EURACOAL

8th edition

Coal industry across Europe

Cover photo: Herne IV, a STEAG-owned 460 MW_e / 550 MW_{th} cogeneration plant built in 1989, is one of many coal-fired power plants in the European Union whose closure plans were postponed during the energy crisis of 2022-2023. It supplies heat and power to the heart of the German industrial Ruhr area. A transformation strategy will see Herne VI, a new 600 MW fossil gas-fired CCGT commissioned by IQONY in 2022, replace older coal units. The new gas plant can operate with up to 15% green hydrogen.

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Introduction

EURACOAL President Dr. Tomasz Rogala

Coal remains a vital, if unloved fuel. In Europe, during a time of unprecedented turmoil in the energy market, coal and lignite replaced lost supplies of Russian pipeline gas. Even as it is phased out, coal will continue to contribute to a reliable and secure energy mix, both domestically mined coal and lignite and imported coal from the diverse and competitive international market. This publication aims to provide readers with an overview of the European coal sector in the context of a just transition towards cleaner, alternative sources of energy. A chapter on the international coal market puts the EU's modest use of coal into perspective while showing coal's importance for electricity generation in many leading economies.

In the European Union, energy policy remains a national competence under Article 194 of the Treaty. Our publication is accordingly structured around a series of national profiles: all the EU member states, plus members and observers of the Energy Community. EURACOAL collected data from its members, as well as from Eurostat and other sources, to present a picture of each country's use of coal (and most countries do use some coal). As the energy mix shifts towards cleaner energy sources, national governments must strike a balance between fulfilling the Paris Agreement goals to reduce greenhouse gas (GHG) emissions while ensuring secure and affordable energy for citizens and enterprises.

Across Europe, it is undoubtedly Ukraine that faces the biggest challenge. The heroic efforts of Ukrainians working in the energy sector, including coal miners and power plant staff, to "keep the lights on" reminds us of the crucial importance of energy to a functioning economy and society. But the war also impacts EU member states: in 2022, many had to replenish their coal stocks to prepare for a winter when coal might be the most secure fossil fuel. Countries such as France, Germany and the Netherlands increased their available coal-fired power generation capacities by keeping coal power plants operational for longer than planned. On top of that, coal importers had to find new sources of supply after the EU banned Russian coal imports. Despite these seismic disturbances to a well-functioning energy market, the EU has not suffered any serious energy shortages thanks to the policy measures put in place at national and European levels, and the quick response of industry to secure new supplies and reduce demand.

Against this geopolitical backdrop, the just transition process continues. During the 9th legislature of the European Parliament, most of the European Commission's "Fit-for-55" proposals were enacted. These aim to reduce greenhouse gas emissions by 55% by 2030 and mean significantly higher carbon prices under the EU emissions trading system (ETS), as well as stricter pollution control measures. To avoid any socio-economic dislocations due to the rapid switch away from fossil fuels, the EU budget for 2021-2027 includes a dedicated Just Transition Mechanism with much-needed support for the coal regions. This money is being allocated to projects that alone cannot replace all the lost jobs but are helping to regenerate the regions with new activities. Looking ahead, the effectiveness of this support should be evaluated and lessons drawn for a "Just Transition Mechanism 2.0" under the next multi-annual financial framework covering 2027-2033. The challenge to replace thousands of skilled, well-paid jobs in the coal value chain will not go away in 2027!

The new Critical Raw Materials Act recognises the importance of coking coal in the manufacture of products for a green economy. For example, the steel in a 15 MW wind turbine requires more than a thousand tonnes of coking coal for its production. To achieve net-zero GHG emissions in the EU by 2050, forecasts include 770 GW of new onshore and 280 GW of new offshore wind turbines – requiring perhaps 120 million tonnes of steel and 80 million tonnes of coking coal. Luckily, the EU has several coking coal mines! Other critical raw materials are also of concern to policymakers. Hence, spoil heaps at European coal mines are being re-assessed as a source of rare earth elements and other scarce metals.

During the energy transition in Europe, we should make use of all our own resources. Also, we should not ignore the role of clean coal technologies to reduce emissions, especially in countries elsewhere in the world that will continue to use coal for decades to come. Cutting-edge research in the coal sector is delivering new ways to reduce emissions, repurpose coal assets and restore landscapes. The EU Research Fund for Coal and Steel, operating under a modernised legal basis since 2021, plays a key role here. The fund currently supports several "big-ticket" projects in the coal regions that showcase how coal companies can transform their operations as part of a net-zero economy. As the chairman of one of those companies and writing on behalf of all EURACOAL members, I promise that the coal industry will continue to strive for a cleaner, brighter future.

