh	117.7
Power generation from lignite	TWh	154.5
Hard coal power generation capacity	MW net	28 224
Lignite power generation capacity	MW net	21 002

Employment		2015
Direct in hard coal mining	thousand	9.640
Direct in lignite mining	thousand	15.428
Other hard coal-related*	thousand	15.700
Other lignite-related*	thousand	5.316

* e.g. *in power generation, equipment supply, services and R&D*

INSIGHT 8

Future technologies at coal power plants in Germany

BoA unit at Niederaussem power plant

New units at the RWE Niederaussem and Neurath power plants, with BoA (*Braunkohlekraftwerk mit optimierter Anlagentechnik* or optimised plant engineering) technology, are the most modern of their kind in the world, enabling 43% efficiency with significantly lower emissions and greater flexibility. In comparison with similar power plants, 9 million tonnes of CO_2 are saved each year.

With BoA technology, the power plants are well prepared for the future when energy markets will demand more flexible plants to balance the growing share of intermittent renewables such as wind and solar. In just fifteen minutes, each BoA unit can increase or decrease its output by more than 500 megawatts, offsetting the large fluctuations in the feed-in of renewable energy.

These technological improvements that protect the environment are possible through innovative components like optical fibres, precision instrumentation and digital control systems. The use of new high-strength steels enables operation at higher pressures and temperatures, while titanium is used for the first time to manufacture some of the largest steam turbine blades.

New projects using the patented WTA (*Wirbelschicht-Trocknung mit interner Abwärmenutzung*) lignite-drying technology offer additional efficiency gains to above 45%.

BoA units at Neurath power plant

Land restoration after lignite mining in Germany

INSIGHT 9

The Wolkenberg vineyard forms a part of the land restoration project at the Welzow Süd lignite mine

Renaturation of the Spree floodplains with Jänschwalde power plant and a wind farm in the distance

Moving to a river without moving house is what residents of the Lusatian villages of Neuliebel and Altliebel in Germany may think of when reflecting back in time. Between 2012 and 2014, the Weißer Schöps river was rerouted into a new riverbed as part of a huge land restoration project by Lausitz Energie Bergbau AG, allowing operations at the Reichwalde opencast lignite mine to swing into its northern field.

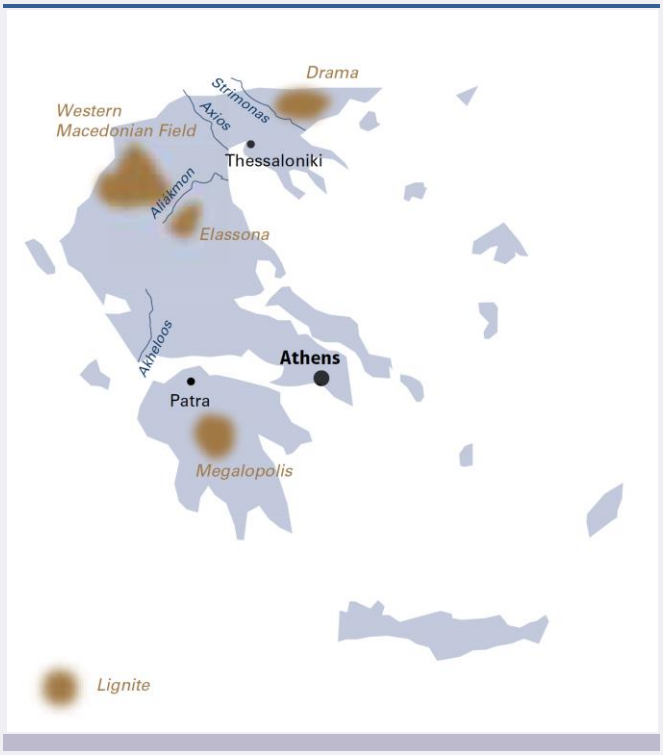
This project was more than just a compensation measure. The Weißer Schöps river was rerouted once before, over twenty years ago when it was channelled into a straight course with a concrete river bed which was not very welcoming to wildlife. The new rerouting offers the opportunities to prioritise nature's needs. By the summer of 2014, the new 5.5-kilometre riverbed was completed and an additional 2.5 kilometres of the original river course were restored. The riverbanks have been planted with black alders and willows. Elms, oaks, rowans, hazels and spindle trees grow on the surrounding higher ground. Ten bridges were constructed, the largest being 53 metres, as well as water fords and ecological passage ways. Water pipes, electricity and telecoms cables were re-laid and now run under the riverbed. Also, a great effort was made to create flood protection measures for people living close to the river, such as dykes and floodplains.

With the success of the project, the old river course was abandoned in October 2014 and the company has handed over the Weißer Schöps river to its new owner – the State Reservoir Administration of Saxony.

Greece

Accounting in 2015 for 23.4% of the country's primary energy supply of 33.7 Mtce, lignite is Greece's most important indigenous energy resource, although the country does have modest oil and gas reserves. At 0.2 Mtce, hard coal imports accounted for 0.6% of total primary energy supply in 2015. Oil accounted for 47.6% of the country's primary energy supply; Greece has a large refining industry which exports oil products. Consumption of imported natural gas increased significantly until the global economic crisis of 2008, but has since declined. Natural gas had an 11.3% share in primary energy supply in 2015. Electricity imports have grown strongly in recent years to reach 11.1 TWh in 2015.

Security of supply, low extraction costs and stable prices are important reasons why lignite will maintain a strong position in the Greek energy mix.



General data		2015
Population	million	10.9
GDP	€ billion	175.7

Lignite

Greece boasts lignite resources of 4.6 billion tonnes and 2.9 billion tonnes of economically workable reserves. The most important deposits are located in the north of the country at Ptolemais-Amynteon and Florina (1.5 billion tonnes) which contribute around 80% of production. Other deposits lie at Drama (900 million tonnes) and at Elassona (170 million tonnes), as well as in the south at Megalopolis (225 million tonnes). There is also a large peat deposit of about 4 billion cubic metres at Philippi in the northern part of Greece (Eastern Macedonia). Only 30% of the total lignite reserves have been extracted to date and remaining reserves are good for over forty years at current production rates.

Lignite deposits in Greece lie at an average depth of 150 to 200 metres and typically comprise layers of lignite alternating with layers of mineral.

The quality of Greek lignite can be characterised as follows: the lowest calorific values are in the areas of Megalopolis and Drama (3 770 to 5 020 kJ/kg) and Ptolemais-Amynteon (5 230 to 6 280 kJ/kg). In Florina and Elassona the calorific value lies between 7 540 and 9 630 kJ/kg. The ash content ranges from 15.1% (Ptolemais) to 19.0% (Elassona), and the water content from 41.0% (Elassona) to 57.9% (Megalopolis). The sulphur content is generally low.

Lignite is mined by the PUBLIC POWER CORPORATION (PPC) exclusively in opencast mines. This majority state-owned company is the largest lignite producer in Greece. It operates mines in Western Macedonia at Main Field, South Field, Kardia Field, Amynteon Field and Florina. PPC also has an opencast site in the Peloponnese region of southern Greece, in the Megalopolis Field. Bucket-wheel excavators, spreaders, tripper cars and conveyor belts are used to mine and transport lignite at these sites. PPC currently operates 48 bucket-wheel excavators and 22 spreaders, together with more than 300 kilometres of belt conveyors. Heavy trucks are used to remove the hard overburden formations found at some mines.

In 2015, lignite production amounted to 46.0 million tonnes, mostly mined by PPC, with 35.7 million tonnes extracted by the company at the West Macedonia Lignite Centre (WMLC) and 8.1 million tonnes at the Megalopolis Lignite Centre (MLC). The few privately operated mines in the West Macedonia area produced a total of 2.2 million tonnes of lignite.

In 2015, WMLC operations removed a total of 201.6 million cubic metres of overburden and interburden, corresponding to an overburden-interburden-to-lignite ratio of 5.6 cubic metres per tonne. At MLC, overburden plus interburden removal was 28.4 million cubic metres, corresponding to an

overburden-interburden-to-lignite ratio of 3.5:1. Although the overburden-interburden-to-lignite ratio has significantly increased in recent years, it is expected to remain stable in the future. The two mining areas, WMLC and MLC, and the head office in Athens, currently employ a total permanent workforce of about 3 439.

Environmental protection is one of the major parameters defining PPC's overall strategy and its daily mining activities. In the lignite mining areas around Ptolemais-Amynteon and Megalopolis, PPC has carried out site restoration projects to create farmland, tree plantations, woodland, sanctuaries for small animals and crop-testing areas.

At the end of 2015, PPC's power generation plants accounted for 49.2% of the country's total installed capacity of 22.0 GW and include lignite- and gas-fired plants, oil-fired plants on interconnected and autonomous islands, hydro plants, wind farms and solar PV plants. There are also seven private power plants with a total capacity of 2 626 MW. PPC owns six lignite-fired power plants comprising fourteen units with a total installed capacity of 4 337 MW. In 2015, lignite-fired power plants accounted for 46.1% of gross power generation of 48.0 TWh. The share of gas was 13.6%, oil 10.8%, hydro 11.7%, wind 9.5%, solar 7.8% and biofuels/waste 0.5%.

Lignite's future role in Greece will depend on changes taking place in the European energy sector, including the cost of CO_2 emission allowances. Nevertheless, low-cost domestic lignite is still competitive compared to imported energy sources such as natural gas. PPC faces important changes relating to the regulatory framework governing energy market liberalisation. Strategic priorities now include the replacement of old and inefficient plants and investment in renewable energy sources. The construction of a new 650 MW lignite-fired power plant at Ptolemaios (unit V) started in 2012 and is planned to be operational in 2018.

The ongoing recession has had a negative impact on other new investments and the government's "green" policy means that while renewables are displacing generation from lignite and natural gas, the cost of producing electricity has increased with consumers asked to pay €18/MWh in renewable subsidies.

Greece

Coal resources and reserves		
Resources lignite	Mt	4 600
Reserves lignite	Mt	2 900

Primary energy production		2015
Total primary energy production	Mtce	12.1
Lignite (saleable output)	Mt / Mtce	45.4 / 8.6

Saleable coal quality		
Lignite net calorific value	kJ/kg	3 770-9 630
Lignite ash content	% a.r.	15.1-19.0
Lignite moisture content	% a.r.	41.0-57.9
Lignite sulphur content	% a.r.	0.4-1.0

Coal imports / exports		2015
Hard coal imports	Mt	0.3

Primary energy consumption		2015
Total primary energy consumption	Mtce	33.7
Hard coal consumption	Mtce	0.2
Lignite consumption	Mtce	7.7

Power supply*		2015
Total gross power generation	TWh	48.0
Net power imports (exports)	TWh	9.6
Total power consumption	TWh	57.6
Power generation from lignite	TWh	22.1
Lignite power generation capacity	MW	4 337

Employment		2015
Direct in lignite mining	thousand	4.919
Other lignite-related**	thousand	2.438

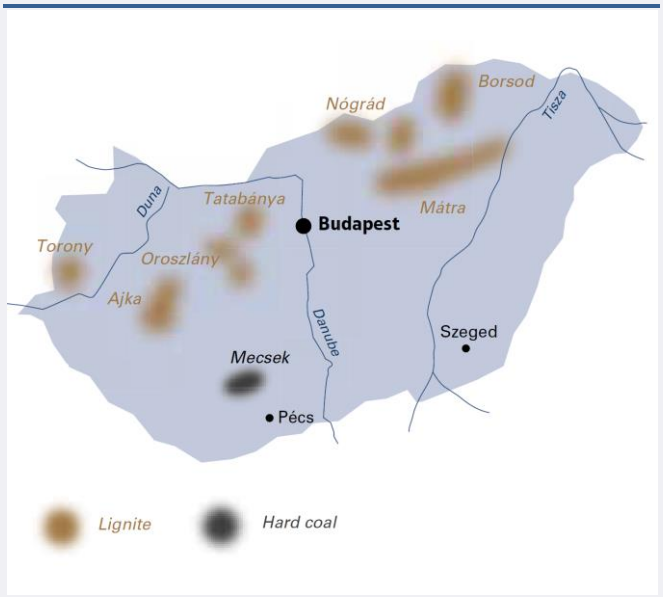
** excluding small islands with independent diesel generators*
**** e.g. *in power generation, equipment supply, services and R&D*

Hungary

Total conventional energy resources in Hungary comprise approximately 10.5 billion tonnes of coal, 2.4 billion cubic metres of natural gas (including unconventional) and 24 million tonnes of oil (including unconventional). Lignite and brown coal reserves account for about half of Hungary's total coal resources and are the most important indigenous sources of energy currently exploited.

Hungary's primary energy consumption in 2015 amounted to 34.2 Mtce. Natural gas had the biggest share in this total (31.3%), followed by oil (28.4%), nuclear energy (17.3%) and coal (9.6%). Hungary is 70% dependent on gas imports.

National electricity generation in 2015 amounted to 30.2 TWh, with an installed capacity totalling around 8.6 GW of which 7.3 GW are constantly available. A net 13.7 TWh of electricity was imported. Nuclear energy from Hungary's sole state-owned nuclear power plant at Paks accounted for 52.5% of domestic electricity production. The Paks power plant has four reactors with a total gross capacity of 2 000 MW. A permission procedure has recently been launched to extend the lifetimes of these units. In addition, there are plans to add new units to the existing nuclear plant in the near future. Gas-fired generation also makes a major contribution to national electricity supply: it had a share of 16.8% in 2015. Electricity produced from coal and lignite had a share of 19.5% in domestic electricity production in 2015, generated mainly by MÁTRAI ERÖMÜ ZRT. Renewable energy had a share of about 9.9%: biomass and wind being the main pillars followed by hydro, biogas and renewable municipal waste. Solar plays only a subordinate role. Hungary aims to increase the renewable energy share in gross final energy consumption to 14.65% by 2020.



General data		2015
Population	million	9.9
GDP	€ billion	109.7

Lignite

Hungary's lignite and brown coal resources are concentrated in the regions of Transdanubia and in northern and north-eastern Hungary. In 2015, Hungary's total lignite output was 9.3 million tonnes. About 91% of this was used for heat and power generation. The remaining lignite went to municipalities, households and other consumers.

There were three main lignite extraction sites in Hungary. About 6% of total production came from the Márkushegy underground mine belonging to VÉRTESI ERŐMŰ ZRT in western Hungary. The mine supplied coal to the associated Oroszlány power plant. At the end of 2014, mining operations ceased, but the power plant continued working using stockpiles at the mine and power plant, as well as lignite from other sources.

The major share of Hungary's lignite production is from the two opencast mines Visonta and Bükkábrány belonging to MÁTRAI ERŐMŰ ZRT. The company is located 90 kilometres north-east of Budapest. In 2015, MÁTRAI produced approximately 8.8 million tonnes of lignite and removed 65.2 million cubic metres of overburden. The lignite is used in the company-owned power plant at Visonta which comprises five lignite-fired units and two topping gas turbines. The power plant has a total capacity of 966 MW (2 x 100 MW units, 1 x 220 MW, 2 x 232 MW, two gas turbines of 2 x 33 MW and a 16 MW solar park).

Besides lignite and gas, biomass is co-fired to a fuel input level of around 10%. To supply the power plant with lignite, the company operates an opencast mine at Visonta adjacent to the power station and a second opencast mine at Bükkábrány, some 50 kilometres away. From there, lignite is transported by rail to the power plant. The approved mining fields of the two MÁTRAI opencast mines have about 0.5 billion tonnes of lignite reserves. The company is exploring further lignite deposits which could be developed at a later date.

Hard coal

At the end of 2014 there were some test mining operations in the Mecsek region. PANNON HŐERŐMŰ KFT will mine around 15 000 tonnes of sub-bituminous coal each year at the Pécs-Vasas opencast mine, supplying local households with affordable fuel.

Coal resources and reserves		
Resources hard coal	Mt	4 820
Resources lignite	Mt	5 725
Reserves hard coal	Mt	4 156
Reserves lignite	Mt	4 321

Primary energy production		2015
Total primary energy production	Mtce	14.5
Hard coal (saleable output)	Mt / Mtce	0.05 / -
Lignite (saleable output)	Mt / Mtce	9.3 / 2.2

Saleable coal quality		
Hard coal net calorific value	kJ/kg	18 333
Lignite net calorific value	kJ/kg	7 186
Lignite ash content	% a.r.	20.5
Lignite moisture content	% a.r.	47.4
Lignite sulphur content	% a.r.	1.3

Coal imports / exports		2015
Hard coal imports	Mt	1.3

Primary energy consumption		2015
Total primary energy consumption	Mtce	34.2
Hard coal consumption	Mtce	1.1
Lignite consumption	Mtce	2.2

Power supply		2015
Total gross power generation	TWh	30.2
Net power imports (exports)	TWh	13.7
Total power consumption	TWh	43.9
Power generation from lignite	TWh	5.8
Lignite power generation capacity	MW	929

Employment		2015
Direct in lignite-mining	thousand	1.655

INSIGHT 10

ICT networks enhance safety and efficiency in coal mines

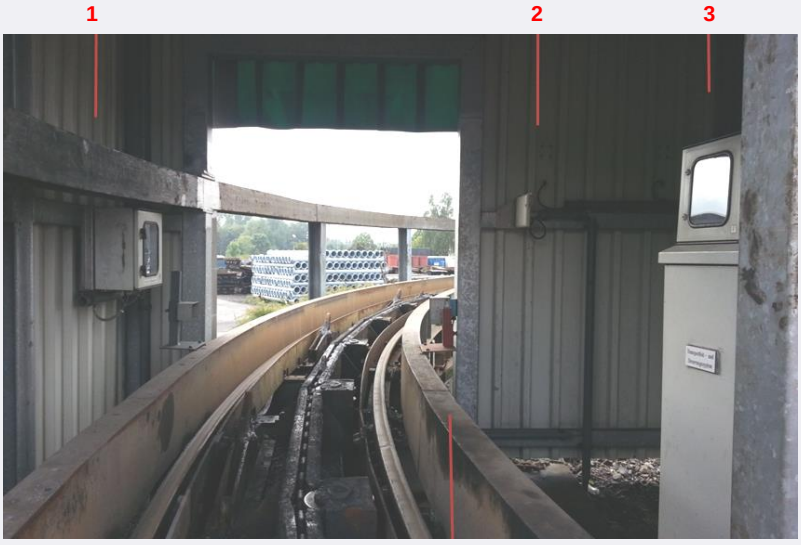
The OPTI-MINE project, funded by the EU Research Fund for Coal and Steel, demonstrated the use of information and communications technology (ICT) networks at five European coal mines and has led to considerable progress with optimising the mining process in the Czech Republic, Germany, Poland, Slovenia and Spain. Different wired and wireless applications were installed, integrating with new equipment as well as existing legacy systems. The universal common open network technology offers interoperability as well as high reliability.

In Germany, project partner RAG implemented network applications for personal communication and information, material logistics and longwall control in the Ibbenbüren anthracite mine. The information exchange between these applications enables optimisation of whole processes, not just of individual operations. Within the project, detailed experience was gained on how the systems should be designed and on how they can be operated successfully. Moreover, the desired operational capability of the technology was achieved and demonstrated.

The material logistics application is based on radio frequency identification (RFID) technology to identify and track material carts and on a barcode system for material information. Combining these two systems enables automatic material tracking by stationary RFID and barcode readers. All information about material, carts, trains and locos is available and displayed in the mine control room. In addition, the logistic data are available underground on mobile personal digital assistants.

The accuracy of material logistics, in terms of location, type and volume, was considerably enhanced. Furthermore, the near-real time material tracking from order to delivery assists both control room staff and underground personnel. Finally, cost reductions were achieved by optimising the use of transport carts, the agreed key performance indicators showing improvements of between 30% and 60%.

Ibbenbüren mine and power station in Germany

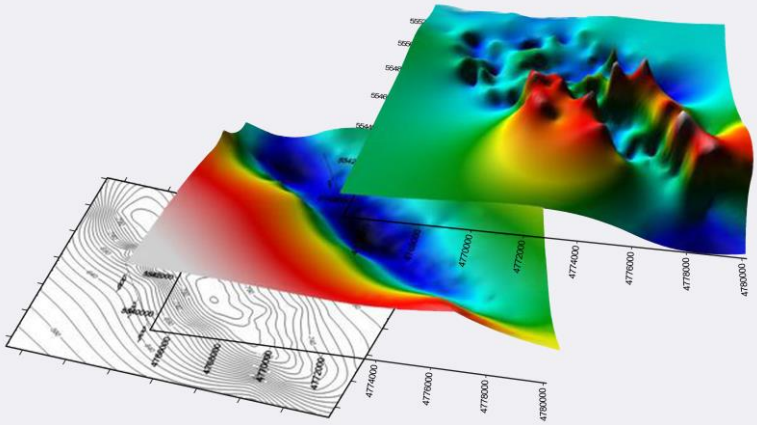


Rail-side equipment for monitoring material movements in the coal mine: 1. barcode scanner, 2. RFID antenna, 3. barcode camera, 4. light barrier

Rail cart with bar code and RFID tag

High-productivity coal mining in Poland

INSIGHT 11



Digital coal deposit modelling: heading and thickness of Seam 389

Bogdanka coal mine near Lublin, Poland

Underground roadways at Bogdanka coal mine

With an annual output of 9 million tonnes and a revenue of about half a billion euros, LW „Bogdanka" SA operates one of the largest underground hard coal mines in Europe. It is also one of the world's most efficient and most advanced hard coal mines with productivity levels that far exceed similar mines elsewhere. Through efficient work organisation and the application of innovative technologies and equipment, the mine has continually improved its productivity over the years.

For example, the company's Intelligent Mine project incorporates cutting-edge mining solutions and uses a decision-support system to help in the process of preparing a coal deposit for extraction. Together with the Polish Academy of Sciences, a deposit management system was designed, that includes digital modelling and mapping of underground workings. This, coupled with a computerised production schedule and automation strategy, has allowed Bogdanka mine to continue to prosper, supporting 5 000 direct jobs in the region near Lublin in eastern Poland.

Looking to the future, the Intelligent Mine project is preparing an object-based map of the underground infrastructure at Bogdanka mine, with a centralised database that will allow personnel to actively monitor assets via wireless communication and electronic notepads.