Socio-economic and global aspects of coal use as the EU phases out fossil fuels

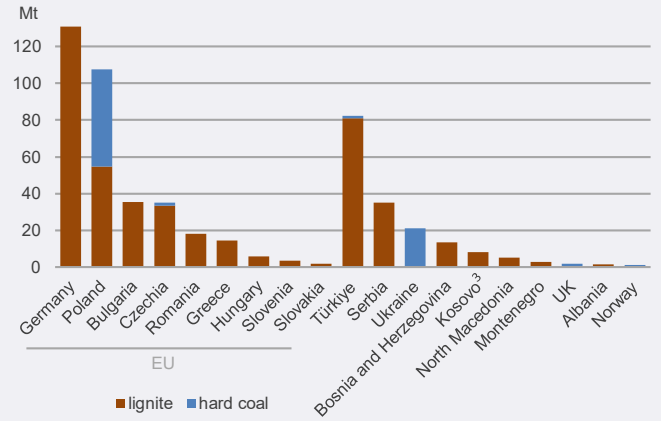
Coal production in Europe has been steadily falling since the 1980s and although coal's importance will continue to decline, the European coal sector remains a key supplier of secure energy, offers well-paid employment and supports long value chains across Europe. In total, the industry employs 144 thousand people in the European Union and a total of 296 thousand people across Europe.

In its proposal for a Just Transition Fund, the European Commission estimated that, "Overall, coal infrastructure is present in 108 European regions and close to 237 000 people are employed in coal-related activities, whereas almost 10 000 people are employed in peat extraction activities and around 6 000 are employed in the oil shale industry." (European Commission, 2020a, p.1).

Coal: a vital and secure component of EU energy supply

Coal (including lignite) is mined in nine EU member states and ten neighbouring countries (Figure 1). It is mainly used for electricity generation and district heating, but is also important for iron and steel making, and cement production.

Figure 1
Coal and lignite production in Europe, 2022



Sources: EURACOAL members and Eurostat

The coal sector plays an important role in terms of energy security with 166 coal-fired power plants operating in eighteen EU countries having a total net capacity of 128 GW

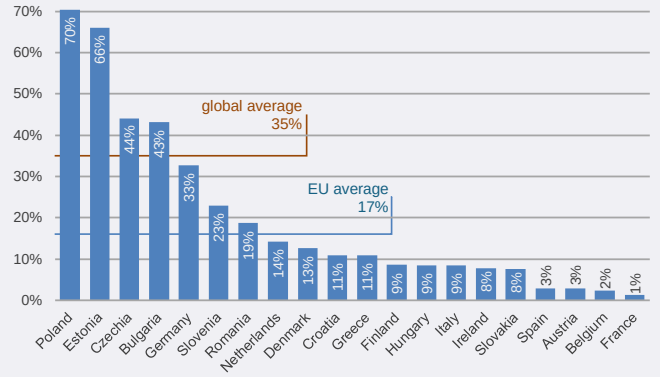
Table 1
Employees in the European coal industry, 2018 and 2022

	2018			2022		
	Hard Coal	Lignite	Total	Hard Coal	Lignite	Total
Albania*	-	*n.a.*	*n.a.*	-	500	500
Bosnia and Herzegovina	-	13 323	13 323	-	13 350	13 350
Bulgaria	-	10 294	10 294	-	11 350	11 350
Czech Republic	6 757	7 147	13 904	3 299	8 247	11 546
Germany	4 125	15 876	20 001	655	17 206	17 861
Greece	-	4 082	4 082	-	3 723	3 723
Hungary	-	1 400	1 400	51	1 300	1 351
Kosovo[3]	-	4 731	4 731	-	3 884	3 884
Montenegro	-	921	921	-	960	960
North Macedonia	-	3 658	3 658	-	4 266	4 266
Norway	126	-	126	53	-	53
Poland	82 843	8 583	91 426	72 911	6 980	79 891
Romania	3 022	13 000	16 022	2 045	12 894	14 939
Serbia	3 500	14 850	18 350	-	16 700	16 700
Slovakia	-	2 000	2 000	-	1 551	1 551
Slovenia	-	1 252	1 252	-	1 196	1 196
Spain	1 549	-	1 549	261	-	261
Türkiye	14 251	37 596	51 847	8 528	44 457	52 985
Ukraine	44 300	-	44 300	58 809	-	58 809
United Kingdom	647	-	647	344	-	344
Total	**161 120**	**138 713**	**299 833**	**146 956**	**148 564**	**295 520**

*Sources: EURACOAL members; JRC, 2021; and *estimate*

in 2022 and generating 481.8 TWh (gross) or 17.1% of EU electricity supply. In the winter of 2021-22, these plants helped the EU survive the shock of losing Russian gas as previously retired coal plants were brought back into service to replace lost gas-fired generation.