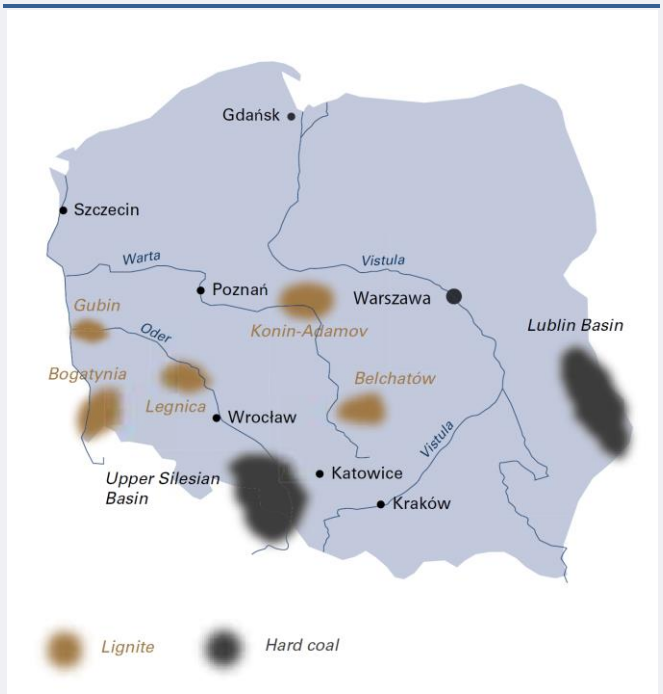
Poland

Hard coal and lignite are of strategic importance to Poland. Compared with other European Union member states, Poland has substantially larger reserves of hard coal and lignite and makes good use of these energy resources for electricity production. Hard coal reserves total 21.1 billion tonnes, located mostly in the Upper Silesian and Lublin coal basins, while lignite reserves amount to 1.4 billion tonnes with a further 22.1 billion tonnes of economic resources. Due to the relatively low potential of replacing coal with other energy sources, current forecasts show coal retaining its major role in the Polish energy mix for many years to come.

At 28.6%, Poland's energy import dependency is far below the EU average of 53.5%; only three member states enjoy a lower import dependency. The country's total primary energy supply in 2015 was dominated by coal (50.8%), with oil (24.5%) and gas (14.6%) also taking significant shares followed by wind (1.0%) and hydro (0.2%). In 2015, total gross power generation in Poland increased to 164.8 TWh. Imports and exports of electricity were largely in balance. Almost half of Polish electricity production, 79.9 TWh (48.4%), was generated at hard coal-fired power plants and 52.9 TWh (32.1%) at lignite-fired power plants. Power generated from wind grew to 11.0 TWh (6.7%), with solar accounting for just 0.04%. Biofuels and waste (6.1%), oil and gas (5.1%) and hydro (1.5%) were the other sources of electricity in 2015.

The average age of coal-fired power units in Poland is approximately forty years; only 10% of units are less than ten-years old. Lignite-fired units are amongst the newest ones and are being refurbished to meet EU environmental standards. Currently, state-controlled energy companies are building around 5 GW of new coal- and gas-fired capacity. With stricter emission standards and an ageing fleet, it is estimated that more than 4 GW of capacity will retire by 2017, rising to 12 GW by 2030. Poland has no nuclear power generation, but has plans to construct a nuclear power plant by 2024.

Further development of coal-based energy production in Poland is currently uncertain due to implementation of EU climate and energy policy. The main objective of this policy is to substantially reduce the emissions of greenhouse gases into the atmosphere. According to this *decarbonisation* policy, emissions should reduce by 40% in 2030 and by 80% in 2050, compared with 1990. If these targets are met, then it would be difficult to imagine Poland's energy mix or its mining industry in their present forms: more than 80% of electric power derives from mainly indigenous coal. If the objectives of EU climate and energy policy remain unchanged, then the share of fossil fuels (chiefly coal) in power generation will have to undergo a drastic reduction and this will have a direct impact on Polish coal producers.



General data		2015
Population	million	38.0
GDP	€ billion	427.7

Hard coal

Exploitable hard coal reserves are located in Upper Silesia and in the Lublin basin in the east of Poland, with the Upper Silesian coalfield accounting for 78.9% of the total. The coal reserves in this region contain some 400 coal seams with thicknesses of 0.8 metres to 3.0 metres. About half of these seams are economically workable. Some 71.6% of the reserves consist of steam coal, 27.0% are coking coal, while other coal types account for the remaining 1.4%. All hard coal is deep mined at an average working depth of approximately 600 metres. Mining is fully mechanised, with over 90% of coal produced by longwall systems.

Since the beginning of the 1990s, the Polish mining industry has been going through a process of transformation to reduce excess coal production capacity and adapt the industry to market conditions. Between 1989 and 2015, coal production decreased from 177.4 to 72.2 million tonnes. During the same period, employment in the Polish hard coal

mining industry decreased from 407 000 to 90 000 employees at the end of 2015.

Despite the significant reduction of mining capacity that took place over the last two decades, Poland remains the largest hard coal producer in Europe. In 2015, a total of 72.2 million tonnes of coal were produced at mines in Poland. The largest producer, KOMPANIA WĘGLOWA (KW), was re-organised in May 2016 when mines were transferred to POLSKA GRUPA GÓRNICZA (PGG – Polish Mining Group). Other leading coal-mining companies are JASTRZĘBSKA SPÓŁKA WĘGLOWA (JSW), KATOWICKI HOLDING WĘGLOWY (KHW) and LUBELSKI WĘGIEL „BOGDANKA" (LW „Bogdanka"). JSW is also the largest coke producer in the European Union, with an output of 4.2 million tonnes in 2015.

After a successful privatisation in 2009, a majority (65%) of the shares in LW „Bogdanka" were acquired in 2015 by ENEA, a Polish energy company providing around 9% of Poland's electricity. In 2011, Poland's largest coking coal producer, JSW, was also privatised and listed on the Warsaw Stock Exchange, although the state retains a majority shareholding. Separately, the Czech group EPH acquired Silesia mine from KW in 2010 and restarted coal production in 2012. In 2015, TAURON, another Polish energy company, agreed to buy the Brzeszcze mine in Southern Poland.

In 2015, steam coal accounted for the majority of hard coal output (59.2 million tonnes or 82%). Coking coal (12.9 million tonnes) is mainly extracted at mines belonging to JSW (hard coking and semi-soft) and KW (semi-soft).

Currently, the Polish hard coal mining industry is troubled by economic problems. As in the United States and elsewhere, the mining industry in Poland has been hit by very low prices on the international coal market, so low that some companies came close to bankruptcy. In Poland, the ongoing process of bringing the sector back to profitability is aimed at investment in modernisation, adjusting production volumes to match market demand, reducing costs and increasing productivity.

A new company has been established, POLSKA GRUPA GÓRNICZA (PGG – Polish Mining Group), that took over assets of KOMPANIA WĘGLOWA comprising eleven mines. Other mining companies are also working to reduce costs. The most unprofitable mines or units of integrated mines are being transferred to SPÓŁKA RESTRUKTURYZACII KOPALŃ (SRK – Mines Restructuring Company) for eventual closure. By November 2016, seven mines had been transferred.

These structural changes to the industry are already showing promise and the decision in November 2016 of the European Commission to allow state aid for the closure by 2018 of uncompetitive units allows the process to continue with the co-operation of investors and social partners.

Coal exporters and importers have an efficient infrastructure at their disposal, with cross-border rail links to neighbouring countries and to the Baltic Sea ports of Gdańsk, Szczecin-Świnoujście and Gdynia. Among these terminals, Gdańsk and Świnoujście are adapted to loading Capesize vessels. Hard coal exports from Poland totalled 9.0 million tonnes in 2015. More than half of the shipments were transported overland to neighbouring countries, mainly Germany, the Czech Republic and Austria, while the remaining volumes were transhipped via the Baltic ports. In 2015, WĘGLOKOKS, the largest coal exporting company in Poland, exported around 4.7 million tonnes, this being more than half of all Polish hard coal exports.

In 2011, coal imports peaked at 15.0 million tonnes, but have since fallen, mainly due to the economic slowdown. In 2015, coal imports were 8.2 million tonnes and were once again dominated by deliveries from Russia (60.3%). Smaller quantities came from Australia (coking coal), the Czech Republic, the United States and Colombia.

In order to improve the combustion and gasification of coal through the use of modern technologies, a Clean Coal Technology Centre (CCTW) has been established in Katowice, co-financed with EU funds and co-managed by the Central Mining Institute (GIG) and the Institute of Chemical Processing of Coal (IChPW). Poland also has a well-developed and technically advanced mining machinery and equipment industry. Together with the research institutes and technology centres KOMAG, EMAG and GIG, the machinery and equipment sector assists the Polish hard coal industry to continuously develop and modernise its activities.

Lignite

Poland exploits its lignite deposits exclusively at surface mines. Two of these operations are located in central Poland and a third one lies in the south-west of the country. In 2015, total lignite production was 63.1 million tonnes, 98.7% of which was used by mine-mouth power plants. Lignite-fired power stations generated 52.8 TWh of electricity, being one third of the total gross power generated in Poland.

The Bełchatów lignite basin, situated in the central part of Poland, incorporates two lignite fields: Bełchatów and Szczerców. In 2015, the Bełchatów mine produced 42.1 million tonnes of lignite or 66.7% of Poland's total lignite production. Mining this lignite required the removal of some 119.7 million cubic metres of overburden, which equates to an overburden-to-lignite ratio of 2.8 cubic metres per tonne. The depth of mining operations in the Bełchatów field is about 300 metres and the average calorific value of the fuel is 8 070 kJ/kg. Bełchatów mine is expected to remain in operation until 2040. The lignite output is supplied entirely to a mine-mouth power plant owned by PGE GiEK, with a capacity of 5 298 MW. This power plant generated 31.7 TWh in 2015, covering about 19% of domestic power consumption. Built between 1981 and 1988, it generates the cheapest electricity in Poland. A new 858 MW power unit was put into service in 2011.

In the Turoszów lignite basin, located in the south-west of Poland, the Turów mine has a production capacity of 15 million tonnes per year (4.1 Mtce). Reserves are estimated at 340 million tonnes (90.5 Mtce). In 2015, the mine produced over 7.3 million tonnes of lignite, or 11.6% of Poland's total lignite production, with a calorific value of 9 500 kJ/kg. Up to 96% of the lignite is supplied to the 1 498 MW PGE GiEK mine-mouth power station, one of the most modern in Poland. In 2015, some 51.1 million cubic metres of overburden were removed, giving a stripping ratio of 6.9 cubic metres per tonne. Turów mine is expected to be in operation until 2045.

The Bełchatów and Turów lignite mines, as well as the adjacent power plants, belong to the group of companies included in PGE Górnictwo i Energetyka Konwencjonalna (PGE GiEK) having its office in Bełchatów. The company is one of the six key companies belonging to the majority state-owned Polish utility POLSKA GRUPA ENERGETYCZNA (PGE).

The Pątnów-Adamów-Konin (PAK) lignite basin, located in central Poland between Warsaw and Poznań, has been producing lignite for over fifty years and now generates approximately 8.5% of Poland's electricity needs. There are two active mines: Konin and Adamów, belonging to ZESPÓŁ ELEKTROWNI PĄTNÓW-ADAMÓW-KONIN (ZE PAK Group) which was listed on the Warsaw stock exchange in October 2012. The mines and power plants are operated by the subsidiary companies PAK KWB Konin SA and PAK KWB Adamów SA.

PAK KWB Konin SA has a production capacity of 15 million tonnes per year (4.1 Mtce). Lignite is produced at three sites: Jóźwin IIB, Drzewce and Tomisławice. Total lignite production reached 9.4 million tonnes in 2015. It required the removal of 73.0 million cubic metres of overburden, a stripping ratio of 7.7 cubic metres per tonne. The working depth at these pits varies between 25 metres and 80 metres. The extracted fuel has an average calorific value of 9 220 kJ/kg. Lignite production from Konin mine is planned through to 2030. The mine supplies lignite to three mine-mouth power plants: Pątnów I with an installed capacity of 1 200 MW, Konin (583 MW) and Pątnów II (464 MW).

PAK KWB Adamów SA operates three opencast pits, namely Adamów, Władysławów and Koźmin. Adamów mine's overall production capacity is 5 million tonnes per year (1.3 Mtce). The depth of mining operations is between 44 metres and 70 metres. The deposits currently being exploited have workable reserves of 44 million tonnes (11.9 Mtce). In 2015, lignite production reached 4.3 million tonnes, all of which was supplied to the 600 MW Adamów mine-mouth power station. Some 31.8 million cubic metres of overburden were removed, which implies a stripping ratio of 7.4 cubic metres per tonne. PAK KWB Adamów SA is expected to remain in operation until 2017.

The average productivity at Poland's lignite mines was 6 500 tonnes per man-year in 2015 and employment totalled 9 574. Poland's lignite mining areas can maintain their annual production output at current levels of around 60 million tonnes and lignite is expected to play an important role in Poland's energy supply until at least 2030.

Coal resources and reserves*		
Total resources hard coal	Mt	56 220
Total resources lignite	Mt	23 516
Reserves hard coal	Mt	21 107
Reserves lignite	Mt	1 419

Primary energy production		2015
Total primary energy production	Mtce	96.6
Hard coal (saleable output)	Mt / Mtce	72.2 / 58.7
Lignite (saleable output)	Mt / Mtce	63.1 / 17.6

Saleable coal quality		
Hard coal net calorific value	kJ/kg	21 000-28 000
Lignite net calorific value	kJ/kg	7 400-10 300
Hard coal ash content	% a.r.	8.0-30.0
Lignite ash content	% a.r.	6.0-12.0
Hard coal moisture content	% a.r.	6.5-11.0
Lignite moisture content	% a.r.	50.0-60.0
Hard coal sulphur content	% a.r.	0.4-1.2
Lignite sulphur content	% a.r.	0.2-1.1

Coal imports / exports		2015
Hard coal imports	Mt	8.2
Hard coal exports	Mt	9.0

Primary energy consumption		2015
Total primary energy consumption	Mtce	135.1
Hard coal consumption	Mtce	51.2
Lignite consumption	Mtce	17.5

Power supply		2015
Total gross power generation	TWh	164.8
Net power imports (exports)	TWh	(0.3)
Total power consumption	TWh	164.5
Power generation from hard coal	TWh	79.9
Power generation from lignite	TWh	52.9
Hard coal power generation capacity	MW	19 348
Lignite power generation capacity	MW	9 290

Employment		2015
Direct in hard coal mining	thousand	89.924
Direct in lignite mining	thousand	9.574

** Source: Państwowy Instytut Geologiczny (Polish Geological Institute) as at 31 December 2015*

Advanced coal power in Poland

INSIGHT 12

New 858 MW unit at the Bełchatów power plant in Poland

Bełchatów power station is Europe's largest

The new 858 MW unit at the PGE Bełchatów power station, commissioned in 2011, is the biggest power generation unit ever built in the history of the Polish power industry and the most advanced unit in Poland. It achieves a net efficiency of 42% on lignite fuel and meets all EU environmental standards, including requirements on carbon capture and storage. The supercritical, once-through boiler technology used at Bełchatów allows greater operating flexibility and means that the unit can be used to maintain grid stability.

With a design life of thirty-five years, the €1.6 billion project included the construction of a 180-metre high cooling tower, being one of the tallest in Europe. The twelve older units at Bełchatów are also gradually being modernised, extending the operating lives of units 3-12 to beyond 2030 whilst improving efficiency and boosting the output of each unit from 370 MW to 380-390 MW.

Romania

Romania enjoys solid economic growth (3.7% in 2015) and a low unemployment rate (6.6%), thanks mainly to its manufacturing sector. The country has significant energy resources, including coal, natural gas and oil. In fact, over 80% of the country's primary energy supply is met by indigenous energy resources, with coal and lignite accounting for a 17.8% share, this being slightly above the EU average.

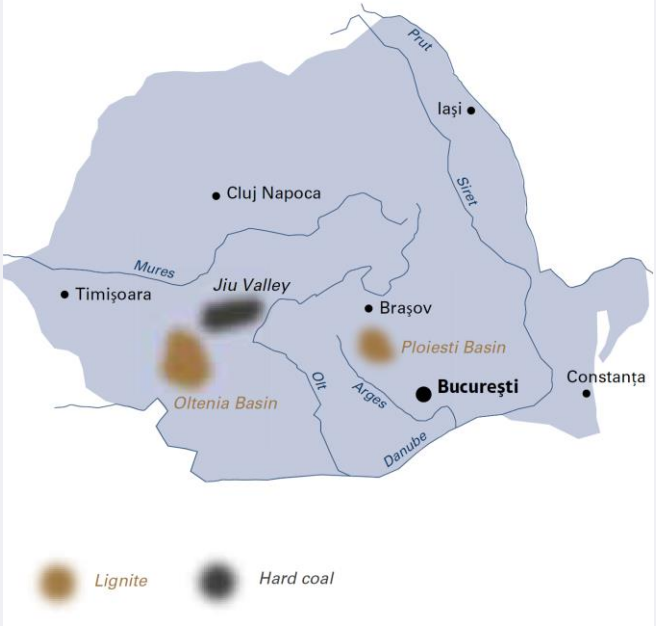
Total hard coal resources are estimated to be 2 446 million tonnes of which 252.5 million tonnes are commercially exploitable within the currently leased areas, although as little as 11 million tonnes might be economically recoverable. Proven reserves of lignite total 280 million tonnes, with a further 9 640 million tonnes of resources. Of these deposits, 95% are situated in the Oltenia mining basin where more than 80% can be surface mined. The remaining lignite deposits have low economic potential, explaining why extraction in most other areas has stopped.

The country has a long coal mining tradition, stretching back over 150 years. Romania's entire hard coal and lignite output is used for heat and power generation. At the end of 2015, the total licensed net capacity of installed generation was 20 419 MW: coal 4 925 MW (24.1% – 1 148 MW hard coal and 3 777 MW lignite), natural gas / fuel oil 3 571 MW (17.5%), hydro 6 339 MW (31.0%), nuclear 1 300 MW (6.4%) and renewables 4 284 MW (21.0%), mostly wind turbines. Peak demand is between 8 000 MW and 8 500 MW, indicating an overcapacity in generation and offering the opportunity for significant exports of electricity.

In 2015, gross electricity production in Romania was 65.6 TWh: 27.4% from hydro, 26.9% from coal, 17.8% from nuclear, 14.2% from renewables and 13.7% from natural gas.

Romania's first commercial nuclear reactor began operating in 1996 and a second CANDU reactor was commissioned in May 2007, thus completing two of the five reactors whose construction began in the 1980s and bringing the total gross capacity at the Cernavodă nuclear power plant to 1 413 MW. The completion of two further 720 MW reactors is planned by SOCIETATEA NATIONALA NUCLEARELECTRICA (SNN) in collaboration with CHINA NUCLEAR POWER ENGINEERING COMPANY (CNPEC) and Chinese investors who will take a majority ownership share.

Romania has established an energy policy framework which is in line with EU law, regulating the production of gas, coal, lignite, oil and nuclear energy, as well as power plant modernisation. The National Regulatory Authority for Energy (ANRE) is the responsible independent authority, reporting to the prime minister.



General data		2015
Population	million	19.9
GDP	€ billion	160.4

Hard coal

Back in January 2011, the National Hard Coal Company had seven underground coal mines (Lonea, Petrila, Livezeni, Vulcan, Paroşeni, Lupeni and Uricani). In September 2012, these mines were merged with hard coal-fired power plants to create the COMPLEXUL ENERGETIC HUNEDOARA (Hunedoara Energy Complex), a state-owned electricity and heat producer headquartered at Petroşani in the Southern Carpathians. The company accounts for approximately 3% of Romanian electricity generation, with a capacity of 1 225 MW and about 6 300 employees.

The main consumers of hard coal are the thermal power plants at Paroşeni (150 MW) and Mintia (1 075 MW). Indigenous hard coal production has the advantage of ensuring a long-term supply for these power plants. However, hard coal mining in Romania faces complex geological conditions, making profitable mining difficult.

The results of an economic analysis determined that the Petrila, Paroşeni and Uricani mines in the Jiu Valley did not have viable prospects and so they were included in a closure plan with Petrila to close in 2015, followed in 2017 by Paroşeni and Uricani. State aid, granted under case SA.33033 that was agreed by the European Commission in February 2012, is intended to facilitate these closures.

Meanwhile, the Hunedoara Energy Complex entered into insolvency in June 2016. Restructuring continues according to Council Decision 787/2010/EU with aid approved by European Commission decision C(2015) 2652.

Of the four mines scheduled to continue after 2018, only two will now continue production (Livezeni and Vulcan). Also, only 385 MW of the 1 225 MW currently installed capacity will remain: a 150 MW unit at Paroşeni TPP, modernised in 2005, and the 235 MW unit 3 at Mintia TPP, modernised in 2009. Nonetheless, this means that hard coal mining and hard coal-fired power generation capacity in Romania will continue after 2018, possibly under a Service of General Economic Interest (SGEI) exemption. Given this situation, it is encouraging that a potential investor has expressed its interest in developing and further modernising the Hunedoara Energy Complex.

Lignite

COMPLEXUL ENERGETIC OLTENIA (Oltenia Energy Complex) is Romania's largest producer of coal-based energy with an installed capacity of 4 337 MW. The company is responsible for 99% of national lignite production. Its mines and power plants provide direct jobs for 15 500 people.

In order to avoid impacts on neighbouring agricultural land, overburden is placed back in the excavated voids, which also helps reduce costs.

Lignite mining offers Romania a competitive advantage with the use of modern technologies and skilled labour to provide low-cost, base-load electricity. Reserves of lignite are concentrated in a relatively small area of 250 square kilometres where lignite is mined in twelve opencast pits licensed for another fifty years. These reserves provide a long-term, secure supply for the adjacent Turceni (1 650 MW) and Rovinari (1 320 MW) power plants. Further to the south lie the 300 MW Craiova and 630 MW Ișalnița power plants, also lignite-fired.

Oltenia Energy Complex and CHINA HUADIAN ENGINEERING COMPANY are currently negotiating to develop a new 600 MW lignite-fired unit that will replace some existing older units. A new company, HUADIAN OLTENIA ENERGY SA, will be registered with headquarters in Rovinari and employ 250 people. During the construction, over 4 000 jobs will be created and, with an annual lignite requirement of 4.6 million tonnes, the project is expected to secure 3 000 jobs.

Coal resources and reserves		
Total resources hard coal	Mt	2 446
Total resources lignite	Mt	9 920
Reserves hard coal	Mt	11
Reserves lignite	Mt	280

Primary energy production		2015
Total primary energy production	Mtce	37.7
Hard coal (saleable output)	Mt / Mtce	1.3 / 0.8
Lignite (saleable output)	Mt / Mtce	24.0 / 6.4

Saleable coal quality		
Hard coal net calorific value	kJ/kg	14 200-15 900
Lignite net calorific value	kJ/kg	7 200-8 200
Hard coal ash content	% a.r.	37-44
Lignite ash content	% a.r.	30-36
Hard coal moisture content	% a.r.	5.0-7.4
Lignite moisture content	% a.r.	40-43
Hard coal sulphur content	% a.r.	0.5-1.8
Lignite sulphur content	% a.r.	1.0-1.5

Coal imports / exports		2015
Coal imports	Mt	1.2
Coal exports	Mt	0.4

Primary energy consumption		2015
Total primary energy consumption	Mtce	45.5
Hard coal consumption	Mtce	1.3
Lignite consumption	Mtce	6.4

Power supply		2015
Total gross power generation	TWh	65.6
Net power imports (exports)	TWh	(6.7)
Total power consumption	TWh	58.9
Power generation from hard coal	TWh	1.8
Power generation from lignite	TWh	15.5
Hard coal power generation capacity	MW net	1 148
Lignite power generation capacity	MW net	3 777

Employment		2015
Direct in hard coal mining	thousand	4.442
Direct in lignite mining	thousand	10.600

Serbia

Serbia has substantial lignite resources which are easily accessible for exploitation. The country relies on lignite for 45% of its total primary energy supply. For electricity generation, the share of lignite was 65.1% in 2014 with hydro (34.1%) accounting for most of the remainder and natural gas making only a very small contribution (0.7%).

The state-owned Electric Power Industry of Serbia (ELEKTROPRIVREDA SRBIJE – EPS) is a vertically integrated enterprise with thirteen subsidiaries and three enterprises in Kosovo. Since June 1999, EPS has not been able to use or operate its power and mining facilities in Kosovo and Metohija.

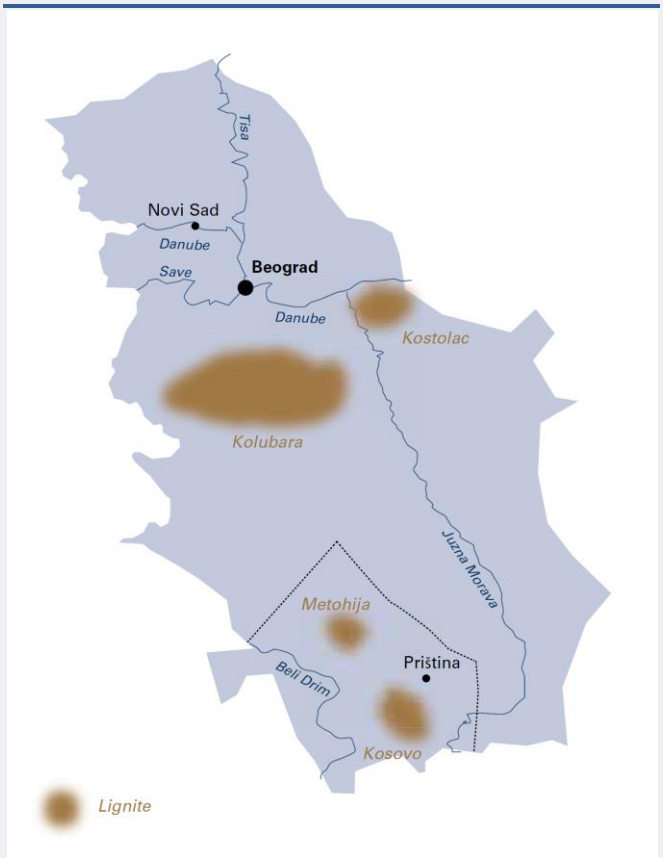
The main activity of EPS is electricity supply. The production, processing and transport of coal, electricity generation, electricity distribution and distribution system management, and steam and hot water production in cogeneration plants are all performed by EPS subsidiaries.

With a staff of 36 500 employees, including workers from Kosovo, and 3.5 million consumers, EPS is the largest enterprise in the country. The installed capacity of EPS power plants totals 7 322 MW net: lignite-fired power plants 4 032 MW; gas-and oil-fired combined heat and power plants 353 MW; and hydro power plants 2 937 MW.

In order to increase the efficiency of the power sector through market mechanisms, the Serbian government has been gradually introducing competition in the electricity sector since adoption of the Law on Energy in 2004. Opening of the electricity market will continue until it is fully opened in line with the country's ratification of the Energy Community Treaty.

EPS's mission is to secure electricity supply to all customers, under the most favourable market conditions, with the continuous upgrading of its services, improvements to environmental protection and greater welfare for the community. The company's vision is a socially responsible, market-oriented and profitable company, competitive on the European market, with a major impact in the region and recognised as a reliable partner among local and international companies.

In the first phase of a restructuring process adopted in November 2014, electricity generation and coal exploitation subsidiaries were integrated within EPS. All five existing distribution companies will be integrated into a single legal entity, while the EPS supply business remains in its existing form. The second phase saw EPS become a joint-stock company on 1 July 2016.



General data		2015
Population	million	7.1
GDP	€ billion	33.5

Lignite

Production of lignite, with an average calorific value of 7 850 kJ/kg, takes places at open-pit mines in the Kolubara and Kostolac mining basins. The Field C, Field D, Veliki Crljeni and Tamnava West Field open-pit mines in the Kolubara basin account for around 75% of Serbian lignite production and supply Kolubara thermal power plant (TPP), TPP Nikola Tesla A and B and TPP Morava. Lignite from open-pit mines in the Kostolac basin accounts for the remaining 25% of production which supplies TPP Kostolac A and B.

In 2015, EPS extracted 37.0 million tonnes of lignite in the Kolubara and Kostolac mining basins, with overburden-to-

production ratios of 2.5 cubic metres per tonne in Kolubara and 4.5 cubic metres per tonne in Kostolac.

In May 2014, heavy rains hit the Kolubara and Kostolac lignite basins, flooding mines and damaging associated facilities, including TPP Nikola Tesla and TPP Kostolac. The worst situation occurred in the Kolubara mining basin where an artificial lake of 20 square kilometres and 50 metres depth formed at the open-pit mine Tamnava West Field. Mining machinery and equipment was trapped underwater, affecting production for almost a year. The flood damage was estimated at €100 million and cut Serbian power generation by 40%, forcing the country to boost electricity and coal imports. The World Bank approved a $300 million loan (€230 million) for the flood mitigation. This loan supported Serbia in meeting the critical need for electricity generation and supply infrastructure. After many difficulties, EPS succeeded in recovering the flooded mines and repairing machinery and equipment.

In December 2014, a loan agreement was signed by the Serbian government with the Exim Bank of China for a $715.6 million project to build a new 350 MW unit (B3) at TPP Kostolac and to extend the annual capacity of Drmno mine from 9 million tonnes to 12 million tonnes of lignite. Construction is expected to take 58 months and the new unit should be operational by 2020. Unit B3 of TPP Kostolac will help stabilise Serbia's energy system while respecting European Union environmental standards.

After many years when available funds were invested only in the maintenance of production capacities, environmental protection has now become a business priority for EPS. This priority change is due to the Serbian government's policy to join the European Union. Almost one third of regulatory commitments and standards in environmental protection are in place, as well as the country's commitments under the Energy Community Treaty. EPS must harmonise the operation of its facilities with the EU *acquis* from 2015.

Serbia

Coal resources and reserves		
Resources hard coal	Mt	182
Resources lignite	Mt	5 295
Reserves hard coal	Mt	173
Reserves lignite	Mt	3 546

Primary energy production		2015
Total primary energy production	Mtce	15.5
Lignite (saleable output)	Mt / Mtce	37.0 / 10.1

Saleable coal quality		
Hard coal net calorific value	kJ/kg	12 000-18 000
Lignite net calorific value	kJ/kg	7 500-8 200
Hard coal ash content	% a.r.	12.0-35.0
Lignite ash content	% a.r.	14.0-18.0
Hard coal moisture content	% a.r.	45.0-54.0
Lignite moisture content	% a.r.	48.0-52.0
Hard coal sulphur content	% a.r.	0.9-3.8
Lignite sulphur content	% a.r.	0.4-0.9

Coal imports / exports		2015
Hard coal imports	Mt	0.4

Primary energy consumption		2015
Total primary energy consumption	Mtce	19.0
Hard coal consumption	Mtce	0.4
Lignite consumption	Mtce	8.5

Power supply		2015
Total gross power generation	TWh	35.7
Net power imports (exports)	TWh	1.0
Total power consumption	TWh	33.4
Power generation from lignite	TWh	25.1
Lignite power generation capacity	MW	4 032

Employment		2015
Direct in hard coal mining	thousand	1.600
Direct in lignite mining	thousand	12.360
Other lignite-related*	thousand	14.050

* e.g. *in power generation, equipment supply, services and R&D*

Slovakia

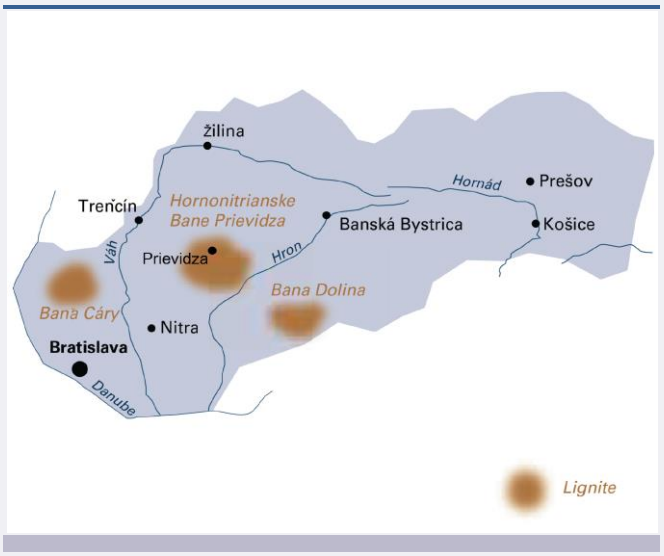
Although its energy resources are relatively large, the Slovak Republic does not have any significant exploitable fossil energy reserves. While the extraction of crude oil and natural gas accounts for a tiny share of overall energy supply, there is quite a large potential for gas storage. In recent years, there has been a public discussion on the exploitation of a uranium deposit at Kurišková.

At 57.6% in 2015, nuclear power has the largest share in electricity generation, followed by hydro (16.2%). Coal and lignite accounted for 11.8% of generation with gas (5.9%) and oil (1.0%) accounting for quite minor shares. The remaining 7.6% came from waste and renewable energy sources.

In the south-east of the country, the coal-fired Elektráreň Vojany I (EVO I) power plant's 4 x 110 MW boilers are designed to use imported semi-anthracitic hard coal from Ukraine. During 2014 and 2015, there were problems with this coal supply due to the conflict in Ukraine.

Two gas-fired power stations were taken off-line in 2013 due to their high operating costs in a low-price electricity market: the 350 MW Malženice CCGT commissioned in 2011 near the town of Trnava, 60 kilometres from Bratislava, and the 4 x 110 MW Vojany II or EVO II which was commissioned in 1973-74 as an oil-fired boiler plant, but converted to gas soon after. Problems with Russian gas supplies through Ukraine in 2012 and 2014 also influenced these decisions.

Overall, the energy mix under the national energy policy is well-balanced, with support for indigenous lignite and renewables. Given the high share of nuclear in its power generation mix, Slovakia's dependency on imported energy sources (60.9%) is only slightly above the EU average, despite an almost 100% dependency on imported oil and gas.



General data		2015
Population	million	5.4
GDP	€ billion	78.7

Lignite

Lignite resources are estimated at more than 400 million tonnes and a further 500 million tonnes should be available in the future. Exploitable lignite reserves, including brown coal, are calculated at 100 million tonnes. There is an insignificant hard coal deposit in the eastern part of Slovakia, which is not exploitable.

In 2015, 1.8 million tonnes of lignite were produced. Lignite is extracted by two companies at four underground mines located in the central and western parts of Slovakia. More than 90% of the total lignite production was used for electricity generation and district heating.

HORNONITRIANSKE BANE PRIEVIDZA (HBP) is a private coal mining company with a history of over one hundred years. Seated in the town of Prievidza, HBP extracts lignite at the Handlová and Nováky deposits located in the Horná Nitra region in central Slovakia. In the past, there were three independent collieries in operation here – Cigeľ, Handlová and Nováky – which were integrated into HBP. The depth of the worked coal seams ranges from 150 metres to 450 metres.

The lignite seams have a thickness of up to 20 metres and are mostly extracted using a long-wall top-coal caving (LTCC) method. Thin seams, of around 4 metres, are extracted with simple slicing long-walls. HBP also operates a mine rescue station which serves all mining districts in Slovakia. All lignite is supplied to the nearby 486 MW Nováky power plant (Elektráreň Nováky – ENO) belonging to the SLOVENSKÉ ELEKTRÁRNE COMPANY which is 50% owned by ENEL of Italy and 50% by EPH of the Czech Republic. Nearly one third of the lignite supplied in 2015 came from mines in the Nováky deposit.

BAŇA DOLINA COMPANY, located near the town of Veľký Krtíš, extracted lignite from the Modrý Kameň deposit in

southern Slovakia at a depth of 150 metres. Lignite was supplied to the ENO power station. The mine was closed in May 2015.

The BAŇA ČÁRY COMPANY near the town of Holíč in western Slovakia extracts around 170 thousand tonnes of lignite each year from a working depth of 180 metres. The mine plans to expand its annual production to reach 350 thousand to 500 thousand tonnes.

BANSKÁ MECHANIZÁCIA A ELEKTRIFIKÁCIA NOVÁKY (BME) is a modern mining equipment supplier owned by HBP that designs and manufactures high-pressure hydraulic roof supports suitable for LTCC mining. BME also produces other mining and construction machinery, as well as equipment for the transport sector.

Together with SLOVENSKÉ ELEKTRÁRNE and ENEL, HBP is actively engaged with modernising the coal-fired ENO power plant at Nováky. In May 2015, work began on a de-NOx system for two of the 110 MW blocks at the plant. HBP also has an interest in research and works with universities on various projects.

Slovakia

Coal resources and reserves		
Resources hard coal	Mt	8
Resources lignite	Mt	900
Reserves hard coal	Mt	0
Reserves lignite	Mt	100

Primary energy production		2015
Total primary energy production	Mtce	9.2
Lignite (saleable output)	Mt / Mtce	1.8 / 0.7

Saleable coal quality		
Lignite net calorific value	kJ/kg	10 450
Lignite ash content	% a.r.	<25
Lignite moisture content	% a.r.	<35
Lignite sulphur content	% a.r.	<2.5

Coal imports / exports		2015
Hard coal imports	Mt	3.7

Primary energy consumption		2015
Total primary energy consumption	Mtce	23.3
Lignite consumption	Mtce	0.7

Power supply		2015
Total gross power generation	TWh	26.3
Net power imports (exports)	TWh	2.4
Total power consumption	TWh	28.7
Power generation from hard coal	TWh	1.3
Power generation from lignite	TWh	1.8
Hard coal power generation capacity	MW	440
Lignite power generation capacity	MW	486

Employment		2015
Direct in lignite mining	thousand	2.190
Other lignite-related*	thousand	0.430

* e.g. *in power generation, equipment supply, services and R&D*

INSIGHT 13

Water treatment at coal mines

Water treatment at a former coal mine: an aeration cascade is used to oxidise mine water which encourages the dissolved iron to become solid and precipitate as iron ochre

The oxygenated mine water then passes through a lagoon system giving the solid iron ochre time to settle out of the water so that it can be collected

The MANAGER project, funded by the EU Research Fund for Coal and Steel, has the goal of mitigating environmental risks connected with mine water discharge through the development of innovative approaches and solutions. Mine water discharge can include heavy metals, metalloids, high salinity, suspended solids and radionuclides, all of which create challenges in respect of environmental protection and sustainable development over the long term.

The project presents a unique approach that combines many aspects involving risk-based assessments, forecasting, advanced treatment technologies, cost-benefit analyses and re-use concepts for the management of mine water discharge. Results have been summarised in guidelines to support the implementation of cost-effective solutions for the sustainable management of mine water discharge with reference to the EU Water Framework Directive. A number of different water treatment technologies have been developed within the project at the laboratory scale, with some technologies being taken forward for pilot-scale field trials.

Baffle curtains being installed in a settlement lagoon to create flow paths that reduce the short-circuiting of mine water

Mining thick coal seams in Slovenia

INSIGHT 14

View of Velenje coal mine and Šoštanj power plant in Slovenia

Underground monorail system at Velenje coal mine

View along the longwall face at Velenje coal mine

Velenje coal mine in Slovenia, with 140 years of mining tradition, developed a world-beating method for extracting thick coal seams. The unique Velenje mining method involves the top caving of hanging seams. The approach extends coal extraction to above the protected area of the face, allowing natural forces to break and crush the hanging seam. Thanks to the innovative mining equipment developed by the mining company itself, a lower number of wider longwall faces can be used.

Premogovnik Velenje continues to develop this method with the help of scientists and engineers, providing a technological edge for the European coal industry. The technology can be exported worldwide, with potential markets in Turkey, Slovakia, Bosnia and Herzegovina, Serbia, Macedonia and Montenegro, as well as in the Asia-Pacific region.

As a partner in projects funded by the EU Research Fund for Coal and Steel and the 7th Framework Programme, the company is promoting new technologies and scientific discoveries that will create a safer and better working environment in mines by predicting gas and rock outbursts and gas emissions from thick coal seams. Optimisation of mine ventilation and dewatering using the latest information and communications technologies will further improve safety and efficiency in coal mines.

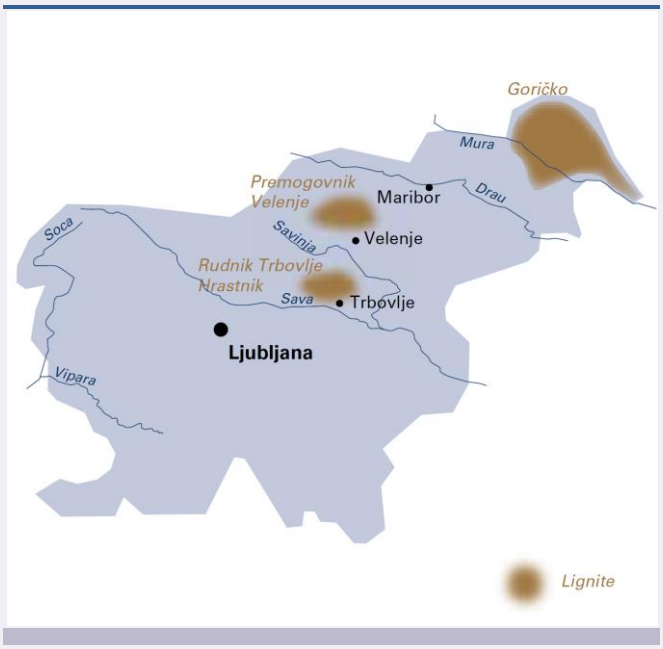
Slovenia

Since its foundation in 1991, the Republic of Slovenia has enjoyed steady economic growth and, between 2000 and 2008, the country's primary energy consumption increased by 40% to reach 11.1 Mtce. Since this peak, energy consumption has fallen by an average of 2.4% per year to 9.4 Mtce in 2015, reflecting slower economic growth.

Resources of lignite and brown coal in Slovenia are estimated to be 1 268 million tonnes, lying at Velenje (370 million tonnes), Zasavje (68 million tonnes) and Goričko (830 million tonnes), with mineable reserves accounting for 120 million tonnes. Approximately 45% of the country's primary energy requirements are met by imports. Indigenous lignite production accounted for approximately 12.7% of primary energy supply in 2015, with imported coal bringing coal's total share to 16.0%. Oil had a share of 34.8%, nuclear 22.4%, biofuels and waste 10.7%, natural gas 10.1%, hydro 5.0% and the remaining 0.9% came from renewable energy sources.

The key elements of Slovenian energy policy are closely aligned with the priorities of the European Union, such as a national plan for renewables and a plan to improve energy efficiency. In the long term, coal and lignite are expected to be partially replaced by renewable energy sources and coal imports will reduce. PREMOGOVNIK VELENJE will continue its lignite production until 2054 as lignite is needed in the currently well-balanced energy mix for security of supply reasons.

At 37.4% in 2015, nuclear power accounted for the largest share of electricity generation in Slovenia, followed by coal and lignite (29.0%) and hydro (27.1%). All other sources have rather small shares, totalling 6.4%.



General data		2015
Population	million	2.1
GDP	€ billion	38.6

Lignite

There is one lignite deposit exploited in Slovenia at Velenje, in the north of the country. The Rudnik Trbovlje Hrastnik (RTH) underground coal mine in the Zasavje region of central Slovenia stopped production in March 2014 leading also to the closure of the nearby Trbovlje (TET) power plant. More than 135 workers lost their jobs.

In 2015, Slovenia produced 3.2 million tonnes of lignite and brown coal. Velenje mine is the only coal mine in Slovenia and the major part of its lignite output is used at the nearby Šoštanj power plant. Operated by PREMOGOVNIK VELENJE and employing a unique mining method, it is one of the largest and most modern underground mines in Europe. The mine is located in the Šaleška dolina Valley and boasts one of the thickest-known lignite seams in the world, at more than 160 metres.

The company's long-term strategy is to operate the mine until 2054, as it is likely to remain Slovenia's only exploitable energy resource. The majority share of Velenje coal mine belongs to the state-owned HOLDING SLOVENSKE ELEKTRARNE (HSE) who also owns the 1 304 MW Šoštanj (TEŠ) thermal power plant as well as hydro power plants.

Imported coal is mostly used at the Termoelektrarna Toplarna Ljubljana (TE-TOL) heat and power plant in Ljubljana, covering over 90% of the capital's heat demand and 3% of its power demand.

Taking into consideration the increasing demand for electricity, the risks of energy import dependence and the abundant coal reserves at Velenje, HSE has commissioned a new 600 MW unit at Šoštanj thermal power plant. Unit 6 uses the best available techniques (BAT) to achieve an efficiency of more than 43% and deliver CO_2 emission reductions of 35%, as older units are replaced. The new unit ran for the first time in 2014 and was fully commissioned in May 2015 prior to receiving an operating permit in February

2016. Unit 6 will have a significant economic and environmental impact in Slovenia by ensuring lower electricity prices and lower emissions.

PREMOGOVNIK VELENJE is a technologically well-developed and strongly integrated company with a 140-year tradition in lignite mining. In 2007, the company received a special award from the Slovenian Chamber of Engineers for its innovative approach to mining engineering.

The "Velenje mining method" is performed by top caving hanging seams. The very first long-wall faces appeared in 1947, quickly followed by the extensive introduction of long-wall faces in 1952. The basic approach is to extend the lignite extraction area above the protected area at the face. The "Velenje mining method" is a registered trade mark and has been proven to be the most effective method for extracting thick coal seams. PREMOGOVNIK VELENJE continues to develop this method in order to gain even more improvements.