Figure 2
Coal, lignite, peat and oil shale in EU electricity generation, 2022

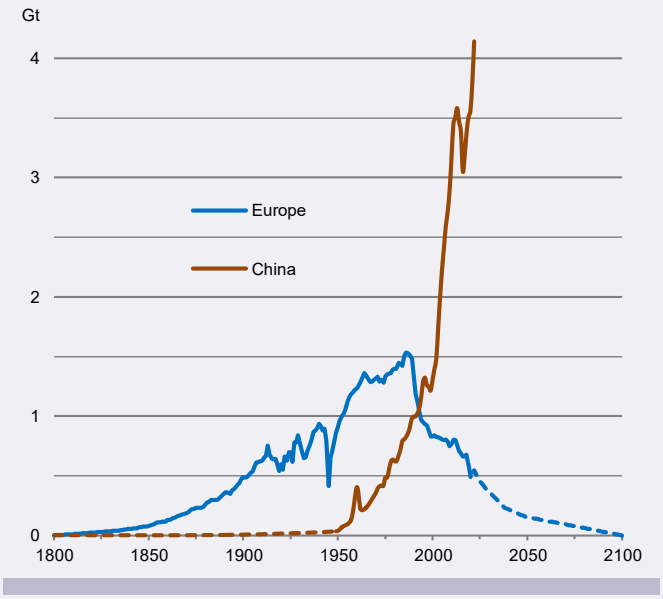


Source: Eurostat nrg_bal_peh database, last updated 19.12.2023

EU coal use in the global context

As the EU phases out coal and eventually all other fossil fuels, coal use in China continues to expand. Figure 3 shows a comparison of coal use in Europe (including Türkiye) since the industrial revolution and coal use in China which industrialised later. Despite some disruptions caused by global events – two world wars and the oil shocks of the 1970s – European coal use has followed an otherwise perfect, bell-shaped Hubbert curve for the production of a finite resource exploited in a free-market economy. Europe is now at the tail end of that curve. China, on the other hand, has only relatively recently begun to exploit its vast coal reserves at scale. There has been a remarkable expansion of coal mining since 2001 when China joined the World Trade Organization. Since then, its industrial output has grown quickly, requiring more and more energy and resources.

Figure 3
European and Chinese coal production, 1800 to 2100



Sources: IEA, 2009, Annex I; IEA databases; and Rutledge, 2011

Carbon leakage through consumption

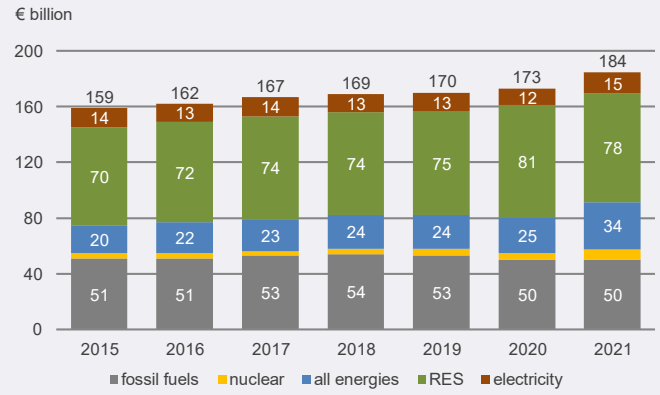
As EU consumers benefit from a great variety of imported products, "carbon leakage" must be addressed. The carbon footprint of EU consumption extends around the world. It is legitimate to ask, for example, why jobs are under threat because of EU climate policy when citizens rely so heavily on products from China where production depends on coal: 64% of electricity generation and 56% of plastics production. In response, it could be said that China now invests more than any other nation in renewable energy sources and, like Europe, will transition in good time. Moreover, the energy transition in the EU can only proceed because of the availability of affordable products from China: solar PV panels, electronic monitoring and control systems, processed raw materials, electric vehicles and their components, heating and cooling equipment, and even the humble light bulb now based on LED technology.

A European holding a smart phone has the energy and atoms of a piece of Chinese coal in their hand

Energy industry subsidies in the EU

The energy transition to renewable energy sources comes at a cost. According to the *2022 Report on Energy Subsidies in the EU* (COM(2022) 642), which draws on a *"Study on energy subsidies and other government interventions in the European Union"* commissioned from Enerdata and Trionomics by DG Energy, renewable energy subsidies reached €81 billion in 2020, a new record. Two thirds of these subsidies or €54 billion were renewable feed-in tariffs, while feed-in premia and quotas added a further €15 billion. Fossil fuel subsidies, on the other hand, decreased to €50 billion, mostly in the form of much-needed financial support to poorer energy consumers who face hardship. Energy companies are estimated to have received direct subsidies of €13 billion in 2021.