The knowledge and products of PREMOGOVNIK VELENJE offer excellent opportunities for co-operation with other countries, particularly where there is a need to introduce new technologies in Europe (*e.g.* in Bosnia and Herzegovina, Macedonia, Montenegro, Serbia, Slovakia and Turkey) and further away in the Asia-Pacific region.

PREMOGOVNIK VELENJE is also a partner in many projects funded by the EU Research Fund for Coal and Steel and the 7th Framework Programme, which aim to develop new technologies for predicting gas and rock outbursts and gas emissions from thick coal seams, for example. PREMOGOVNIK VELENJE also has a long history in underground coal gasification.

PREMOGOVNIK VELENJE has always aimed to prevent and eliminate any negative environmental impacts of its operations and has played an active role in land rehabilitation and air/water protection programmes in the Šaleška Valley. The company regularly monitors its environmental impacts, but the clearest testament to sustainable development is the tourist and sports resort that has been developed around the man-made lakes above the mine.

Slovenia

Coal resources and reserves		
Resources lignite	Mt	1 268
Reserves lignite	Mt	120

Primary energy production		2015
Total primary energy production	Mtce	4.8
Lignite (saleable output)	Mt / Mtce	3.2 / 1.2

Saleable coal quality		
Lignite net calorific value	kJ/kg	11 300
Lignite ash content	% a.r.	14
Lignite moisture content	% a.r.	36
Lignite sulphur content	% a.r.	1.4

Coal imports / exports		2015
Hard coal imports	Mt	0.4
Lignite imports	Mt	0.01

Primary energy consumption		2015
Total primary energy consumption	Mtce	9.4
Lignite consumption	Mtce	1.2

Power supply		2015
Total gross power generation	TWh	15.1
Net power imports (exports)	TWh	(0.1)
Total power consumption	TWh	15.0
Power generation from lignite	TWh	4.0
Lignite power generation capacity	MW	1 304

Employment		2015
Direct in lignite mining	thousand	1.274
Other lignite-related	thousand	2.467

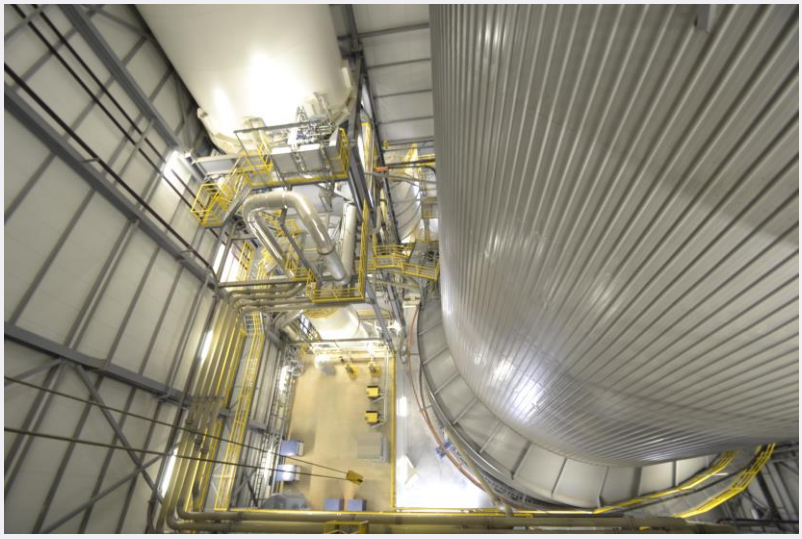
* e.g. *in power generation, equipment supply, services and R&D*

INSIGHT 15

Coal power saves fuel and reduces emissions in Slovenia

Alstom was responsible for the construction of the new 600 MW Unit 6 at Šoštanj power plant in Slovenia (seen here on the right)

Flue gas desulphurisation equipment at Šoštanj power plant



A state-of-the-art 600 MW unit at Šoštanj power plant has replaced four old units. The lignite-fired TEŠ Unit 6 achieves an efficiency of 43%, thus reducing fuel consumption and emissions by around 30%. Its environmental performance meets and exceeds all anticipated standards under EU law. Moreover, the new unit has been designed to be “carbon capture ready” in readiness for the next step towards a low-emission future.

TEŠ Unit 6 extends the life of the Premogovnik Velenje underground mine in the Šalek valley from 2025 to 2054, as well as securing two hundred direct jobs at the power plant. The project was financed by loans on commercial terms from the European Investment Bank and the European Bank for Reconstruction and Development, as well as from private banks and with further capital from the plant’s owner. By 2020, Slovenia will need an additional 2.5 TWh of electricity generation and while renewable energy sources will meet some of this growth, TEŠ Unit 6 means demand will be met with secure and affordable electricity supplies from indigenous coal.

Carbon sinks through new forest planting in Spain

INSIGHT 16

Restoration by Endesa of an opencast coal mine site at Puertollano in Spain

Overview of the Encasur opencast coal mine at Puertollano in Spain

Over 1.2 million trees have been planted in Spain by the power company Endesa. Land recultivation following mining involves planting a wide variety of tree species and covers approximately 5 200 hectares in the coal mining areas around Puertollano, As Pontes, Peñarroya, Utrillas, Cercs and in Andorra.

Endesa's current coal mining activity is carried out in the Puertollano Mining Centre (Emma mine). Coal production of 200 to 600 thousand tonnes represents an important share of Spain's total national coal production. In 2014, a mine expansion plan was approved by environmental regulators, allowing operations for another thirty years. Coal from the mine is delivered to nearby power plants.

A study of forest ecosystems performed in the Catalan Pre-Pyrenees has allowed Endesa to refine its forest planting project. In this area, cypress trees were originally planted to retain soil. However, it is now considered that native tree species, together with bushes and plants present in the local region, would be better able to adapt to the environment. The project has the support of local stakeholders, including environmental associations which collaborate in the area of the Caza de Boumort national nature reserve.

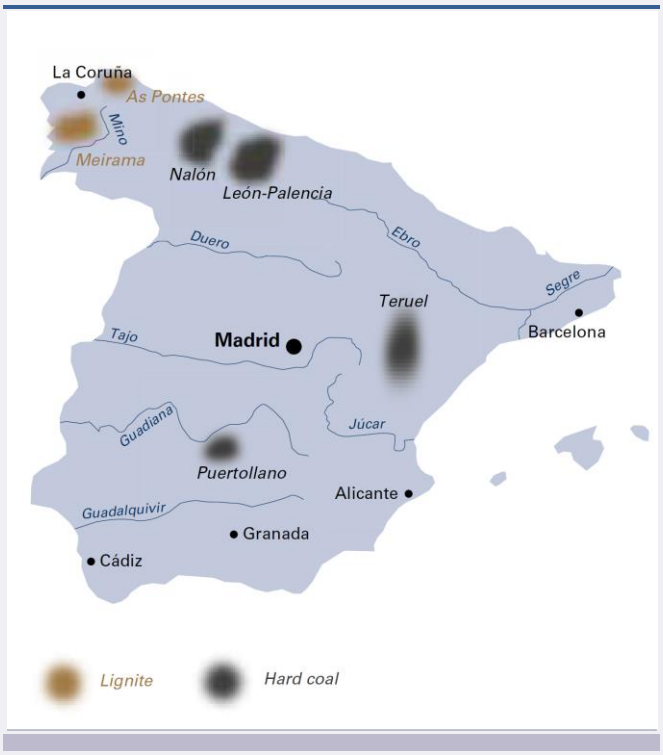
Spain

The economic crisis has been particularly harsh in Spain and the government has been forced to introduce many austerity measures which have had a direct impact on the coal industry. At the same time, the country is highly dependent on imported oil and natural gas. It has an overall import dependence of 72.9%, well above the EU average of 53.5%. This places a burden on the Spanish economy by increasing its trade deficit and foreign indebtedness. Spain's primary energy production was 48.7 Mtce in 2015.

The only significant indigenous energy resource that Spain possesses is coal, totalling 4 500 million tonnes, including accessible reserves of 1 156 million tonnes. In 2015, coal met 10.9% of the country's energy demand through a combination of 3.0 million tonnes of domestic production and 19.0 million tonnes of imported coal. Oil, natural gas and nuclear are the other principal energy sources, with wind and solar providing 6.2% of total primary energy supply.

Electricity supplied in 2015 came mainly from conventional sources: nuclear power with 57.3 TWh gross (20.4%), followed by hard coal 52.9 TWh (18.9%), natural gas 51.3 TWh (18.3%) and hydro 31.2 TWh (11.1%). Solar and wind have grown strongly since 2000 to 63.2 TWh (22.5%) in 2015, while biomass and waste accounted for the remaining 2.7%.

Spain has one of the most dynamic electricity markets in Europe. There is fierce competition between coal-fired and natural gas-fired power generation for the market that remains after nuclear, hydro and must-run renewables have supplied. Hydro output can vary significantly from one year to the next and, with a system capacity margin of over 100%, there is plenty of room for switching between energy sources.



General data		2015
Population	million	46.4
GDP	€ billion	1 075.6

Hard coal

Hard coal deposits in the north-west Principality of Asturias are located in the Nalón Valley and are of a low calorific value. Nevertheless, in the past they were Spain's biggest source of coal. Today, high extraction costs have led to the gradual closure of mines. In 2015, 1.2 million tonnes were produced in Asturias. The deposits at León-Palencia are also of a low calorific value, although some anthracite seams are present. Coal in the Astur-Leonesa basin north of La Robla in the region of Castilla y León, where anthracite is mined by HULLERA VASCO-LEONESA and CARBONAR, has a high calorific value (5 500 kcal/kg or 23 000 kJ/kg) and low volatile matter, making its extraction more economic. Hard coal mines located in the region, especially in the León and Palencia provinces, produced 363 thousand tonnes in 2015.

The hard coal basin at Puertollano in the Ciudad Real province south of Madrid has reserves for several decades. Mining is very important at Puertollano with an output of 169 thousand tonnes in 2015.

The province of Teruel in the Aragon region boasts the largest sub-bituminous hard coal reserves in Spain, of which some 200 million tonnes can be extracted by opencast mining. The high sulphur content of this coal (4% to 6%) made it less attractive for use at power plants in the past, before plants were fitted with flue gas desulphurisation. 1.3 million tonnes of coal were produced in 2015.

In all, there are thirteen active coal mining companies operating in Spain: BIERZO ALTO, CARBONES ARLANZA, CARBONAR, CARBONES DEL PUERTO, CÍA GRAL MINERA DE TERUEL, CÍA ASTUR LEONESA, ENDESA, ENCASUR, HIJOS DE BALDOMERO GARCÍA, HULLERA VASCO-LEONESA, MINERA CATALANO ARAGONESA, UNIÓN MINERA DEL NORTE and HULLERA DEL NORTE.

On energy policy developments, the "Coal Plan for the years 2013 to 2018" was agreed in 2014. The Spanish government committed itself to find a mechanism to facilitate indigenous coal consumption after expiry on 31 December 2014 of the Royal Decree 134/2010 which had been approved by the European Commission in 2010 (N178/2010). Although this decree was challenged in the courts, the decision of the European Court of Justice on 3 December 2014 was favourable for coal producers (Castelnou vs. Commission). CARBUNIÓN (the Spanish National Coal Mining Employers' Association) participated as a co-defendant while Castelnou is an EDF Group company that operates two CCGTs on the Spanish Mediterranean. It had argued that its CCGTs were idle because of the Royal Decree's support for coal. This argument was annulled by all the evidence presented, both by the Commission and the Spanish government.

In summary, the European Court of Justice held that the Decree was fair because the public interest is more important than that of a private company. The arguments used and the decision taken in this case set an important precedent for future decisions of the European Court of Justice that may affect coal producers in other EU member states.

In May 2016, the European Commission announced that the Spanish government's plan of October 2013 to grant €2.13 billion for the orderly closure of twenty-six coal mines by 2018 was in line with EU rules on state aid, in particular Council Decision 2010/787/EU (case SA.34332).

Lignite

At the end of 2007, Spain's last lignite mines located in Galicia on the north-west side of the Iberian Peninsula were closed. Lignite reserves of 210 million tonnes remain.

The FUNDACIÓN CIUDAD DE LA ENERGÍA (CIUDEN) is the leading public developer of CO_2 capture, transport and geological storage in Spain. Its development centre for carbon capture technologies in León is testing injection and monitoring techniques for supercritical CO_2 injection in underground strata at Hontomín. CIUDEN has links with other international research centres and currently has contracts with the European Commission under the 7th Framework Programme.

Spain

Coal resources and reserves		
Total resources hard coal	Mt	4 500
Total resources lignite	Mt	210
Reserves hard coal	Mt	1 156
Reserves lignite	Mt	210

Primary energy production		2015
Total primary energy production	Mtce	48.7
Hard coal (saleable output)	Mt / Mtce	3.0 / 1.8

Saleable coal quality		
Hard coal net calorific value	kJ/kg	18 231
Hard coal ash content	% a.r.	34.6
Hard coal moisture content	% a.r.	13.2
Hard coal sulphur content	% a.r.	2.5

Coal imports / exports		2015
Hard coal imports	Mt	19.0

Primary energy consumption		2015
Total primary energy consumption	Mtce	170.6
Hard coal consumption	Mtce	18.5

Power supply		2015
Total gross power generation	TWh	280.5
Net power imports (exports)	TWh	(0.1)
Total power consumption	TWh	280.4
Power generation from hard coal	TWh	54.6
Hard coal power generation capacity	MW	11 906

Employment		2015
Direct in hard coal mining	thousand	3.324

Turkey

Turkey is a large country with a population surpassed only by Germany in the European Union. GDP growth was around 7.3% in 2015 and averaged 5.5% from 2000 to 2015. The Ministry of Energy and Natural Resources (MENR) is responsible for the preparation and implementation of energy policies, plans and programmes in co-ordination with its affiliated institutions and other public and private entities. It has statutory duties covering coal mines, power stations and the electricity grid.

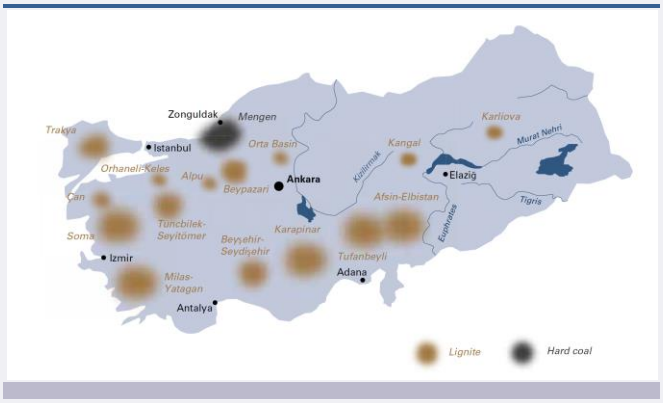
Total primary energy supply was 185.3 Mtce in 2015. With *per-capita* energy use in Turkey still comparatively low at 1.7 tonnes of oil equivalent (compared with an EU-average of 3.2 toe), energy demand is expected to grow rapidly due to the growing economy and the demographic impact of a young population.

Turkey's indigenous energy resources consist almost exclusively of lignite and small amounts of hard coal. Together with coal imports, coal and lignite met 27.3% of total primary energy supply. At 30.2%, natural gas has the highest share in the energy mix, 99% imported. Oil accounted for 30.1% of energy supply in 2015, 89% imported. Overall, the country had an import dependency of 80% in 2015.

Turkey has large coal resources, in contrast to its limited oil and gas resources. The Turkish coal sector produced 1.5 million tonnes of hard coal and 41.8 million tonnes of lignite in 2015, this being 41.8% of total primary energy production and was used mostly for power generation. Coal imports have doubled since 2005 and stood at 31.5 million tonnes in 2015, again used mostly for power generation.

In total, Turkish coal-fired power plants had an installed capacity of approximately 15 200 MW at the end of 2015 (20.6% of total capacity). Hard coal-fired power plant installed capacity was 6 500 MW (8.8%) and the installed capacity using domestic lignite was 8 700 MW (11.8%). Turkey has embarked on an ambitious programme to build new power plants, some with the latest supercritical and circulating fluidised bed boiler technologies to burn mainly lignite and imported coal: Izdemir Enerji (350 MW), ICDAS Elektrik (600 MW) and Atlas Enerji (600 MW) started operations in 2014; Tufanbeyli Enerjisa (300 MW), Silopi (270 MW) and Bolu-Göynük 1 (135 MW) started operation in 2015; and Bolu-Göynük 2 (135 MW) started operation in 2016. All new power plants must comply with the EU Large Combustion Plants Directive (2001/80/EC).

Another 7 000 MW of coal-fired power plants are under construction, this being the largest such construction programme outside China and India. In 2015 alone, the Turkish government approved the construction of three new coal-fired power plants, that will increase capacity by 2 480 MW: Filiz Enerji was given approval for a 1 200 MW coal plant in Canakkale on the Aegean coast; Atakaş Energy received approval for a 680 MW power plant at İskenderun on the Mediterranean coast; and IC İçtaş Energy has permission for a 600 MW power plant near the city of Adana in the south of the country. In 2016, Tosyalı Electricity received approval for another 1 200 MW power plant at İskenderun.



General data		2015
Population	million	77.7
GDP	€ billion	647.7

In 2015, 72.1 TWh (27.8%) of Turkey's gross electricity production of 259.7 TWh was generated from hard coal (15.2%) and lignite (12.5%). Of the remainder, 38.6% was provided by natural gas, 25.8% by hydropower, 0.8% by oil and the remaining 7.0% from waste, wind, geothermal and other renewable energy sources, including an insignificant quantity from solar. Turkey, through its Vision 2023 strategy that marks the 100th anniversary of the Republic, aims to increase its domestic electricity production by constructing new lignite-fired power plants and raising the shares of wind and geothermal power. Two new nuclear power plants are under construction with a combined capacity of 9 200 MW.

Turkish lignite production has doubled over the last ten years while hard coal production remained insignificant and heavily subsidised. Coal is extracted by three state-owned enterprises – TÜRKIYE KÖMÜR İŞLETMELERI (TKİ – Turkish Coal Enterprises), ELEKTRIK ÜRETIM (EÜAŞ – Electricity Generation Company) and TÜRKIYE TAŞKÖMÜRÜ KURUMU (TTK – Turkish Hard Coal Enterprises) – and a growing number of private companies, some under contract to the state-owned companies.

Hard coal

Turkey's main hard coal deposits are located in the Zonguldak basin, between Ereğli and Amasra on the Black Sea coast in north-western Turkey. Hard coal resources in the basin are estimated at some 1.3 billion tonnes. The calorific value of hard coal reserves varies between 6 200 and 7 200 kcal/kg. This coal basin is the only region in Turkey where hard coal is extracted and it has a very complex geological structure which makes mechanised coal production almost impossible and requires labour-intensive coal production methods.

The state-owned TTK has a *de-facto* monopoly in the production, processing and distribution of hard coal, although there are no legal restrictions on private sector involvement. TTK operates five deep mines in the Zonguldak coal basin and produced approximately 1.5 million tonnes of saleable coal in 2015, supplying the 300 MW Catalağzı thermal power plant owned by Bereket Energy as well as other customers.

In 2015, Turkey also imported 31.5 million tonnes of hard coal for thermal power plants, steel production, industry and domestic heating purposes – one third from Russia, one third from Colombia and smaller quantities from South Africa (15%), Australia (8%) and elsewhere. Coal imports to Turkey are expected to continue to increase in the future.

At Silopi near the Iraqi border, the third unit of Ciner Group's 405 MW asphaltite-fired power plant was commissioned in 2015 by China National Machinery Engineering Corporation.

Lignite

Lignite is Turkey's most important indigenous energy resource, with proven reserves of 15.6 billion tonnes. Deposits are spread across the country, the most important one being the Afşin-Elbistan lignite basin of south-eastern Anatolia, near the city of Maraş where the economic reserves are estimated at around 7 billion tonnes. The Soma basin is the second-largest lignite mining area in Turkey. Other exploited deposits are located in: Muğla province with the Yeniköy lignite facility at Ören (Milas) and the South Aegean lignite facility at Yatağan; Kütahya province with the Seyitömer lignite facility at Seyitömer and the Tunçbilek mining centre at Tavşanlı; Çanakkale province with the Çan lignite facility; Bursa province with the Bursa lignite facility at Orhaneli; and Konya province with the Ilgın lignite facility. The quality of Turkish lignite is generally very poor and only around 5.1% of existing reserves have a heat content of more than 3 000 kcal/kg (12 500 kJ/kg). A project to explore new deposits was initiated in 2005. By 2015, 7.38 billion tonnes of new reserves had been proven.

The scale of Turkey's surface mining operations allows lignite to be produced at a relatively low cost, making it competitive with imported energy resources. In 2015, lignite output totalled 41.8 million tonnes, far below the 59.6 million tonnes of 2014. Most of Turkey's lignite production is from opencast mines. However, there are some underground mining activities, mainly in the Soma, Tunçbilek and Beypazarı basins. The drop in production in 2015 was due to the tragic accident at Soma mine in May 2014 and the subsequent safety measures taken across the mining industry.

TKİ is working in collaboration with TÜBİTAK, the Turkish Scientific and Technical Research Council, and other international partners on lignite drying and gasification research projects, some partly supported by the EU.