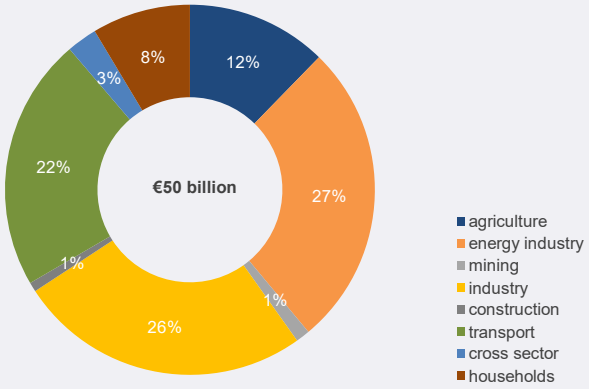
Figure 4
EU energy subsidies by type of energy, 2015 to 2021



Source: European Commission, 2022a, Figure 3

At the same time, fossil fuel companies are subject to significant corporate taxes, royalties, environmental fees, and most importantly the EU ETS which raised €30 billion across the EU member states in 2022 (Figure 6). EU-wide funds – the Innovation Fund and the Modernisation Fund – have redistributed a small part of EU ETS revenues, €6 billion in 2021. With the doubling of the rate of EU ETS allowance removals from 2024 and the introduction of a new trading system from 2028 for buildings, transport and other sectors (ETS 2), government revenues from EU carbon trading alone will exceed all types of fossil fuel subsidies.

Figure 5
Fossil fuel subsidies by sector in the EU, 2021

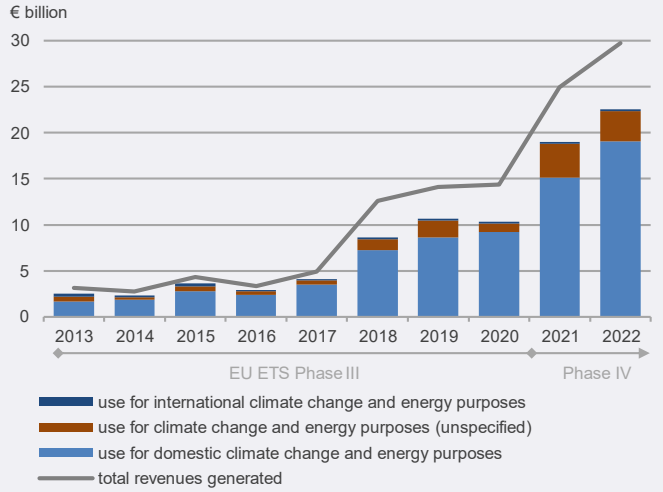


Source: ibid.*, Figure 6*

Embracing industrial change – a century of coal in transition

As more countries announce coal phase-outs for electricity generation, it is worth noting that this is by no means the first sector to switch away from coal. The UK Royal Navy converted its fleet to oil in the 1910s; from the 1920s and 1930s onwards, diesel-electric trains proved more convenient than steam trains, by the 1950s many countries had electrified mainline railways, since the 1960s North Sea gas replaced coal for heating in a number of Western European countries, and the same gas began to compete with coal for utility-scale power generation in the 1990s. Today, coal is used mainly for heat and power generation, iron and steel making and cement production, so the 2030s and 2040s will likely see some dramatic changes in these industries. While steel producers might gradually turn to "green" hydrogen and the direct reduction of iron ore, a complete switch would require enormous volumes of hydrogen from electrolysers powered by renewable energy sources or nuclear power. Perhaps steel itself will be

Figure 6
EU Emissions Trading System revenues, 2013 to 2022



Source: EEA, 2023

replaced by a better alternative that does not suffer from corrosion. The cement sector and others are considering alternatives such as carbon capture, use and storage (CCUS) and this maturing technology is likely to become more important as the EU strives for net-zero greenhouse gas (GHG) emissions by 2050.

The road ahead for Europe's coal regions during a just transition

The phase-out of coal for power generation is a political, rather than an economic decision, and has uncertain outcomes. To fulfil its obligations under the UNFCCC Paris Agreement of 2015, the European Union has decided to steadily wind down electricity production from solid fossil fuels – coal, lignite, peat and oil shale. For coal-intensive regions, this has led to or will lead to radical disruptions of coal value chains and labour markets. In response, the EU has agreed a Just Transition Mechanism mobilising around €55 billion over the period 2021-2027 to alleviate the impacts of the energy transition. Other, similar programmes also exist at the nation state level.

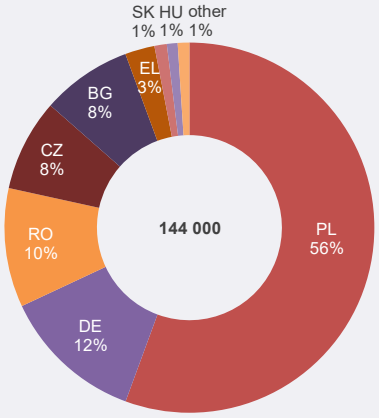
Coal industry's position on just transition

The European coal industry supports the principle of a "just transition" and policies to implement it that are effective, fair and transparent. For example, EURACOAL members participate in the EU initiative for the coal regions in transition or "coal platform", as well as the related initiative for the Western Balkans and Ukraine. These initiatives now sit under the broader Just Transition Platform that addresses the issues of a clean transition for all energy-intensive industries. The exchange of best practices and targeted support for those regions and companies undergoing transition are important aspects of the EU initiatives. An ideal just transition would enable coal companies to transform their businesses so that jobs are preserved. A productive dialogue between politicians, industrialists, trade unionists, citizens and other stakeholders can help to achieve this outcome.

Energy transition is a socio-economic challenge

Three quarters of all coal-related jobs are in the mining sector. The regions with the highest number of jobs at coal mines and coal power plants lie in Poland, Germany, Romania, Czechia and Bulgaria. Even with a successful transition, it will be challenging to replace the long coal-value chains that support thousands of skilled jobs at equipment and material suppliers and service providers, as well as professional jobs for managers, engineers and scientists. The European Commission estimates that there are nearly 130 000 indirect jobs in coal-related activities (JRC, 2021). The regions with the highest shares of indirect jobs are found in Germany (Brandenburg, 28 000 indirect jobs), Poland (Silesia, 14 000 and Łódzkie, 7 300) and Romania (South-West Oltenia, 6 400). Other sources estimate that the coal-value chain – including power generation, equipment supply, services, research and development and other activities – supports 215 000 indirect jobs in the European Union (European Parliament, 2019).

Figure 7
Share by member state of the EU total number of jobs at coal mines and coal-fired power plants, 2022



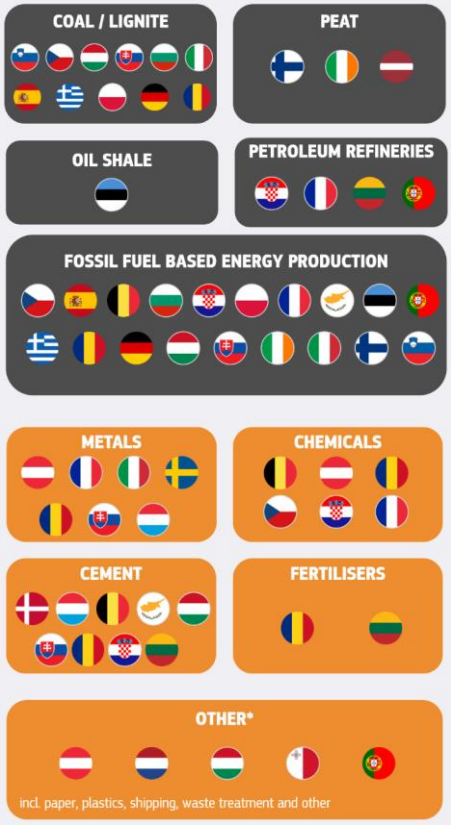
Source: Table 1 above

A big challenge is to mitigate the impacts of losing three hundred thousand direct and indirect jobs in a timely fashion. While early retirement can be attractive to some, younger employees in regions with coal phase-out plans face the risk of unemployment. Policy must encourage enough new jobs – ideally within the existing energy companies – to give continuity and stability during what should be a just or fair transition.

The Just Transition Mechanism offers compensation and vision

With its budget of €55 billion over six years, the Just Transition Mechanism aims to disburse around €9 billion each year between 2021 and 2027. For comparison, the turnover of the EU coal mining industry was an estimated €27 billion in 2022, while the value of coal imports into the EU added €21 billion to give a coal sector value of €48 billion. The value of downstream activities in power generation, so excluding coke, iron, steel and cement production, was approximately €110 billion. This hints at the scale of the challenge ahead: EU funds compensate for only a small fraction of the added value created each year by such a large industry. While jobs in one industry are phased out, new jobs need to be created. This requires public and private investment – tens of billions of euros – and a willingness by skilled workers in the coal industry to take up new positions in what are likely to be very different working environments.

Figure 8
Declining sectors (grey) / Transforming sectors (orange)