Coal resources and reserves		
Total resources hard coal	Mt	1 300
Total resources lignite	Mt	16 000
Reserves hard coal	Mt	380
Reserves lignite	Mt	15 600

Primary energy production		2015
Total primary energy production	Mtce	45.9
Hard coal (saleable output)	Mt / Mtce	1.5 / 1.2
Lignite (saleable output)	Mt / Mtce	41.8 / 14.0

Saleable coal quality		
Hard coal net calorific value	kJ/kg	26 000-30 000
Lignite net calorific value	kJ/kg	8 665
Hard coal ash content	% a.r.	10.0-15.0
Lignite ash content	% a.r.	11.0-46.0
Hard coal moisture content	% a.r.	4.0-14.0
Lignite moisture content	% a.r.	6.0-55.0
Hard coal sulphur content	% a.r.	0.8-1.0
Lignite sulphur content	% a.r.	0.2-5.0

Coal imports / exports		2015
Hard coal imports	Mt	31.5

Primary energy consumption		2015
Total primary energy consumption	Mtce	185.3
Hard coal consumption	Mtce	33.2
Lignite consumption	Mtce	16.9

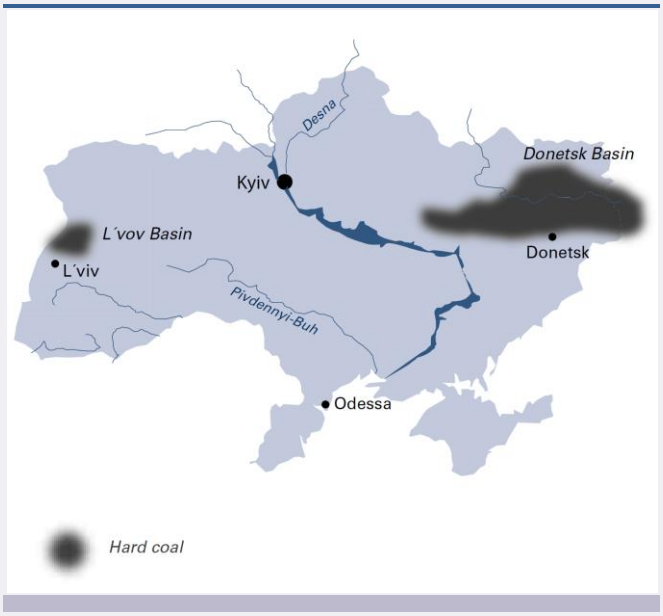
Power supply		2015
Total gross power generation	TWh	259.7
Net power imports (exports)	TWh	4.4
Total power consumption	TWh	264.1
Power generation from hard coal	TWh	39.6
Power generation from lignite	TWh	32.6
Hard coal power generation capacity	MW	6 500
Lignite power generation capacity	MW	8 700

Employment		2015
Direct in hard coal mining	thousand	15.668
Direct in lignite mining	thousand	28.856

Ukraine

Ukraine has considerable reserves of coal which will last for at least one hundred years, being exploitable at a cost that is competitive with imported coal and other energy resources. One third (33.7%) of the country's total primary energy supply came from coal in 2014, with mainly imported natural gas (31.6%) and nuclear power (21.9%) also being important. Oil and renewable energy sources had rather small shares in total energy supply (10.1% and 2.6%).

Nuclear power is the most important energy source for electricity generation in Ukraine, at 48.3% of gross generation in 2014. Coal (38.6%), natural gas (7.0%) and hydro power (5.1%) were also important, with other sources accounting for the remaining 1.0%. Coal's share in the fuel balance for thermal power plants (TPPs) grew to 98% in 2015.



Hard coal

Ukraine has significant proven reserves of coal, being the sixth largest after China, the United States, China, India, Russia and Australia. *In-situ* coal reserves amount to 56 billion tonnes, of which steam coal accounts for 70% and coking coal 30%.

The main resources can be found in the Donetsk coal basin (101.9 billion tonnes), the Dnipropetrovsk coal basin (4.1 billion tonnes) and the Lviv-Volyn coal basin (2.3 billion tonnes), as well as in the Dniprovsko-Donetska coal depression (8.7 billion tonnes) and the Zakarpattya or Transcarpathian coal depression (0.2 billion tonnes). The deposits are characterised by their great depth – operations take place at 500 to 1 000 metres – and by thin seams of 0.8 to 1.0 metre.

As of 1 January 2016, there were 150 mines of all ownership types in Ukraine, including ninety state-owned mines subordinated to the Ministry of Energy and Coal Industry. Eighty-five mines, accounting for 57% of total production, lie in the area temporarily not controlled by the Ukrainian government (also known as the anti-terrorist operation or ATO zone). The state authorities have received no reports on the operations of the majority of coal mines in the non-controlled area since July 2014. Only thirty-five of the state-owned mines are outside the ATO zone.

According to the State Statistics Service of Ukraine, the total number of people employed by the Ukrainian coal industry was 122 000 as of 1 January 2016, including 51 000 at state-owned mines.

General data		2015
Population	million	42.8
GDP	€ billion	81.7

According to the Ministry of Energy and Coal Industry, coal production in Ukraine dropped by 38.8% in 2015 to 39.7 million tonnes. Steam coal production dropped by 35.7% to 31.4 million tonnes, while coking coal production fell by 48.4% to 8.3 million tonnes. Coal mining companies managed by the ministry reduced total production by 62% to 6.7 million tonnes.

DTEK, the largest private energy company in Ukraine, produced 28.7 million tonnes of coal in 2015. The company owns, leases or has concession rights to operate thirty-one coal mines and thirteen coal preparation plants, including three mines and one coal preparation plant in Russia.

The decline in coal production in Ukraine is explained primarily by the continuing military hostilities in Donbass. Budget financing reductions and lower loads at thermal power plants (TPPs) have also affected demand for coal. In 2015, state support to coal mining companies was stopped. This resulted in a growing arrears of salary payments and debts for the electricity consumed at state-owned mines. After protests by miners, the parliament reallocated budget funds amounting to UAH 900 million to support the coal mining industry. However, this sum was insufficient and the coal industry began 2016 with three-months of unpaid wages.

Given the problems at state-owned mines, private companies have had to bear the burden of satisfying the Ukrainian economy's demand for coal. For example, DTEK has concentrated on the production of gas coal (G grade) for TPPs, which helped maintain output of this grade of coal at the 2014 level of 22 million tonnes.

Ukraine has been experiencing anthracite shortages since 2014. To cover the demand for electricity generation, 8.5 million tonnes of anthracite were received from the ATO zone in 2015 and 1.6 million tonnes were imported. In 2015, the coal import structure changed significantly as coal supplies from Russia dropped markedly.

Lignite

Ukraine produces only small volumes of lignite – less than 200 thousand tonnes each year – from the Olexandria and Mokra Kalyhirka deposits in the Kirovohrad and Cherkasy regions, near the Dnipro River.

Pricing and policy

Coal in Ukraine is sold through direct contracts between mining companies and consumers or via VUHILLIA UKRAINY, a state company which operates the wholesale market for around one third of the output from state-owned mines. Wholesale coal prices are fixed, so loss-making state-owned mines are cross-subsidised by profitable mines. In 2015, the wholesale price of coal increased by 59.5% to UAH 1 001.5 per tonne, while the cost of production grew by 17.2% to UAH 2 069.3 per tonne. Private companies price coal based on supply and demand, having regard to international coal market price trends.

The Ministry of Energy and Coal Industry is responsible for coal policy, acting in accordance with the goals and tasks set out in the Action Plan of the Cabinet of Ministers of Ukraine, the "European Ukraine" Coalition Agreement between political factions and the national Sustainable Development Strategy to 2020.

In May 2015, the Cabinet of Ministers updated a list of coal mining companies to be privatised, comprising twenty-six facilities (Resolution No. 271 on Transparent and Competitive Privatisation). Preparations were subsequently made for the sale of Velykomostivska, Chervonohradska and Vidrodzhennia mines, as well as Mezhurichanska mine of state enterprise LVIVVUHILLIA and Buzhanska mine of state enterprise VOLYNVUHILLIA. The privatisation preparations for the sale of other companies were suspended due to a lack of funds and in view of the anti-terrorist operation in eastern Ukraine.

In July 2015, the Cabinet of Ministers agreed to liquidate some loss-making coal mining companies (Resolution No. 696-p), namely: Rodynska mine of state enterprise KRASNOARMIISKVUHILLIA, Zarichna mine of state enterprise LVIVVUHILLIA and Mine No. 9 Novovolynska of state enterprise VOLYNVUHILLIA.

To streamline government support to the coal sector and make progress with restructuring through the closure and mothballing of certain mines, a draft law was prepared and published by the Ministry of Energy and Coal. The ministry is also pursuing coal market liberalisation and exchange-based coal trading (e-trading). To create a favourable investment climate for the privatisation of mines by increasing production, improving efficiency and removing subsidies, the Ministry of Energy and Coal Industry has drafted a new programme of coal sector reforms for 2015-20.

Coal resources and reserves		
Total resources hard coal	Mt	117 200
Total resources lignite	Mt	7 717
Reserves hard coal	Mt	56 000
Reserves lignite	Mt	2 336

Primary energy production		2015
Total primary energy production	Mtce	*c.*100.0
Hard coal (saleable output)	Mt / Mtce	39.7 / 32.3

Saleable coal quality		
Hard coal calorific value	kJ/kg	20 000
Hard coal ash content	% a.r.	5.0-35.0
Hard coal moisture content	% a.r.	5.0-14.0
Hard coal sulphur content	% a.r.	0.8-4.0

Coal imports / exports		2015
Hard coal imports	Mt	14.6
Hard coal exports	Mt	0.6

Primary energy consumption		2015
Total primary energy consumption	Mtce	*c.*150.0
Hard coal consumption	Mtce	38.7

Power supply		2015
Total gross power generation*	TWh	157.7
Net power imports (exports)	TWh	(1.5)
Total power consumption*	TWh	148.3
Power generation from hard coal**	TWh	52.9
Coal power generation capacity**	MW	23 612

Employment		2015
Direct in hard coal mining	thousand	122.000

** excluding non-controlled territories from May 2015*
*** excluding Zuevskaya and Starobeshevskaya TPPs as from May 2015*

United Kingdom

The United Kingdom is one of the largest energy consumers in Europe, third only to Germany and France. It is by far the largest oil producer in the EU, accounting for half of all oil production, and is also a significant producer of natural gas. As such, the country's energy import dependence of 45.5% is below the EU average.

The UK has identified hard coal resources of 3 560 million tonnes, although total resources could be as large as 187 billion tonnes. About 80 million tonnes of the economically recoverable reserves are available in shallow deposits capable of being extracted by surface mining. There are also about 1 000 million tonnes of lignite resources, mainly in Northern Ireland, although no lignite is mined at present.

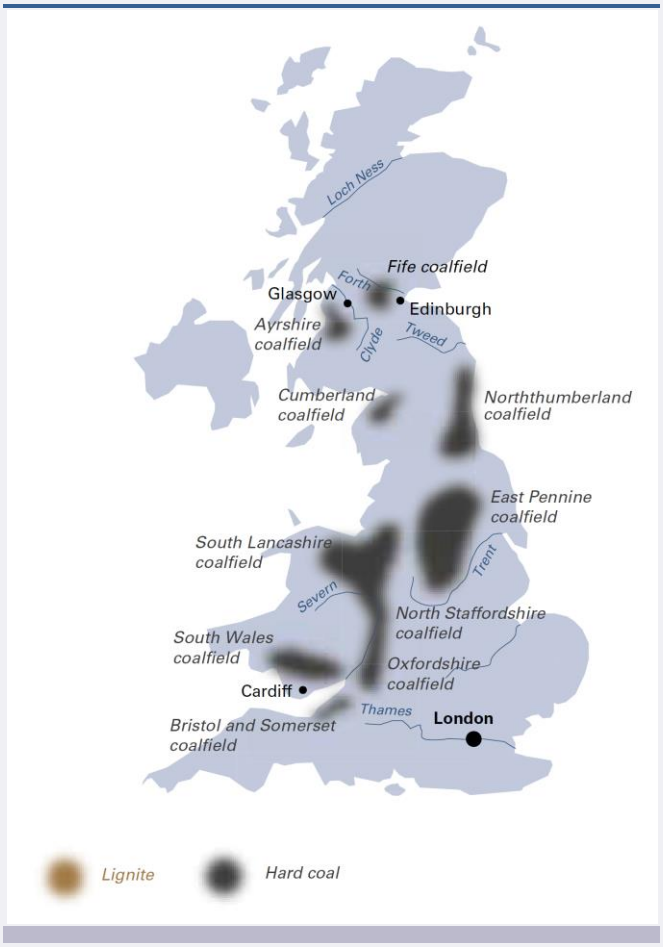
In 2015, UK primary energy production was 168.1 Mtce, with coal accounting for just 7.1 Mtce (4.2%). Total primary energy consumption was 257.2 Mtce, with oil (33.3%) and natural gas (34.1%) having the largest shares, followed by coal (13.3%) and nuclear (10.2%). Biofuels and waste accounted for 5.5%, while hydro, wind and solar totalled 2.6%.

After spending most of the previous twenty-five years as a net exporter of energy, the UK became a net importer in 2004. The gap between imports and exports has since increased and in 2011 imports of energy outstripped indigenous production for the first time. This trend looks set to continue as North Sea oil and gas reserves deplete. In 2014, the UK became a net importer of petroleum products for the first time.

Power generation in the UK reflects a diverse energy mix. In 2015, gross power supply was 337.7 TWh, dominated by gas (29.5%), coal (22.8%) and nuclear power (20.8%), coal having lost the number one position in 2015. Wind and solar contributed with 14.2%, biofuels and waste 9.5%, hydropower 2.6% and oil 0.5%.

All the coal-fired capacity that had opted out of the EU Large Combustion Plants Directive had been closed by the end of 2014. Two UK generators have been granted state support through feed-in tariffs to enable biomass conversions of their power stations at Lynemouth and three units at Drax.

Coal-fired electricity generation decreased significantly in 2016 because of the UK carbon tax: 4.8 GW of capacity was closed (2.4 GW Longannet, 1.0 GW Ferrybridge and 1.0 GW Rugeley). The remaining coal-fired power plants in the UK are RWE Aberthaw B, EDF Cottam, Drax, Eggborough, SSE Fiddlers Ferry, AES Kilroot, UNIPER Ratcliffe, SIMEC Uskmouth and EDF West Burton A.



General data		2015
Population	million	64.9
GDP	€ billion	2 577.3

The UK power generation sector has little new capacity under construction or planned. Even the proposed nuclear power plant at Hinkley Point C has stalled because of technical issues associated with the supply of the reactor pressure vessel and commercial issues with the finance agreements to fund the project.

The UK's carbon price support mechanism placed an additional levy on coal-fired generation from April 2013. It increased in April 2014 to £9.55 per tonne of CO_2 emitted and to £18.08 per tonne in April 2015. The levy is frozen at this level until 2020, but its trajectory thereafter is uncertain. It adds a tax of around £42 per tonne of coal to the cost of coal-fired generation, in addition to the *c.*€6/tCO_2 added by the EU emissions trading system (*c.*£10 per tonne of coal).

A capacity market auction which was designed to give guaranteed capacity for the winter of 2018/19 was held at the end of 2014. The clearing price was lower than analysts had predicted, with little appetite to build the new gas-fired plants desired by government.

Hard coal

The UK's remaining surface coal mines are mainly located in central and northern England, South Wales and central and southern Scotland. In 2015, all UK deep coal mining ended: Thoresby and Hatfield collieries closed early in 2015 and Kellingley colliery in December, with thousands of job losses.

In 2015, hard coal supply totalled 34.0 million tonnes, with 8.5 million tonnes of indigenous production and 25.5 million tonnes of imports. Coal imports decreased by a massive 14.1 million tonnes (-37.1%); Russia, Colombia and the United States are the main sources, accounting for almost 90% of all imports. Indigenous production was split between deep mines with 2.8 million tonnes and surface mines with 5.8 million tonnes. There was a significant stock decrease of 4.1 million tonnes as electricity generators used stocks built up in anticipation of the April 2015 increase in the carbon price support tax. The UK exported just less than 0.4 million tonnes of hard coal in 2015.

Coal consumption in 2015 was 38.0 million tonnes (34.3 Mtce), of which 29.2 million tonnes were used for electricity generation, with the iron and steel industry being another large consumer. The residential heating market is now less than 0.5 million tonnes per year.

Imports supplied virtually the whole of the coking coal market, as the UK no longer produces significant quantities of coal suitable for use in coke ovens. Nevertheless, UK steelmakers use locally produced coal for pulverised coal injection (PCI) at their blast furnaces.

As the size of the UK coal market fluctuates markedly, depending on the relative pricing of international coal and natural gas, along with carbon allowance prices and taxes, coal imports are expected to remain a swing component of energy supply.

The UK government is hostile towards coal: on 18 November 2015, the Secretary of State for Energy and Climate Change proposed a public consultation on the closure of all coal-fired power plants without CCS by 2025, which raises questions on whether UK electricity supply is market-driven or politically driven. A few days after this announcement, the UK government cancelled its £1 billion support for the flagship White Rose CCS project.

Low international coal prices, rising domestic production costs and a national energy policy that encourages fuel switching away from coal to natural gas have put pressure on all UK coal producers. Several companies have been forced either to financially restructure or go into administration. Meanwhile, UK producers are reluctant to invest in long-term production capacity under current policies.

Important surface mine coal producers include CELTIC ENERGY, H J BANKS, KIER MINING, MILLER-ARGENT and UKCSMR. There are five licenced deep mines with insignificant or no coal production. The industry's sole trade association is the Association of UK Coal Importers and Producers (CoalImP). Total direct employment in the coal mining sector at the end of 2015 was 1 975 (477 at deep mines and 1 498 at surface mines).

United Kingdom

Coal resources and reserves		
Total resources hard coal	Mt	3 560
Total resources lignite	Mt	1 000
Reserves hard coal	Mt	277

Primary energy production		2015
Total primary energy production	Mtce	168.1
Hard coal (saleable output)	Mt / Mtce	8.5 / 7.1

Saleable coal quality		
Hard coal net calorific value	kJ/kg	22 000-27 000
Hard coal ash content	% a.r.	14.0-18.0
Hard coal moisture content	% a.r.	10.0-12.0
Hard coal sulphur content	% a.r.	0.8-2.5

Coal imports / exports		2015
Hard coal imports	Mt	25.5
Hard coal exports	Mt	0.4

Primary energy consumption		2015
Total primary energy consumption	Mtce	257.2
Hard coal consumption	Mtce	34.3

Power supply		2015
Total gross power generation	TWh	337.7
Net power imports (exports)	TWh	20.9
Total power consumption	TWh	358.6
Power generation from hard coal	TWh	76.9
Hard coal power generation capacity	MW	19 300

Employment		2015
Direct in hard coal mining	thousand	1.975

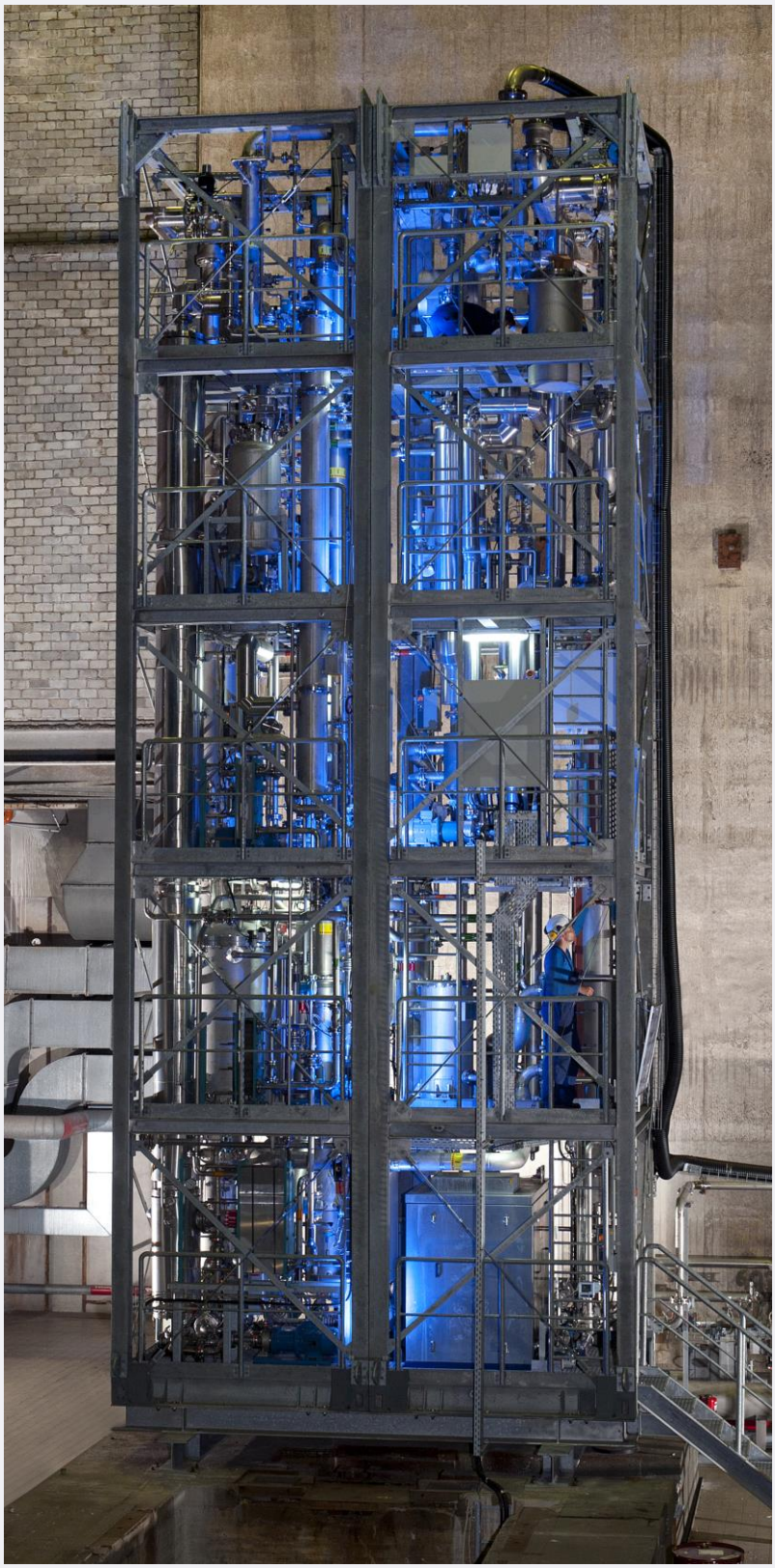
INSIGHT 17

Power-to-Fuel: from CO_2 to methanol

Development work at the German utility, STEAG GmbH, aims to transform CO_2 emissions into methanol, an alcohol used in biodiesel production and in the manufacture of raw materials for the chemical industry. The plan is to test a new carbon capture and use (CCU) technology, which will benefit both the transport and industrial sectors, at the Lünen power plant.

The 507 MW coal-fired plant at Lünen provides electricity to 400 000 households and district heating to the city of Lünen. 110 MW of so-called “traction current” power or *Bahnstrom-Turbosatz* is available at 16.7 Hz to the German railway company, Deutsche Bahn, for clean and safe public transport. The existing CO_2 separation facility at Lünen power plant will be used for the new “Power-to-Fuel” unit which is designed to transform CO_2 into methanol. Methanol is a high octane gasoline improver and is widely used in the synthesis of polymers and plastics.

Scientists and engineers from STEAG are working with several international partners to develop the technology – Carbon Recycling International, Mitsubishi Hitachi Power Systems Europe, Hydrogenics and i-deals – alongside several universities and research institutes from Europe. The research team working on this promising new technology is supported by an €11 million grant from the EU Horizon 2020 programme.



CO_2 separation unit at the STEAG Lünen power plant – source of CO_2 for the “Power-to-Fuel” research project

Chinese investment brings secure power from lignite to South East Europe

INSIGHT 18

Stanari power plant and mine in Bosnia and Herzegovina

In Bosnia and Herzegovina, EFT Group has now completed the largest energy project since the 1980s. The 300 MW lignite-fired Stanari power plant came online in September 2016, built by Dongfang Electric Corporation and financed by the China Development Bank. The plant was built on time and on budget with a circulating fluidised bed boiler manufactured in China that meets all EU environmental standards. To fuel the plant, further investment will see the annual output from an adjacent lignite mine almost double.

Other Chinese-supported coal projects in Europe include a 450 MW lignite-fired power plant at Tuzla in Bosnia with a €786 million investment, a 350 MW lignite-fired power plant at Banovići, also in Bosnia, with around €400 million of investment, a 350 MW lignite-fired power plant at Kostolac in Serbia with a €700 million investment, a 500 MW lignite-fired power plant at Rovinari in Romania with a €1 billion investment and modernisation of the Mintia-Deva coal-fired power plant in Romania with an investment of €250 million.

Other EU Member States and Energy Community stakeholders

Earlier chapters have reported on the key coal-producing countries of the EU and its neighbours. This chapter examines the other EU member states that all use coal to a greater or lesser extent. Also included, because of their alignment towards EU energy policy, are the contracting parties and observers to the Energy Community.

The 2005 treaty establishing the Energy Community requires contracting parties to implement important parts of the EU *acquis* on energy markets and environmental protection. It provides for the creation of a single energy market and a mechanism for the operation of networks in the South East European region which disintegrated following the conflicts of the 1990s. In 2011, the contracting parties agreed to implement the EU's third internal energy package by January 2015, although parties are not obliged to join the EU emissions trading system.

The Energy Community offers opportunities to owners of coal-fired power plants in South East Europe who will gain access to what should soon become the world's largest electricity market. At the same time, plant owners will be required to make very substantial investments in pollution control equipment to meet stringent EU emissions legislation.

Figure 15
EU-28 Member States and Energy Community stakeholders

Source: Energy Community
*** the 16 EU member states shown in bold on the map hold participant status*

Austria

Austria has limited primary energy resources and is dependent on energy imports for two thirds of its primary energy supply. Although no longer exploited, lignite resources total 333 million tonnes, lying mainly in western Styria, near Graz.

During the Monarchy, the country's energy demand was largely met by coal from Moravia and Silesia. After each of the world wars, hard coal and lignite mining in Austria was expanded to replace production lost elsewhere; lignite output peaked at over 6 million tonnes in 1963, when hard coal output was 100 thousand tonnes. However, with increasing trade and the trend towards greater oil and natural gas use, Austria's underground hard coal mines became less competitive and were closed during the 1960s. After more than two centuries, Austrian coal mining ended in 2006 with the re-cultivation of Oberdorf lignite mine.

Poland, the Czech Republic, the United States and Russia are the main coal exporters to Austria. In 2015, 3.8 million tonnes of coal were consumed, mostly by the power and steel industries. The integrated steel works operated by VOESTALPINE at Linz has an annual crude steel production capacity of 6 million tonnes. At Dürnrohr power plant in Lower Austria, EVN owns and operates a 352 MW unit. A second 405 MW unit owned by VERBUND at the same site was closed in April 2015.

Baltic States

The neighbouring states of Estonia, Latvia and Lithuania lie between the Baltic Sea and Russia. In 2004, these former Soviet states joined the EU and by 2015 all had joined the eurozone. To their south, the Russian enclave of Kaliningrad Oblast borders Lithuania and Poland.

Estonia, Latvia and Lithuania seem poised to join the continental European electricity network after the signing in December 2014 of a roadmap by TSOs and then, in January 2015, of a declaration by energy ministers. The intention is to desynchronise the Baltic States from the Russian IPS/UPS network, leaving Kaliningrad isolated unless DC links are built or the enclave joins the ENTSO system.

While no coal is produced in the Baltic States, all three countries consume modest volumes of imported coal, mostly from Russia, and offer important transit routes for Russian coal exported elsewhere.

In **Latvia**, shipments through the Baltic Coal Terminal at Ventspils fell to just 1.9 million tonnes in 2015 as a result of retaliatory sanctions by Russia. A planned expansion of the 6.0 million tonne terminal to an annual capacity 10.5 million tonnes looks doubtful. Ust-Luga, 120 km west of St. Petersburg, has become the largest port for coal in the region, although ice can hinder operations there as well as at St. Petersburg and Vyborg (Vysotsk) ports. Alternative routes for Russian coal exports include via ports at Tallinn (Muuga) in Estonia, Riga and Liepāja in Latvia, Klaipėda in Lithuania and Kaliningrad. Klaipėda port is strategically important as the northernmost ice-free port on the eastern coast of the Baltic Sea, with good infrastructure links to Russia.

The **Kaliningrad** enclave is dependent on imported energy from Russia, although power is generated locally. The 450 MW gas-fired CHPP-2 was commissioned in 2010, supplementing the heat and power output from many smaller plants totalling 200 MW. To ensure power supply security, three new gas-fired units and a coal-fired unit are planned with a combined capacity of 1 000 MW.

Although construction stopped in June 2013 of a new 2 400 MW nuclear power plant at Neman close to the Lithuanian border, it remains a viable project if customers for its electricity can be found in Germany, Poland and the Baltic States. With three years of civil works completed, major pieces of power plant equipment delivered to the site are being kept in storage in readiness of a decision to restart construction,

In **Lithuania**, the closure of Ignalina nuclear power plant (NPP) at the end of 2009 left a power vacuum in the Baltic region. This could have been filled by the proposed Visaginas NPP, but a consultative referendum in October 2012 saw Lithuanians vote against this project. Meanwhile, the 2 400 MW Astravyets NPP, 50 kilometres from Vilnius, is under construction in Belarus, with commissioning of the first unit scheduled for 2019 followed by the second unit in 2020.

In October 2014, a new floating LNG terminal was opened at Klaipėda with an annual capacity of 4 billion cubic metres, partially filled with contracted gas from STATOIL of Norway.

Estonia is uniquely dependent on indigenous oil shale for its energy supply and enjoys an energy import dependency of just 8.9%, the lowest in the European Union. Large quantities of oil shale are used to generate competitively priced electricity at thermal power plants where it is used in much the same way as coal – either as a pulverised fuel in older boilers or in new circulating fluidised beds (CFBs).

Oil shale is a sedimentary rock containing up to 50% organic matter – Estonian oil shale extracted from the Baltic kukersite deposit has a heating value of 8 000-11 000 kJ/kg and 1.5% to 1.8% sulphur content. Once extracted from the ground, the rock can be either used directly as a fuel in power plants or processed into petroleum products. The only other countries that exploit oil shale are Brazil, China and Israel, with prospects in Jordan and the United States.

Estonia's accessible oil shale resources total approximately 1.3 billion tonnes. In 2015, 15.2 million tonnes of oil shale (6.0 Mtce) were mined by EESTI ENERGIA and VIRU KEEMIA GRUPP at underground mines and by EESTI ENERGIA, KIVIÕLI KEEMIATÖÖSTUS and KUNDA NORDIC TSEMENT at surface mines. Oil shale production has grown to meet growing demand for oil products produced from oil shale. In 2008, the annual limit of oil shale mining established by the government was 20 million tonnes and its objective was to reduce mining to 15 million tonnes by 2015. EESTI ENERGIA plans to implement longwall mining at its Estonia mine to improve recovery rates above those achieved with the room-and-pillar mining method employed to date.

In 2015, Estonia generated 83.2% of its gross electricity supply of 10.4 TWh from oil shale, a share that is expected to decrease in the future in line with government policy. Around 75% of oil shale production is used for electricity and heat generation, notably at the EESTI ENERGIA Narva energy complex, comprising the 1 615 MW Eesti power plant and the 405 MW Balti power plant which also supplies heat to the town of Narva. The adjacent 300 MW Auvere power plant will be completed by GE in 2017, running on oil shale and biomass.

The environmental issues associated with oil shale exploitation are complex. With 45% incombustibles, ash can occupy 25% *more* volume than the original shale which does not collapse when burnt. To meet EU directives on emissions to air, all old pulverised-fuel boilers have been closed or upgraded. Balti 11 and Eesti 8 were repowered with CFB boilers and further units have been fitted with a novel integrated desulphurisation system, supplemented with lime injection, and with deNOx systems.

7 400 people are employed in the Estonian oil shale industry, of which 3 200 are employed at mines.

Belgium

In the 19th century, the Walloon coal mines of southern Belgium fuelled the country's industry-led expansion. Later, in 1917, coal mining started in the north-east around Limburg where the geological conditions were favourable. National coal production peaked at 30 million tonnes between 1952 and 1953 and was maintained at this level until the late 1950s. Output gradually declined as the Walloon and Limburg mines closed: Eisden mine closed in 1987 and Belgium's last colliery at Heusden-Zolder ceased production in 1992. Remaining hard coal resources are estimated to be 4 100 million tonnes.

Imported coal totalled 4.2 million tonnes in 2015, coming mostly from Russia, Australia and the USA (more coal is imported into Antwerp for onward delivery to customers in other EU countries). Coal provides about 6% of Belgium's primary energy supply and is used mainly by the steel industry, notably by ARCELORMITTAL at Ghent. With the decommissioning of Ruien coal-fired power plant in 2013 and the conversion of other coal plants to fire biomass, coal consumption for power generation is no longer significant.

Gross electricity supply in 2015 totalled 68.1 TWh of which 26.1 TWh (38.3%) was from nuclear power stations, 21.3 TWh (31.3%) from gas-fired plants, 4.2 TWh (6.2%) from coal (mainly at the 556 MW Langerlo power plant now owned by GRAANUL INVEST) and 8.7 TWh (12.8%) from wind and solar. Other coal-fired plants in Belgium consumed biomass which, together with generation from other biofuels and waste, accounted for 6.3 TWh (9.3%) of generation, with hydro (2.1%) and oil (0.2%) the remainder. Electricity imports have risen fivefold since 1990 to 23.7 TWh in 2015 due to capacity closures and lower prices in France, the Netherlands and Luxembourg. Belgium's largest power utility, ELECTRABEL – a subsidiary of ENGIE – has invested in coal-fired power plants in the Netherlands.

Cyprus

Cyprus imports small quantities of hard coal for use mainly by its cement industry (CYPRUS CEMENT and VASSILICO CEMENT). An offshore discovery of natural gas reserves in the Levant basin, estimated to be at least 500 billion cubic metres, has the potential to significantly enhance the energy sector in Cyprus. With the new offshore gas exploration taking place, Cyprus may become an important LNG hub between Europe and Asia.

Denmark

With the rise in its oil and gas production from the North Sea, Denmark became energy self-sufficient in 1999 and, in 2004, a net exporter of primary energy. The country is the third largest oil producer in Western Europe, after Norway and the UK. However, oil and gas production are in decline and Denmark returned to being a net energy importer in 2013. Gas production in 2015 was 4.6 billion cubic metres – less than half of its 2005 peak and placing Denmark as the tenth-largest gas producer in Europe.

Danish energy production has changed significantly as a result of political efforts to promote renewable energy, combined heat and power (CHP) and energy efficiency. The Danish Climate Policy Plan of 2013 aims at fossil-free energy and transport sectors by 2050. In 2015, more than half of all electricity generation was from renewable sources. Coal-fired power generation totalled 7.0 TWh (24.2%) and is expected to be gradually phased out, perhaps by 2030 if a previous government's target is met.

The relatively high use of wind turbines for electricity generation (49.2% in 2015) enhances supply security, but also poses balancing challenges. The Danish electricity system has connections to Norway, Sweden and Germany, and electricity is traded across these borders: Denmark's net electricity imports in 2015 were 5.9 TWh or 17.1% of gross supply. As a part of the integrated Nordic electricity market, Denmark's coal-fired power plants play an important role in balancing not only wind power, but also hydro power from Norway and Sweden which depends on annual precipitation.

Coal-fired power plants in Denmark have a total generation capacity of 4.5 GW. Majority state-owned DONG ENERGY is the owner of Asnæs (827 MW), Avedøre (262 MW), Ensted (626 MW), Esbjerg (417 MW), Stigsnæs (455 MW) and Studstrup (700 MW) power plants. VATTENFALL, the Swedish state-owned energy company, has retreated from the last of its fossil-fuelled assets in Denmark. The 319 MW Amager power plant was sold in 2013 and Fyn power plant (409 MW), initially intended for decommissioning, was sold in 2014 to a local municipality company. Finally, in 2015, the 410 MW Nordjylland plant was sold to another local municipality company.

Some plants co-fire coal with biomass and many are CHP plants with connections to district heating systems, including Nordjyllandsværket 3 which is one of the world's most efficient coal-fired power plants. Its supercritical boilers and steam turbines result in a very high electrical generation efficiency of 47% and, with the supply of heat, the overall efficiency can exceed 95%. Some larger coal-fired CHP plants are being converted to fire 100% biomass, mainly wood pellets.

Denmark has no indigenous coal resources. In 2015, the country imported 2.8 million tonnes of coal, mainly from Russia, Colombia and South Africa. Over 95% of this coal is used for electricity and heat generation, including district heating. Having peaked in 1984 at 96%, the share of electricity produced from coal has fallen and the Danish government expects this decrease to continue to 15% in 2030.

Finland

With an energy import dependency of 48.8% in 2014, Finland is dependent on foreign energy supplies because the country lacks oil, natural gas and coal reserves. This situation means that Finnish energy policy aims to maximise the country's energy diversity. One third of electricity production is from nuclear power plants and Finland's fifth nuclear reactor, a 1 600 MW EPR, is under construction at Olkiluoto, with more reactors planned. Locally produced peat (3.6 million tonnes in 2015) is used as a fuel, mainly at dedicated district heating plants and at combined heat and power (CHP) plants, the latter accounting for 4.2% of total electricity supply in 2015.

Finland is one of the world leaders in renewable energy, especially bio-energy. Overall, renewable energy sources provide one third of Finland's total primary energy supply and accounted for 33.3% of power generation in 2015. Nevertheless, coal and natural gas are the main fuels for CHP plants in Finland. For conventional thermal power generation, coal is the leading source of energy, although its share in conventional generation is falling. In 2015, gross electricity generation from coal was 6.2 TWh (9.1% of total) and coal fuelled around one quarter of district heating. The efficiency of heat and power production in Finland is very high; approximately one third of electricity is produced at CHP plants which operate with overall efficiencies of 80% to 90%. These plants are used widely by industry and for both district heating and cooling.

Annual coal imports to Finland were 3.5 million tonnes in 2015: 2.2 million tonnes of steam coal for energy production and 1.3 million tonnes of coking coal for the steel industry. Small quantities of coal are used by the cement industry. All coal is imported, steam coal mostly from Russia and coking coal from North America.

The EU's influence on domestic energy policy has increased in recent years, notably the 20-20-20 targets. Finland is implementing many integrated energy and climate policy measures, in particular energy efficiency and energy-saving measures, and increasing the share of renewable energy to 38% by 2020. As well as the increased share of renewable energy, the national energy and climate strategy aims to maintain the position of peat as an indigenous energy

resource, but to diminish the share of fossil fuels, in particular coal. Therefore, the construction of new coal-fired capacity is unlikely, except where coal is co-fired with biomass or used in multi-fuel boilers. Energy sources for electricity production should continue to be diversified and versatile, thanks to the flexibility and variety of CHP plants.

France

Hard coal mining in France ended in April 2004 with the closure of the last operational mine, La Houve in the Lorraine region. The state-owned coal company Charbonnages de France ceased activity at the end of 2007. Small quantities of coal are recovered from spoil tips in Northern France and slurry ponds in Lorraine, but this was just 20 thousand tonnes in 2015. Today, all coal is imported.

Coal resources in France are estimated by the French geological survey (BRGM) to be 425 million tonnes of hard coal plus an additional 300 million tonnes of lignite. Despite several proposals, there has been, to date, no successful project to revive coal mining in France.

In 2015, coal imports amounted to 14.3 million tonnes, including a significant amount of coking coal. Coal is delivered through the ports of Dunkerque, Le Havre, Rouen, Montoir and Fos-sur-Mer, as well as via the ARA ports.

Gross power generation in France was 562.8 TWh in 2015, with 77.0% of this total generated at nuclear power plants. Conventional thermal electricity production contributed 6.0%, hydro 10.5%, wind 3.7% and solar PV 1.3%. Coal-fired generation accounted for 2.2% of the total while the share of renewables was 16.4%.

Coal consumption amounted to 13.6 million tonnes in 2015, of which 3.4 million tonnes were consumed at power plants. The largest plants are located at Cordemais (1 200 MW) and Le Havre (600 MW), both owned by EDF, adjacent to ports, and the single remaining unit 6 at Emile-Huchet (600 MW) owned by UNIPER in Lorraine. In compliance with the Large Combustion Plants Directive (LCPD), two of Le Havre's three units closed in 2013. The remaining unit 4 is expected to operate until 2035. With a view to the future, EDF commissioned a pilot-scale CO_2 capture plant at Le Havre in 2012. The company owns three smaller coal-fired plants: Blénod (500 MW), Bouchain (250 MW) and La Maxe (500 MW). Blénod closed in 2014 and the two others closed in 2015. Similarly, UNIPER closed the four oldest units at its French coal-fired power plants (235 MW Hornaing 3, 245 MW Lucy 3 and Emile Huchet 4 and 5) between 2013 and 2015, as required by the LCPD, while the 230 MW Gardanne 4 (170 MW) in Provence is being converted to biomass by DOOSAN, leaving the 595 MW unit 5 on coal.

The French steel industry consumes important volumes of coal – 1.9 million tonnes for coking and 5.9 million tonnes in integrated steel works in 2015. ARCELORMITTAL plants at Dunkerque, Florange and Fos-sur-Mer are the biggest coal consumers in this sector.

Georgia

Lying in the Caucasus region between Europe and Asia, Georgia has significant hard coal reserves of 201 million tonnes plus resources of 700 million tonnes in the Tkibuli-Shaori and Tkvarcheli deposits. The Akhaltsikhe lignite deposit near Vale has reserves of 76 million tonnes, currently not exploited. Coal production in Georgia peaked at 3 million tonnes in 1958, but by 2000 production had collapsed to almost zero. Today, following the "Rose Revolution" of 2003 and conflict with Russia in 2008, the coal industry is being revitalised. In 2015, Georgia produced 353 thousand tonnes of lignite from mines at Tkibuli and imported 112 thousand tonnes of hard coal mainly for industrial use.

Coal provided 6.6% of Georgia's total primary energy supply of 6.3 million tonnes of coal equivalent in 2014. Natural gas is the main primary energy source (41.8%), followed by oil (23.8%), hydro (16.3%) and biomass (10.6%). Wood consumption, mainly for space heating, water heating and cooking, leads to significant problems with deforestation. Hydro power plants are the most important source of electricity (78% of the 10.8 TWh total in 2015) with thermal power plants fired on imported natural gas from Russia accounting for the remainder. There is potential to expand hydro and wind power generation for export. To this end, the 2 x 350 MW Black Sea Transmission Network HVDC link with Turkey was completed in December 2013 with support from the European Investment Bank and the German government. Georgia is now looking to construct another HVDC link to Armenia.

SAQNAKHSHIRI, a subsidiary of the GEORGIAN INDUSTRIAL GROUP (GIG), owns and operates two underground coal mines, Dzidziguri and Mindeli in the city of Tkibuli, the only coal mines in Georgia. These mines were rehabilitated and a new coal preparation plant commissioned in 2009 to supply cement works at Kaspi and Rustavi as well as the ferroalloy industry. The mines employed 1 400 workers in 2015. With GIG's license covering more than 331 million tonnes of resources, the Tkibuli coal mining development plan envisages raising output to one million tonnes per year by 2020.

GIG operates a small coal-fired power plant with a capacity of 49 MW at Tkibuli. Tenders have been invited for the modernisation of a damaged 300 MW power unit at Gardabani near Tbilisi with a coal-fired CFB boiler which would lead to an expansion of mining in the Tkibuli-Shaori

coalfield. GIG plans to have more than 1 000 MW of capacity by 2020, a significant increase on the company's current capacity of 662 MW or around 20% of Georgia's total generation capacity.

In June 2014, Georgia signed an Association Agreement with the European Union which includes a "deep and comprehensive free trade area". The country is also a candidate party to the Energy Community Treaty and hopes to join the European Network of Transmission System operators for Electricity (ENTSO-E).

In the breakaway republic of Abkhazia, the Turkish operator TAMSASH produces coking coal from an opencast mine in the Tkvarcheli coalfield.

Ireland

The Republic of Ireland has no indigenous coal production, although 3.5 million tonnes of peat were extracted in 2015 for energy use, this being 39.4% of total indigenous energy production. Coal imports totalled 2.4 million tonnes in 2015, all steam coal and coming mostly from Colombia. Coal and peat use have declined, but together still accounted for 16.3% of the country's total primary energy supply of 18.9 million tonnes of coal equivalent in 2015, used mainly for power generation.

BORD NA MÓNA is the leading peat producer and distributes solid fuel products within the residential heating market in Ireland. The company's peat briquettes are popular due to their low sulphur emissions and competitive price.

Since 2001, peat-fired power plants have been supported by a public service obligation as they contribute to security of electricity supply with the use of indigenous fuels. However, this support is expiring: in 2015 in the case of the Edenderry power plant and in 2019 in the cases of the West Offaly and Lough Ree plants. In addition, the government has set biomass dilution targets for peat used as a fuel. For example, the 128 MW Edenderry power plant was designed and built to fire peat, but is now co-fired with a mixture of peat and carbon-neutral biomass from forests and energy crops. The use of such biomass commenced in 2008 and has increased steadily. Taken together, these developments will further reduce the demand for peat and mean that, by 2030, no energy peat will be harvested. In 2015, 8.7% of Irish electricity was generated at peat-fired power plants.

Ireland has a single coal-fired power plant at Moneypoint in County Clare operated by the ELECTRICITY SUPPLY BOARD (ESB). At 915 MW, it is Ireland's largest power station, having been fully commissioned in 1987 as part of a fuel diversity strategy. Significant refurbishments have been carried out by ESB to meet environmental standards, including a €368 million investment in pollution control equipment to meet EU regulations on NOx and SO_2. Moneypoint is expected to operate until at least 2025.

Natural gas was the dominant fuel for power generation in 2015 with a 44.6% share of generation, followed by wind (22.9%) and coal (17.2%). In 2015, Ireland imported 96.5% of its natural gas needs. This points to a high security of supply risk since all imports must flow through a single transit point at Moffat in Scotland. However, the Corrib offshore gas field came on stream in late 2015 and is expected to meet approximately 40% of the combined gas demand of Ireland and Northern Ireland over the first two years of production before output starts to decline. Overall, Ireland had an 85.3% energy import dependence, compared with an EU average of 53.5% in 2014.