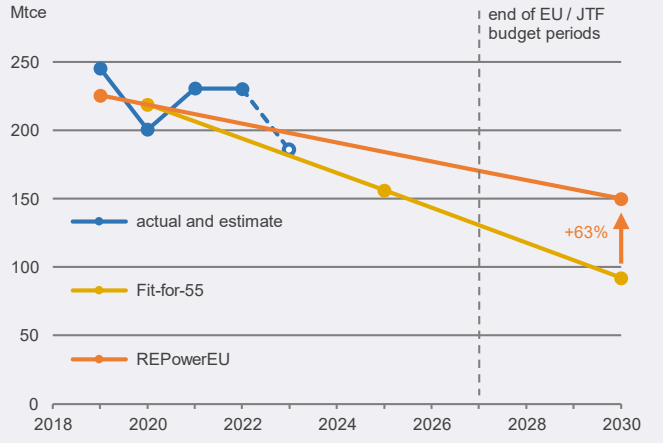
Source: European Commission, 2021a, p.4

In 1997, Germany decided to phase down hard coal mining. In another key decision, taken in 2007, the policy switched to a phase out and the last mine closed in December 2018. Hard coal mining in the Ruhrgebiet and Saarland from 1958 to 2019 received public subventions of €152 billion (perhaps €500 billion in today's money).[1] For a just or fair transition, comparable sums and comparable timeframes are needed in other coal regions. In its REPowerEU initiative, the European Commission (2022b, p.10) aims at 36% less coal use in the EU by 2030 which would mean a 25% reduction by 2027 when the Just Transition Mechanism ends (Figure 9). So, the European Commission's own projections show that the Just Transition Mechanism's €55 billion covers only one quarter of the likely aid needed to transform the EU coal sector.

The costs of transition are not shared uniformly: the largest burdens fall on national governments, the coal regions, energy companies, and the citizens affected. EU funds are a small but politically important part of the whole as they can incentivise action. In Europe, the countries and regions facing the biggest coal phase-out challenges also have a lower *per-capita* GDP than the EU average (EURACOAL, 2020, p.12). This has been a factor behind the slower deployment of renewable energy sources in carbon-intensive regions. For example, the €81 billion of state support for renewable power generation in 2021 – over €180 per person (or €410 per household) – was skewed towards richer member states. While today, some renewable projects are auctioned, and costs have decreased, countries with tighter budget constraints have not developed as much clean power generation as their more affluent neighbours. Coal phase-outs are thus a matter of European cohesion, a policy area where the European Commission Directorate-General for Regional and Urban Policy can and does exercise its wide competences.

The citizens of Europe's coal regions are the first to face the consequences of transition through rising energy prices, collapsing regional value chains and job losses. The EU ETS – now expanding to cover households and transport – is designed to increase the costs of fossil fuels for all consumers and so encourage energy savings and a switch to alternatives. However, paying for alternatives such as heat pumps is not always easy for consumers, so lower costs and targeted support are prerequisites for success.

Figure 9
EU coal demand according to the REPowerEU Action Plan



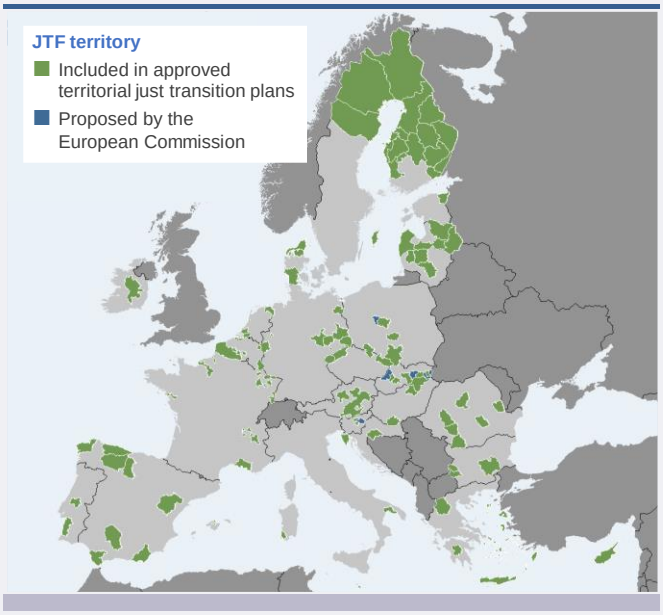
Sources: European Commission, 2022b, Figure 1; Eurostat nrg_bal_s database, last updated 19.12.2023; and Eurostat nrg_cb_sffm database last updated 21.12.2023 (2023 estimate)

The Just Transition Fund in focus

Since July 2021, the three pillars of the Just Transition Mechanism – the Just Transition Fund, the InvestEU "Just Transition" scheme and the European Investment Bank's public sector loan facility – have helped reduce the burdens of energy transition in the EU coal regions. Eligible regions have a heavy economic dependence on the fossil fuel industry or other energy-intensive industries (*e.g.* steel, cement and chemicals) – territories were identified by member states and the European Commission. EU funds are allocated to the identified regions based on their *territorial just transition plans* which must be prepared to align with EU emission reduction targets for 2030 and on track to achieve net-zero emissions by 2050.