According to a government consultation paper "Towards a New Affordable Energy Strategy for Ireland" which reviewed the national energy strategy in 2015, more can be done on energy affordability. Work by the Irish Institute of Public Health suggests that Ireland experiences a significant level of excess winter deaths with over 50% of these being attributable to poor heating due to energy poverty.

Italy

Italy's energy demand peaked in 2005. Then, following the global financial crisis of 2008, the country's GDP stagnated and its total primary energy supply fell. The worldwide decrease in energy commodity prices, especially oil prices, led to a helpful 23% reduction in the country's energy import bill from €44.6 billion in 2014 to €34.5 billion in 2015. Apart from renewable energy sources, which have grown with strong hydroelectric production, the use of all other energy sources has decreased, reflecting and worsening the economic situation.

The only coal reserves and resources in Italy are located in the Sulcis Iglesiente basin, in south-west Sardinia, totalling an estimated 610 million tonnes. Mining activities were stopped there in 1972, but restarted in 1997 with many environmental improvements. CARBOSULCIS, owned by the Autonomous Government of Sardinia, will close its single mine in December 2018, with production gradually declining from 73 thousand tonnes in 2015 to 30 thousand in 2018.

Italian electricity production is unique in Europe and among the G8 countries without any solid base of nuclear power or coal-fired power generation and an overdependence on oil and gas for power generation. Natural gas dominates with a 38.2% share of power generation in 2015, followed by coal (16.6%), hydro (16.0%), solar (8.9%), wind (5.2%) and oil (4.8%). Biofuels, energy from waste and geothermal

accounted for the balance of electricity production. Net electricity imports of 46.4 TWh met over 14% of gross electricity supply, coming mainly from nuclear and hydro power plants in Switzerland, France and Slovenia. This strong dependence on imported electricity is expected to grow over the coming years.

In a decisive June 2011 referendum, Italian voters rejected government proposals to restart a nuclear programme that was abandoned following an earlier referendum held after the 1986 Chernobyl disaster. The government responded with a National Energy Strategy. Approved in March 2013, this strategy places an emphasis on renewable energy sources and the greater use of natural gas for power generation – both of which have further increased the cost of electricity in Italy. High electricity costs have a negative impact on industrial competitiveness: in 2015, Italian industry paid 16.14 €c/kWh compared with an EU average of 11.75 €c/kWh, being the highest in the EU.

Italy had an overall energy import dependence of 75.9% in 2014, rising to 89.7% in the case of natural gas which comes mainly from Russia (43%), Algeria (12%), Libya (12%) and the Netherlands (12%), at unattractive prices. In 2015, Italy imported 16.0 million tonnes of steam coal and 3.5 million tonnes of coking coal. The main supply countries are South Africa, Russia, Indonesia, the USA, Colombia and Australia. ENEL has a 10% shareholding in PT BAYAN RESOURCES of Indonesia which produced 11.3 million tonnes in 2015. Coal imports peaked in 2008 at 25.1 million tonnes and have since fallen because of the forced closure of the 660 MW Vado Ligure coal-fired power plant owned by TIRRENO POWER and the enduring troubles at the ILVA steel plant in Taranto.

With the conversions from fuel oil to coal and modernisation of many power plants, Italy now has some of the best-performing plants in Europe, with an average efficiency of 40% compared with the European average of 35%. ENEL's 1 980 MW coal-fired Torrevaldaliga Nord power plant attains an efficiency of 46%, thus matching the world-leading performance of plants in Japan and Denmark.

Alongside much work on carbon capture and storage, Italy has committed to a programme of industrial innovation aimed at engineering oxy-fuel combustion technology for CO_2 capture and geological storage under a project developed by the Sotacarbo Technology Hub for Clean Energy.

Luxembourg

In 1952, when its prosperity was based on steelmaking, the Grand Duchy of Luxembourg was chosen as the site of the European Coal and Steel Community, marking the start of the institutional development that led to the European Union.

With an energy-import dependence of 96.6%, second only to Malta among the EU member states, Luxembourg is almost entirely dependent on imports for its energy needs. The country has two major power generation sites: a 1 300 MW pumped-storage hydro plant at Vianden and a 385 MW combined-cycle gas turbine (CCGT) plant at Esch-sur-Alzette operated by TWINERG. The domestic electricity grid forms part of the German control bloc managed by the transmission system operator AMPRION.

The steel industry's conversion to electric-arc furnaces (ARCELORMITTAL steel works at Belval, Differdange and Schifflange) has practically eliminated Luxembourg's coal use. Coal is used today mainly for the production of cement at the CIMALUX Rumelange plant. All coal is imported – 73 thousand tonnes in 2015 – and makes only a small contribution to the country's primary energy supply. Yet, in 2014, Luxembourg had the highest *per capita* CO_2 emissions (16.57 tCO_2/capita) of all the OECD countries.

Malta

Malta has no conventional energy production and reports no coal consumption. Until 1995, coal was imported for power generation. ENEMALTA's Delimara power station, with a capacity of 444 MW, burns imported fuel oil in steam boilers/turbines and diesel engines, as well as distillate fuel in gas turbines. In 2014, the Malta Environment and Planning Authority approved the building of a new 215 MW gas-fired power plant at Delimara with floating LNG storage and regasification facilities. A new 200 MW interconnector between Malta and Sicily was inaugurated in April 2015.

Moldova

The Republic of Moldova does not produce coal or lignite. It imports small quantities of hard coal for use by industry and in heating plants – 183 thousand tonnes in 2015. Coal represents about 3% of gross inland energy consumption.

Electricity is imported from Ukraine, but mostly from the 2 520 MW Kuchurgan thermal power plant located in the Transnistria region. The plant can be fuelled by coal, natural gas or fuel oil. In 1990, over 4 million tonnes of coal were consumed there, but since the late 1990s the station has used virtually no coal. Although the Moldovan electricity grid

is synchronised with Russia's (IPS/UPS), some units at Kuchurgan could be synchronised with Continental Europe to allow exports of electricity via Romania. Owned by MOLDAVSKAYA GRES, a subsidiary of the Russian company INTER RAO UES, the plant is in need of refurbishment and only operates at around 20% of its installed capacity.

The remaining supply of electricity is covered by a 330 MW gas-fired combined heat and power (CHP) plant, several more CHP plants at sugar refineries (totalling 98 MW) and two hydro power plants (16 MW and 48 MW).

The Netherlands

Hard coal mining dominated the South Limburg area of the Netherlands from the early 1900s to the mid-1970s. The coalfield, located in the south of the country close to the German and Belgian borders, was mainly exploited from underground mines.

Since around 1915, lignite was extracted at opencast mines near the towns of Eygelshoven and Hoensbroek. These deposits were located on the north-west fringe of the large German lignite basin to the west of Cologne. Lignite mining ceased in 1968 with the closure of the Carisborg site.

The Netherlands is home to the main trans-loading ports for coal imports into Europe. Rotterdam and Amsterdam ports, along with Antwerp in Belgium, constitute the ARA trading area for imported coking coal and steam coal in north-west Europe.

Over 15% of the Netherlands' primary energy supply is provided by coal. In 2015, the country imported 12.4 million tonnes, comprising 8.9 million tonnes of steam coal and 3.5 million tonnes of coking coal. The main supplier countries were Colombia, South Africa, the USA and Russia.

Most imported coal is used for coal-fired power generation and coal had a 37.3% share of the Dutch power generation market in 2015 which totalled 110.0 TWh. The new ENGIE Maasvlakte power plant (800 MW) was commissioned in early 2015. Two other new plants are the RWE/ESSENT Eemshaven plant (1 560 MW) near Groningen and the UNIPER Maasvlakte 3 plant (1 116 MW) in the Rotterdam area. All three of these plants employ the latest supercritical steam technologies to achieve high energy efficiencies. Older installed and operating coal-fired plants are located at Geertruidenberg (Amer 600 MW), Borssele (426 MW) and Amsterdam (Hemweg 630 MW). All these plants co-fire coal with biomass, to a greater or lesser extent. Ownership is very diverse, with ESSENT (a subsidiary of RWE), ELECTRABEL (a subsidiary of ENGIE), UNIPER, EPZ and NUON (a subsidiary of VATTENFALL) being the major players in coal-fired generation.

The Netherlands has a progressive policy on coal and the government has supported CCS demonstration projects, including the ROAD project (Rotterdam Opslag en Afvang Demonstratieproject).

TATA STEEL owns the IJmuiden integrated steel works which has a crude steel annual production capacity of 7 million tonnes and consumes most of the coking and PCI coal imported by the Netherlands. A pilot project at IJmuiden to demonstrate a new iron-making process, called Hisarna, aims to reduce CO_2 emissions from steelmaking.

Norway

Norway, Europe's northernmost country, opted to stay out of the EU by referendum in 1994, but is a significant supplier to the EU of coal, oil and natural gas. In 2014, 31.6% of EU gas imports came from Norway, the world's second largest gas exporter after Russia. Hydro power plants supplied 95.9% of Norway's gross electricity generation in 2015 and the country is a significant net exporter of electricity: 10% of gross production.

In 2015, Norway produced 1.1 million tonnes of hard coal and imported 0.7 million tonnes of steam coal plus 0.4 million tonnes of coke for use in the metallurgical industry, chemicals production and cement manufacture.

Norway has access to deposits of good quality, high calorific value coal at Svalbard lying within the Arctic Circle where resources are estimated to total 53.1 million tonnes, with reserves of 1.9 million tonnes.

Coal mining on Spitsbergen, the largest and only permanently populated island of the Svalbard archipelago, serves multiple government goals, not all related to energy. Without continued peaceful economic activity on Spitsbergen, Norwegian sovereignty might be weakened by foreign economic activity since the Svalbard Treaty of 1920 grants rights to all thirty-nine signatories. The state-owned STORE NORSKE SPITSBERGEN KULKOMPANI (SNSK) operates three drift mines employing 207 people: Svea Nord longwall mine located 60 kilometres south of Longyearbyen, the new Lunckefjell mine north-east of Svea which opened in February 2014 and Gruve 7 room-and-pillar mine in the valley of Adventdalen near Longyearbyen. Coal production at Svea Nord in 2015 was 1 040 450 tonnes, Gruve 7 produced 57 782 tonnes and Lunckefjell 7 359 tonnes before it was mothballed in January 2015. There is no road connection between Longyearbyen and Svea, so all personnel transport is by plane or snowmobile in the winter. Spitsbergen's 10 MW coal-fired combined heat and power

plant takes coal from Gruve 7 and a decision must be taken soon on its replacement. At NOK 3-5 billion, an underwater cable from the mainland is possible, but hugely expensive.

A difficult economic situation throughout 2015, caused by low coal prices, led to extensive cost reductions and a significant downsizing of SNSK, a process that has continued in 2016. The plan is to resume coal production at Lunckefjell when prices pick up. To bring in some revenue from tourists, Gruve 3 which closed in 1996 re-opened as a museum with underground tours.

Coal is sold on the international market – 71% for energy production, 13% to industry (cement, paper and other speciality applications) and 16% to steelworks at an average selling price of 450 NOK (50 USD) per tonne in 2015 – with Germany being the largest customer. SNSK cannot provide a year-round supply of coal because the sea port at Sveagruva is frozen for much of the year. Twenty shipments to Rotterdam and Hamburg were made between 7 August and 21 November 2015.

Political guidance for SNSK's operations is laid down in a government White Paper (No. 22 to the Storting, 2008-2009), establishing that SNSK and its coal mining operations are – and will remain – important for maintaining a Norwegian community in Longyearbyen on Spitsbergen. In March 2015, the Norwegian government decided that, in order to enable continued mining operations during the period of low coal prices, it would award NOK 649 million in subsidies to SNSK between 2016 and 2019. Completely at odds with this decision, Norway's sovereign-wealth fund, the world's largest, has sold most of its shareholdings in coal mining companies after succumbing to a global campaign against coal.

In co-operation with SINTEF and the Arctic University of Norway, SNSK is engaged in research projects supported by the Norwegian Research Council on alternative uses for coal and processed coal with the aim of increasing the value of Svalbard coal.

Norwegians are conscious that end-use emissions from the country's exports of oil and gas are very substantial. In response, Norway has been a pioneer in the field of carbon capture and storage: at the Sleipner natural gas field and at the Snøhvit LNG project. The CO_2 Technology Centre Mongstad was inaugurated in May 2012 to develop CO_2 capture technologies for both gas- and coal-fired power plants.

Portugal

Portugal has limited indigenous energy resources, leading to a 71.6% energy-import dependence in 2014. Its last coal mine, Germunde in the Castelo de Paiva region, was closed in 1994, leaving behind reserves of 3 million tonnes. The country also has lignite resources of 66 million tonnes.

In 2015, 48.9% of Portugal's electricity production came from renewable energy sources: wind, hydro, solar PV, geothermal and wave. Nevertheless, coal-fired electricity generation remains crucial to cover those periods when wind and solar power are not available and to balance the annual variations in hydro electricity production on the Iberian Peninsula. Imported coal accounted for 14.7% of total primary energy supply in 2015 with imports of 5.6 million tonnes coming almost entirely from Colombia. Most of this coal was consumed at Portugal's two coal-fired power plants located at Sines (1 256 MW) and Pego (628 MW). Both are fitted with flue gas desulphurisation and selective catalytic reduction to reduce emissions of sulphur dioxide and NOx.

Sines power plant, adjacent to a coal import terminal on the Atlantic coast, was built in the late 1980s and is owned by ENERGIAS DE PORTUGAL (EDP). The inland Pego power plant, about 120 kilometres north-west of Lisbon, was fully commissioned in 1995 and is now owned by TRUST ENERGY, a joint venture of ENGIE, MARUBENI and ENDESA, a subsidiary of ENEL.

By 2020, Portugal intends to generate 60% of its electricity from renewable energy sources in order to satisfy 31% of its final energy consumption. Although Portugal has this ambitious target, austerity measures following the economic crisis mean that the government has had to scale back support for renewable energy and revise capacity payments. Moreover, the country faces a massive "tariff deficit", this being the shortfall between electricity sector tariff revenues and actual costs, including the payment of renewable subsidies. At the end of 2014, the total accumulated tariff deficit was estimated at €4.69 billion or 3.1% of GDP.

South East Europe

The countries of South East Europe not covered in earlier chapters include Albania, Bosnia and Herzegovina, Croatia, Kosovo, the Former Yugoslav Republic of Macedonia and Montenegro.

Albania produces very small volumes of lignite, about 4 thousand tonnes in 2015, and imports further volumes to meet demand totalling an estimated 106 thousand tonnes at industrial and residential customers, including the Antea cement works. With total resources of 727 million tonnes, the country has the potential to support a much larger lignite mining industry. During the 1980s, annual production of around 2.4 million tonnes came from mines in central Albania at Valias, Manëz and Krrabë; at Mborje and Drenovë in the

Korçë district; in northern Tepelenë at Memaliaj and at Alarup to the south of Lake Ohrid.

The country produces all of its electricity at hydro plants. ENEL planned to build an 800 MW coal-fired power plant at Porto Romano and export electricity to Italy, but Albania is now focussed on increasing its hydro capacity and completing a 400 kV interconnector with Kosovo.

In **Bosnia and Herzegovina**, brown coal and lignite make a large contribution to primary energy supply (56.7% in 2014). In 2015, the country produced a total of 12.6 million tonnes of brown coal and lignite, consumed mainly at power plants near to mines that accounted for 62.8% of gross electricity production in 2014. The country imported 1.4 million tonnes of hard coal in 2015. At 2 264 million tonnes, Bosnia and Herzegovina's reserves of lignite are substantial and total resources of 5 274 million tonnes are reported. The largest coal deposits are located in the north-east of the country around Tuzla in the Kreka-Banovići coal basin. Bosnian lignite parameters (a.r.) are: lower calorific value: 9 100 kJ/kg (2 200 kcal/kg), moisture: 49%, ash: 3.8%, sulphur: 0.13%.

ELEKTROPRIVREDA BiH dd SARAJEVO is the state-owned parent company of KONCERN EPBiH which has seven subsidiary coal mining companies: Rudnici „Kreka" Tuzla (Sikulje and Dubrave opencast lignite mines and Mramor underground mine); RMU „Kakanj" d.o.o.-Kakanj (Vrtlište opencast mine, Haljinići undergound mine and the Begići-Bištrani underground mine which opened in July 2013); RMU „Zenica" d.o.o Zenica (Stara Jama, Raspotočje and Stranjani underground mines); RMU „Breza" d.o.o. Breza (underground mines at Sretno and Kamenice); RMU „Đurđevik" u Đurđeviku, d.o.o. (Višća opencast brown coal mine and Đurđevik underground mine); RMU „Abid Lolić" d.o.o Travnik-Bila; and RU „Gračanica" d.o.o Gornji Vakuf-Uskoplje.

RMU BANOVIĆI dd operates large opencast mines at Grivice and Čubrić, employing shovel dredgers and 170-tonne trucks to mine a 17-metre seam, and has developed a third opencast mine at Turija. The company also operates one partly mechanised underground mine at Omazići. In November 2015, RMU BANOVIĆI signed an agreement with DONGFANG ELECTRIC CORP to build a new power plant in Banovići. The project includes a 350 MW lignite-fired unit with a Chinese-designed supercritical circulating fluidised bed.

Coal mines situated in northeast and central Bosnia serve the Tuzla and Kakanj power plants owned and operated by ELEKTROPRIVREDA BiH. The Gacko coal mine and power plant in the south of the country and the Ugljevik coal mine and power plant in the east are operated by the state-owned ELEKTROPRIVREDA REPUBLIKE SRPSKE (EPRS). Other mines include Livno and Tušnica which supply the Ugljevik power plant as well as Kamengrad mine, although not all are in production.

The 715 MW Tuzla power plant has three units and supplies heat to Tuzla and Lukavac as well as process steam to nearby industries, industrial water and fly ash to the cement works at Lukavac. After the Bosnian war of 1992-95, major overhauls were completed at the plant, including boiler upgrades and the installation of new precipitators. The 450 MW Kakanj power plant has three units and was similarly reconstructed and modernised after the war. In addition to the generation of electricity, the power plant supplies heat to the city of Kakanj as well as ash and slag to the Kakanj cement works.

The Gacko and Ugljevik power plants, each of 300 MW, were commissioned in 1983 and 1985 respectively. In July 2016, EPRS signed a FGD supply contract with MITSUBISHI HITACHI POWER SYSTEMS and RUDIS of Slovenia. The Ugljevik power plant is expected to re-start commercial operations in July 2019.

A new 300 MW lignite-fired power plant came online in September 2016 at Stanari in northern Bosnia and Herzegovina. The plant was built by China's DONGFANG ELECTRIC CORPORATION and financed by the CHINA DEVELOPMENT BANK with a €350 million loan. To supply the power plant, Stanari coal mine at Doboj, with reserves of 108 million tonnes, has increased its annual output capacity from 0.6 million tonnes to 2 million tonnes with a loan from SBERBANK of Russia. FAM MAGDEBURGER supplied a new belt conveyor and a semi-mobile crusher.

Looking to the future, seven new coal-fired power plant projects and coal mines, including rehabilitations and expansions, are being discussed in Bosnia and Herzegovina.

Croatia became the newest member state of the European Union on 1 July 2013. The country does not produce coal, but imported just over 1.0 million tonnes in 2015 mainly for use at the 335 MW Plomin power plant, 100% owned by HRVATSKA ELEKTROPRIVREDA. Coal accounted for 17% of total generation in 2014. At Plomin, a 500 MW unit C will replace unit A and thus increase the plant's overall capacity to 710 MW while reducing CO_2 emissions per unit of electricity generated by 22%. Contract negotiations began in September 2014 and an agreement with the preferred bidder, MARUBENI, was signed in February 2015.

Kosovo is governed by the United Nations Interim Administration Mission in Kosovo (UNMIK), following the

violent conflict of 1996-99. It has very large lignite resources, totalling 10.8 billion tonnes and fourth only to Poland, Germany and Serbia in Europe. Reserves are located in the Kosova, Dukagjini, Drenica and Skenderaj basins, although mining has been limited to the Kosova basin to date. Lignite production in 2015 was 8.4 million tonnes.

For electricity, Kosovo was 96.9% dependent on lignite, with the rest coming from hydro plants and imports, including from a 32 MW hydro plant at Ujman/Gazivoda and other smaller plants.

The state-owned KORPORATA ENERGJETIKE E KOSOVËS (KEK) has a monopoly position in lignite mining and electricity generation. The Kosova A (five units of which the 200 MW unit A3, 210 MW unit A4 and 210 MW unit A5 are operational) and Kosova B (2 x 339 MW units) power plants near Pristina are supplied with lignite from Sibovc Southwest mine near Obiliq which opened in 2010.

In December 2014, a bid for the new 500 MW "Kosova e Re" thermal power plant (a.k.a. Kosovo C) submitted by CONTOUR GLOBAL of the United States was opened by the Ministry of Economic Development. This €1.5 billion project will replace Kosova A and will, with the development of the Sibovc mine, create 10 000 jobs, improve the environment and end the electricity blackouts that plague the country. Construction is expected to start in 2017.

The **Former Yugoslav Republic of Macedonia** is a significant lignite producer: 5.9 million tonnes in 2015 from the state-owned ELEM Suvodol and ELEM Oslomej surface mines and a number of smaller privately owned surface mines. Coal resources are estimated at 2.5 billion tonnes in the Pelagonija and Kicevo basins, including deposits at Suvodol, Brod-Gneotino, Zhivojno, Oslomej, Popovjani and Stragomiste. Lignite from the Mariovo basin may be exploited to fuel a proposed new 300 MW power plant at Mariovo.

The country also imports coal in small quantities, 280 thousand tonnes in 2015. Most coal and lignite is used for power generation which accounted for 69.6% of gross generation in 2014, mainly at the state-owned ELEM 675 MW Bitola and ELEM 125 MW Oslomej power plants. The balance is used almost entirely by the steel industry, including the DOJRAN STEEL plant at Nikolic, DUFERCO MAKSTIL's integrated steel works at Skopje, and ARCELORMITTAL's steel mill, also at Skopje.

Montenegro produced and consumed 1.8 million tonnes of brown coal in 2015, mostly for power generation – 1.4 TWh in 2014 this being 44.8% of total generation. Hydro power supplied the remaining 55.2%. Although not currently exploited, Montenegro has hard coal resources of 337 million tonnes.

Montenegro's 220 MW Pljevlja coal-fired power plant, commissioned in 1982, is supplied with brown coal from two surface mines operated by RUDNIK UGLJA AD PLJEVLJA employing 1 053 people. A €324.5 million contract to build a new 254 MW block was signed in September 2016 with the Czech engineering group SKODA PRAHA, a subsidiary of ČEZ.