[1] *Estimated from Storchmann, 2005; Frondel* et al.*, 2006; European Commission, 2011; and Oei* et al.*, 2020.*

Figure 10
JTF territories in the EU



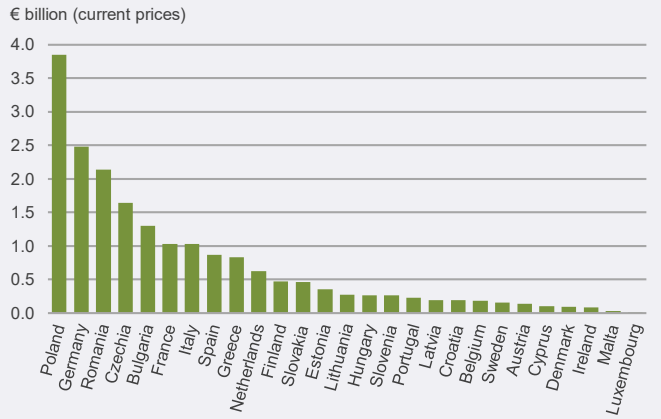
Source: Just Transition Platform, DG REGIO, January 2024

As of October 2023, most territorial just transition plans had been approved and the focus has switched to their speedy implementation to disburse funds during the EU multi-annual financial framework that ends in 2027. Funding aims to diversify local economies and "reskill or upskill" workers and jobseekers, alongside technical assistance and support for research and innovation, energy efficiency, renewables, smart and sustainable local mobility, digitalisation, soil regeneration, a circular economy, facilities for child- and elderly-care, and training centres.

Unfortunately, large enterprises can only benefit from funding for productive investments under very specific criteria, hampering the continuity of employment at long-established, regional companies who wish now to diversify their activities. Explicitly excluded is investment related to the production, processing, transport, distribution, storage or combustion of fossil fuels. This then would exclude environmentally friendly investments into, for example, efficiency improvements at district heating plants or the capture and use of coal mine methane at mines.

Projects selected in territorial just transition plans include the €19 million construction of a rare-earth magnet factory in Narva, Estonia, creating up to one thousand new jobs in an oil shale mining region, and decarbonisation projects at industrial processes in Sweden, such as the direct reduction of iron ore with hydrogen at a steel plant in Norrbotten to eliminate the need for coking coal, and the construction of a carbon capture and storage (CCS) facility at a cement works in Gotland. All these and others will keep industrial activity in the respective regions, saving jobs and value chains.

Figure 11
Just Transition Fund (JTF) allocations by member state



Sources: European Commission, 2020b and 2022c

Land restoration post mining

In line with the "polluter pays principle", coal companies have a good record of restoring the landscape at mines and power plants, often leading to a net increase in biodiversity. In some of the EU's mining regions, dedicated agencies,

companies or foundations have been set up to organise mine closures, the rehabilitation of mining sites and the ongoing tasks of subsidence monitoring, water management and gas control, such as SRK in Poland and the RAG Foundation in the German Ruhrgebiet and Saarland. The energy transition away from coal means an acceleration of these efforts, often earlier than planned. This is recognised in the Just Transition Mechanism, as territorial just transition plans must address issues such as land restoration, soil contamination, water treatment, geophysical instability, and other environmental hazards.

Research and innovation can support transition

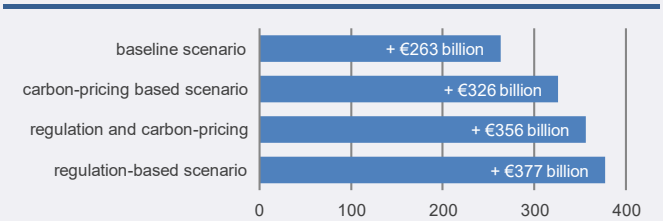
An important source of funding for the coal sector's transition is the EU Research Fund for Coal and Steel (RFCS). This fund has the clearly stated goal to support research projects on formerly operating coal mines or coal mines in the process of closure and related infrastructure in line with the EU treaties and the European Green Deal. This includes the methane abatement and use projects that are excluded from the Just Transition Mechanism. In the recently awarded Mine-to-H_2 project, partners will demonstrate how existing mine water management installations can be used together with renewable energy sources and an electrolyser to produce green hydrogen. This is just one example of how innovative solutions can repurpose coal-related infrastructure in the regions, create new economic value, and offer continued, high-skilled employment.

A long-term perspective on just transition

If supported with sufficient, well-targeted, long-term funding, the energy transition is an opportunity for the EU to show that structural change does not need to be feared. As other sectors of the economy must also curb their emissions, they will face challenges like the coal sector. The automotive sector of the 2030s will look very different from today as long supply chains must switch to produce components for electric vehicles in an increasingly globalised market. The reverse is also true: if the just transition is seen to be failing, EU policy makers will struggle to convince citizens and stakeholders to support further initiatives under the European Green Deal.

The coal regions will need support beyond 2027; according to the REPowerEU Action Plan, EU coal consumption in 2027 will be at 75% of 2020 levels, *i.e.* around 340 million tonnes. If the EU wants to continue the path of a gradual coal phase-out, continued support will be needed. At the same time, policy instruments should be flexible enough to support evolving carbon capture and storage technologies, as well as to protect against sudden energy-supply crises, as witnessed in 2021 and 2022. It will take time and effort to replace the energy security that coal offers.