In 2014, METALFER acquired an underground coal mine at Berane which had been flooded and idle since 2005. Exploitable reserves are estimated at over 50 million tonnes of brown coal with a calorific value of 14 000-17 000 kJ/kg. In January 2015, commercial mining restarted at a depth of 200 metres, employing 140 people.

Sweden

There is currently no coal mining in Sweden and imported coal accounted for only 4.3% of the country's primary energy supply in 2015. Coal reserves and resources are estimated at 5 million tonnes in southern Sweden. In 2015, 420 thousand tonnes of peat were extracted.

Since the mid-1990s, coal imports have been stable at close to 3 million tonnes per year (2.7 million tonnes in 2015). Demand for high-quality coking coal from Australia and the USA comes mainly from Sweden's speciality steel industry. Limited quantities of steam coal are used at combined heat and power plants in combination with biomass, including at FORTUM's clean and efficient Värtan plant in Stockholm – site of the world's first commercial pressurised fluidised bed combustor. Small quantities of coal are used in the pulp and paper industry which also relies heavily on biofuels.

Almost half of Sweden's electricity demand is met by hydro power (46.1% in 2015) with nuclear power (34.8%) also being significant. The balance was met by wind power (10.3%) and CHP plants firing mainly solid wastes and biofuels (6.5%) and fossil fuels (2.2%). Wind and biomass are generously subsidised while nuclear and fossil fuels are heavily taxed.

The role of nuclear power is again the subject of political discussions in Sweden. Following the 2014 election and to appease the junior coalition Green Party, the government appointed an energy commission to develop a long-term energy strategy with nuclear phase out. In June 2010, the parliament had agreed that new nuclear power plants could replace old ones at existing sites. After long negotiations, this policy was restated in a framework agreement of June 2016.

EU Statistics

Data for EU member states that use only imported coal, 2015

	Population (million)	GDP (€ billion)	Primary energy production (Mtce)	Total primary energy consumption (Mtce)	Primary coal & peat consumption (Mtce)	Gross power generation (TWh)	Gross coal power generation (TWh)	Capacity of coal-fired generation (GW)
Austria	8.6	339.9	17.1	46.9	4.6	61.8	3.0	2.0
Belgium	11.3	410.4	15.0	75.5	4.5	67.0	2.2	0.5
Croatia	4.2	43.8	*6.3	*11.7	*0.9	*13.6	*2.4	0.3
Denmark	5.7	266.2	22.5	22.9	2.5	28.7	6.9	4.5
Finland	5.5	209.1	25.4	46.4	5.5	68.6	5.8	6.1
France	66.4	2 181.1	196.2	351.0	12.7	563.2	9.9	5.1
Ireland	4.6	255.8	2.7	18.9	3.1	28.4	4.9	0.9
Italy	60.8	1 642.4	50.8	215.3	17.7	280.7	42.6	10.9
Netherlands	16.9	676.5	66.6	102.4	15.7	110.0	38.1	5.1
Portugal	10.4	179.5	7.3	31.5	4.6	51.0	14.8	1.9
Sweden	9.7	446.9	53.8	71.4	3.0	161.4	0.5	1.5

*Sources: EURACOAL members, Eurostat and IEA. See country chapters for data on coal-producing member states. * 2014 data*

Coal production and imports in 2015 for the EU-28

	Hard coal production (million tonnes)	Lignite production (million tonnes)	Hard coal imports (million tonnes)
Austria			3.0
Belgium			4.2
Bulgaria		35.9	1.1
Croatia			1.0
Czech Republic	8.2	38.1	2.9
Denmark			2.8
Finland			3.5
France			14.3
Germany	6.7	178.1	55.5
Greece		45.4	0.3
Hungary		9.3	1.3
Ireland			2.4
Italy			19.6
Netherlands			12.4
Poland	72.2	63.1	8.2
Portugal			5.6
Romania	1.3	24.0	1.2
Slovakia		1.8	3.7
Slovenia		3.2	0.4
Spain	3.0		19.0
Sweden			2.7
United Kingdom	8.5		25.5
others			0.6
EU-28	99.9	398.9	191.2

Source: EURACOAL members

Power generation structure in the EU-28 in 2014

	Total gross power generation (TWh)	EU share (%)	Coal & coal products (%)	Oil (%)	Natural gas (%)	Nuclear energy (%)	Hydro (%)	Renewables, waste & other (%)
Austria	65.4	2.1	8	<1	8	0	69	15
Belgium	72.7	2.3	6	<1	27	46	2	19
Bulgaria	47.5	1.5	45	<1	5	33	11	6
Croatia	13.6	0.4	17	<1	7	0	67	7
Cyprus	4.4	0.1	0	93	0	0	0	7
Czech Republic	86.0	2.7	51	<1	2	35	3	9
Denmark	32.2	1.0	34	<1	7	0	<1	58
Estonia*	12.4	0.4	87	<1	<1	0	<1	12
Finland**	68.1	2.1	17	<1	8	35	20	20
France	562.8	17.6	2	<1	2	78	12	6
Germany	627.8	19.7	45	<1	10	15	4	24
Greece	50.5	1.6	51	11	13	0	9	15
Hungary	29.4	0.9	21	<1	14	53	1	10
Ireland**	26.3	0.8	25	<1	49	0	4	22
Italy	279.8	8.8	17	5	33	0	22	23
Latvia	5.1	0.2	0	0	45	0	39	16
Lithuania	4.4	0.1	<1	4	40	0	25	32
Luxembourg	3.0	0.1	0	0	49	0	39	12
Malta	2.2	0.1	0	97	0	0	0	3
Netherlands	103.4	3.2	31	2	50	4	<1	13
Poland	159.1	5.0	83	1	3	0	2	11
Portugal	52.8	1.7	23	3	13	0	31	31
Romania	65.7	2.1	27	<1	12	18	29	13
Slovakia	27.4	0.9	12	1	6	57	16	8
Slovenia	17.4	0.5	22	<1	2	37	37	3
Spain	278.7	8.7	16	5	17	21	15	26
Sweden**	153.7	4.8	<1	<1	<1	42	42	15
United Kingdom	338.9	10.6	30	<1	30	19	3	18
EU-28	**3 190.7**	**100.0**	**26**	**2**	**14**	**27**	**13**	**17**

* *coal figure includes oil shale*
** *coal figure includes peat*

Source: Eurostat (nrg_105a database, last update 22.06.2016)

EURACOAL

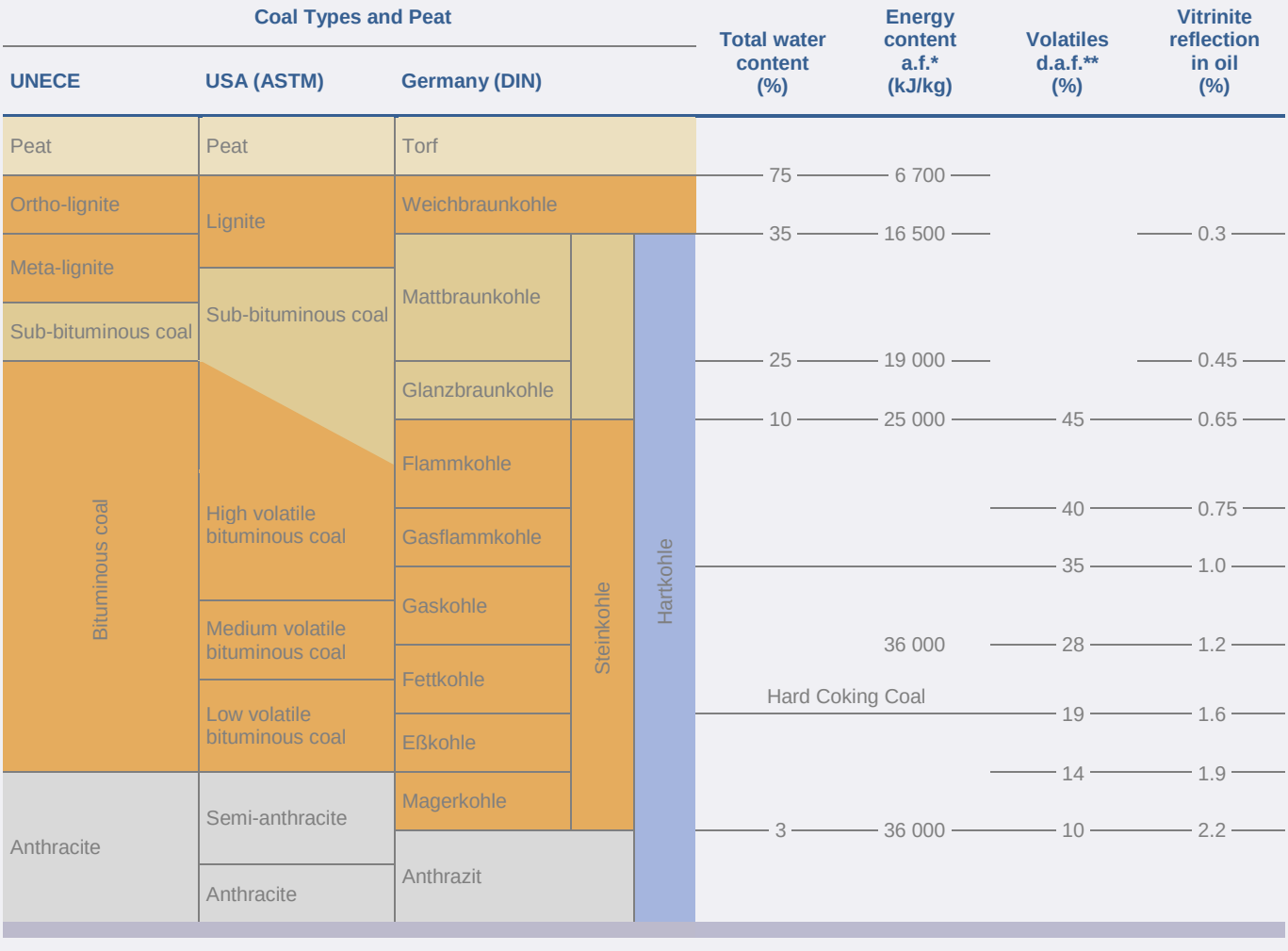
The European Association for Coal and Lignite is the umbrella organisation of the European coal industry. Associations and companies from eighteen countries work together in EURACOAL to ensure that the interests of coal producers, importers, traders and consumers are properly served. Its thirty-two members come from across the EU-28 and Energy Community. As the voice of coal in Brussels, EURACOAL evolved from CECSO (European Solid Fuels Association) after the expiry of the treaty establishing the European Coal and Steel Community in 2002.

EURACOAL's mission is to highlight the importance of the European coal industry to energy supply security, energy price stability, economic added value and environmental protection. EURACOAL seeks to be an active communicator, with the aim of creating an appropriate framework within which the coal industry and coal consumers can operate.

Country	Member Association / Company
Belgium	ISSeP – Institut Scientifique de Service Public (Scientific Institute of Public Service)
Bosnia-Herzegovina	RMU "Banovići" d.d. Banovići
Bulgaria	MMI – Mini Maritsa Iztok EAD
Czech Republic	ZSDNP – Zaměstnavatelský svaz důlního a naftového průmyslu (Employers' Association of Mining and Oil Industries)
Finland	Finnish Coal Info
France	BRGM – Bureau de Recherches Géologiques et Minières (The French Geological Survey)
Germany	DEBRIV – Deutscher Braunkohlen-Industrie-Verein e.V. (German Association of Lignite Producers)
	GVSt – Gesamtverband Steinkohle e.V. (German Coal Association)
	VDKi – Verein der Kohlenimporteure e.V. (Coal Importers' Association)
Greece	PPC – Public Power Corporation S.A.
	CERTH/CPERI – Chemical Process and Energy Resources Institute
Hungary	Borsod-Abaúj-Zemplén County Government
Poland	PPWB – Porozumienie Producetów Węgla Brunatnego (Confederation of Polish Lignite Producers)
	GIPH – Górnicza Izba Przemysłowo-Handlowa (Mining Chamber of Industry and Commerce)
	Lubelski Węgiel „Bogdanka" S.A.
	GIG – Główny Instytut Górnictwa (Central Mining Institute)
	EMAG Institute of Innovative Technologies
	KOMAG Institute of Mining Technology
Romania	PATROMIN – Asociaţia Patronală Minieră din Romania (Mining Employers Association of Romania)
Serbia	EPS – Elektroprivreda Srbije (Electric Power Industry of Serbia)
Slovak Republic	HBP – Hornonitrianske bane Prievidza a.s.
Slovenia	Premogovnik Velenje d.d.
Spain	CARBUNIÓN – Federación Nacional de Empresarios de Minas de Carbón (National Coal Mining Employers' Association)
	Geocontrol S.A.
	SUBTERRA Ingeniería S.L.
Turkey	TKİ – Turkish Coal Enterprises
Ukraine	DTEK
	Ukrvuglerobotodavtsy (All-Ukrainian Coal Industry Employers' Association)
United Kingdom	CoalImP – Association of UK Coal Importers and Producers
	Golder Associates (UK) Ltd.
	Trolex Ltd.
	University of Nottingham

As at 20 June 2016

Coal classification



* a.f. = ash-free basis
** d.a.f. = dry, ash-free basis

UNECE: Ortho-Lignite up to 15 000 kJ/kg
Meta-Lignite up to 20 000 kJ/kg
Sub-bituminous Coal up to 24 000 kJ/kg
Bituminous Coal up to 2% average vitrinite reflection

USA (ASTM): Lignite up to 19 300 kJ/kg

Source: BGR

Note: There is no separate definition of the term "brown coal" as it is synonymous with "lignite".

Glossary

a. r. – as received

As-received condition or as-received basis describes the condition of coal as received by the consumer or the laboratory analysing the coal, including moisture.

Brown coal

The terms “brown coal” and “lignite” are used interchangeably in this report. The terms are synonymous – there is no separate definition of brown coal. Where the word “coal” is used, it can refer to all types of coal.

Coal reserves

The portion of known coal resources that can be profitably mined and marketed with today’s mining techniques.

Coal resources

Coal deposits that are either proven, but at present are not economically recoverable, or not proven, but expected to be present based on geological knowledge.

Mtce

Million tonnes of coal equivalent (1 tce = 0.7 toe or 29.307 gigajoules or 7 million kcal)

Total primary energy supply

TPES refers to the direct use of primary energy (*e.g.* coal) prior to any conversion or transformation processes. It is equivalent to total primary energy demand or consumption.

For a glossary of terms used in energy statistics, see Eurostat’s Statistics Explained website.

Data sources and references

Data and information has been provided by EURACOAL members and national government agencies. Eurostat, IEA and World Bank databases have also been valuable sources. Other data and information has come from the following publications.

BAFA (Bundesamt für Wirtschaft und Ausfuhrkontrolle – German Federal Office of Economics and Export Control (2016), *Aufkommen und Export von Erdgas Entwicklung der Grenzübergangspreise ab 1991*, BMWi, Eschborn.

BGR (Bundesanstalt für Geowissenschaften und Rohstoffe – Federal Institute for Geosciences and Natural Resources) (2015), *Energy Study 2015 – Reserves, Resources and Availability of Energy Resources*, Hannover, December.

BP (2016), *BP Statistical Review of World Energy 2016*, BP plc, London, June.

European Commission (2011), *Impact Assessment accompanying the Energy Roadmap 2050*, Commission Staff Working Paper SEC(2011) 1565, European Commission, Brussels, December.

European Commission (2016), *EU Reference Scenario 2016: Energy, transport and GHG emissions trends to 2050*, European Union, Luxembourg, July.

European Commission DG Energy (2016), *EU Energy in Figures – statistical pocketbook 2016*, European Union, Luxembourg, September.

IEA (International Energy Agency) (2016a), *World Energy Outlook 2016*, OECD/IEA, Paris.

IEA (2016b), *Coal Information 2016*, OECD/IEA, Paris.

IHS (2016), *IHS McCloskey Coal Report*, IHS Markit, London.

NERA (2014), *Energy Taxation and Subsidies in Europe: A report on government revenues, subsidies and support measures for fossil fuels and renewables in the EU and Norway*, report for the International Association of Oil and Gas Producers, NERA Economic Consulting, May.

VDKi (2016), *Annual Report 2016 – facts and trends 2015/16*, Verein der Kohlenimporteure e.V., Hamburg.

World Energy Council (2015), *World Energy Trilemma: Priority actions on climate change and how to balance the trilemma*, World Energy Council, London, May.

Photo credits

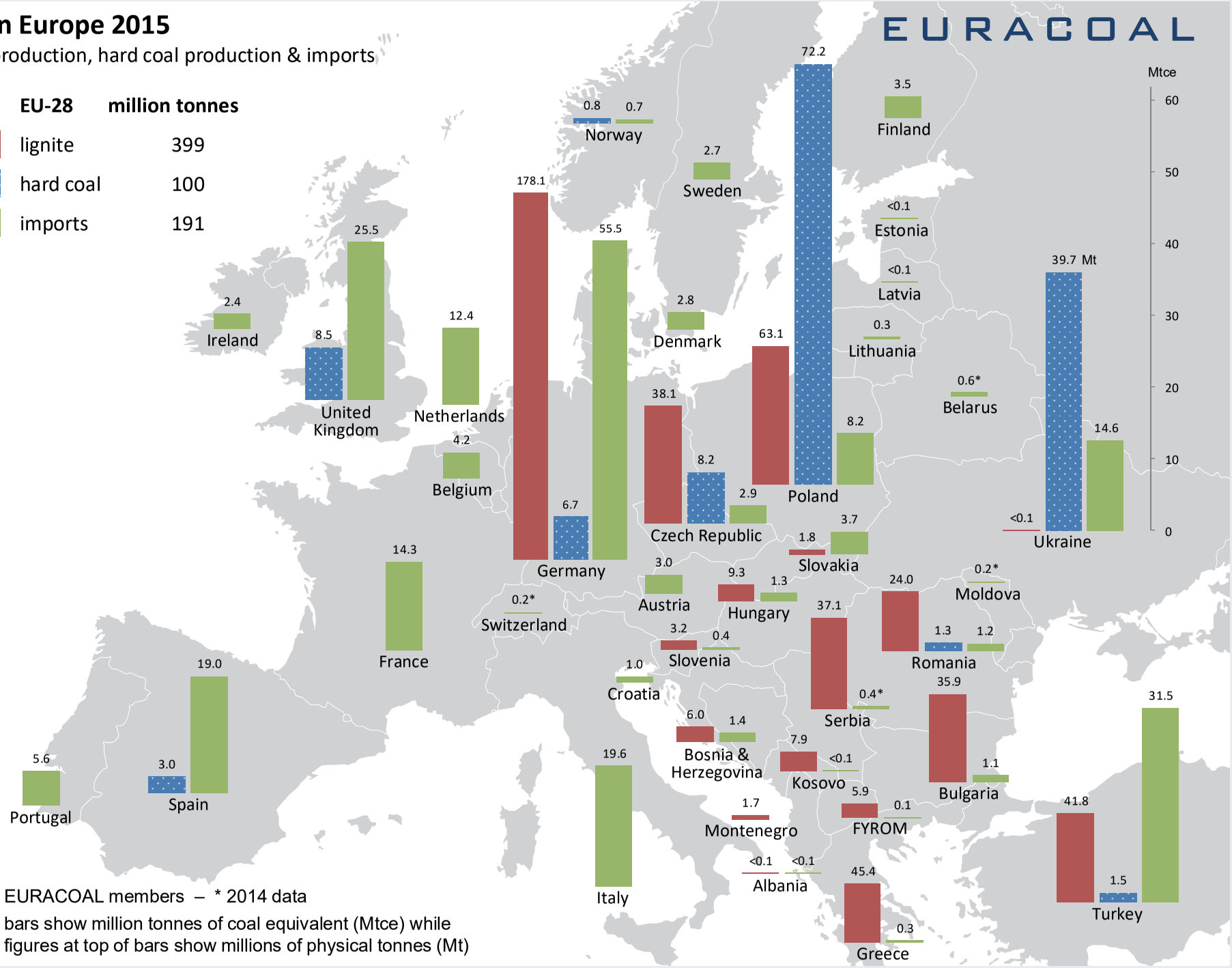
EURACOAL members, © EFT Group and © artjazz / Shutterstock (cover), © The Weir Group PLC (page 4, middle), © SWR Media Services GmbH / TLT-Turbo GmbH (page 4, bottom), © Uniper S.E. (page 7, top), © Marco van Middelkoop / Aerophoto-Schiphol (page 7, middle & bottom), © RUBNER Ingenieurholzbau S.p.A. (page 8), © Monty Rakusen / Alamy stock photo (page 12, middle), © J-POWER / Electric Power Development Co. Ltd. (page 12, bottom), © Gypsum to Gypsum (page 17, top), © RUDIS d.o.o. Trbovlje (page 17, middle), © FAM Förderanlagen Magdeburg und Baumaschinen GmbH (page 17, bottom), © Rob Lavinsky / iRocks.com (page 18, top), © Radim Beznoska / Alamy stock photo (page 24, top), ČEZ Group (page 24, bottom), © FALKENSTEINFOTO / Alamy stock photo (page 29, top), © RWE Power AG (page 29, bottom), © Andreas Franke (page 30, top & middle), © Lausitz Energie Bergbau AG (page 30, bottom), © RWE Power AG (page 35, top), © LW „Bogdanka” S.A. (page 36), © Polska Grupa Energetyczna S.A. (page 40, top), © Artur Marciniec / Alamy stock photo (page 40, bottom), © The Coal Authority (page 47), © Premogovnik Velenje d.d. (page 48), © Aleksander Kavčnik / Premogovnik Velenje d.d. (page 51, top), © RUDIS d.o.o. Trbovlje (page 51, middle & bottom), © puertollano.es / ENCASUR – ENDESA (page 52), © STEAG GmbH (page 61), © EFT Group (page 62), © Redpixart LLC (flags).

Coal in Europe 2015

lignite production, hard coal production & imports

EURACOAL

EU-28	million tonnes
lignite	399
hard coal	100
imports	191



Source: EURACOAL members – * 2014 data

Note: bars show million tonnes of coal equivalent (Mtce) while figures at top of bars show millions of physical tonnes (Mt)

Published by
EURACOAL
European Association for Coal and Lignite AISBL
Avenue de Tervueren 168 boîte 11,1150 Brussels, Belgium
tel +32 2 771 31 70
euracoal@euracoal.org
www.euracoal.eu

Authored by
EURACOAL members and secretariat

Project managed by
Mike Bostan, EURACOAL

Edited by
Brian Ricketts, EURACOAL

Original design by
agreement werbeagentur gmbh
Alt-Moabit 62, 10555 Berlin, Germany
www.agreement-berlin.de

January 2017

ISSN 2034-5682

EURACOAL

European Association for Coal and Lignite
AISBL