Figure 12
Additional investment needed for an energy transition in the EU, 2021 to 2030



Source: European Commission, 2020c, p.69

Economists and scientists believe the race to net-zero emissions will lead to higher, more sustainable growth. They do not agree, however, on the costs of energy transition. Some compare the challenge to the Arab oil embargo of 1973 and resulting oil price shock which saw prices quadruple in the first quarter of 1974, leading to inflationary pressures and slower growth in all Western economies. For some sectors, the rapid increase in carbon prices in the EU coupled with high fossil gas prices have a similar impact today.

According to the European Commission, additional investments in the EU energy sector in the decade to 2030, compared with the previous decade, should be in the range of €263 billion to €377 billion, or 1.5% to 1.8% of GDP (Figure 12). Although the impact on individual member states is still to be assessed by the European Commission, the additional investment over a business-as-usual scenario is about €2 000 per household – the cost of a room-sized heat pump. While incentives and subsidies could help, it is not clear whether governments are willing or able to increase national debts.

If these green investments replace other, more productive investments, they may have a similarly negative impact on growth as the oil shocks of the 1970s; reducing fossil fuel use does not necessarily increase productivity. More generally, the rapid market changes will mean job losses in some sectors, while others struggle to find the skilled workers they need, thus driving wages and inflation higher as in the 1970s. The challenges of a clean energy transition should not be underestimated!

International coal market and global energy trends

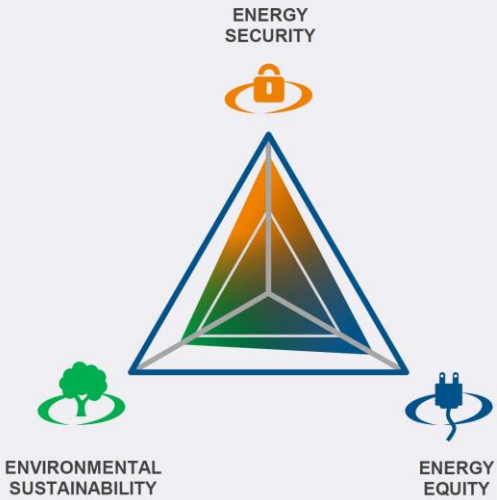
Around the world, coal makes a vital contribution to the security of energy supply. It is a competitive fuel and adds economic value wherever it is used: for steelmaking, for cement production and, most importantly, for electricity and heat generation. A diverse energy mix with modest coal use can be part of a strategy that reduces risk and underpins 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 growing 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 will influence these trends.

Coal and sustainability

The European coal industry believes that the three energy sustainability objectives – security of supply, competitiveness and environmental compatibility, including climate protection – must be pursued with equal vigour. 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 be needed for some years to come, so they need to be sustainable.

Figure 13
The energy trilemma according to the World Energy Council



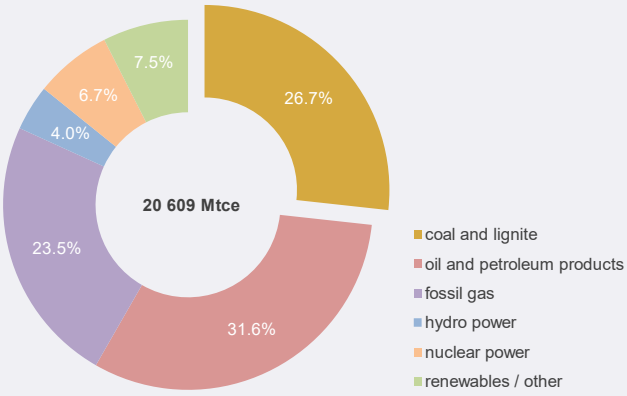
Source: WEC, 2022

A key requirement for sustainable energy supplies in Europe is competitiveness. Energy at affordable and equitable prices helps to maintain the competitiveness of European industry as a whole and allows citizens to enjoy a high standard of living.

In 2021, even after accounting for exports, the EU imported 57.1% of all the energy it consumed: 95.1% of its crude oil needs, 83.5% of its fossil gas and 37.5% of its coal. This import dependency is rising. Managing energy supply risks was an integral part of the Energy Union strategy of 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 indigenous and imported energy sources, including hard coal and lignite, helps to limit supply risks.

Electric power is no longer generated using conventional hydro, coal, gas and nuclear energy alone. Today, new renewable energy sources, mainly wind turbines and solar PV, are growing in importance, but still require reliable backup from conventional sources, at least until large-scale electricity storage options become available. By valuing the flexibility and reliability of coal- and lignite-fired power generation, there is great scope for deploying renewables to the maximum possible extent. The key to Europe's future power generation lies in a broad mix of energy sources, so that supply risks are minimised, reliability maximised, affordable electricity enjoyed, and further progress made in environmental and climate protection towards net-zero emissions by 2050.

Figure 14
World total primary energy supply by fuel, 2022

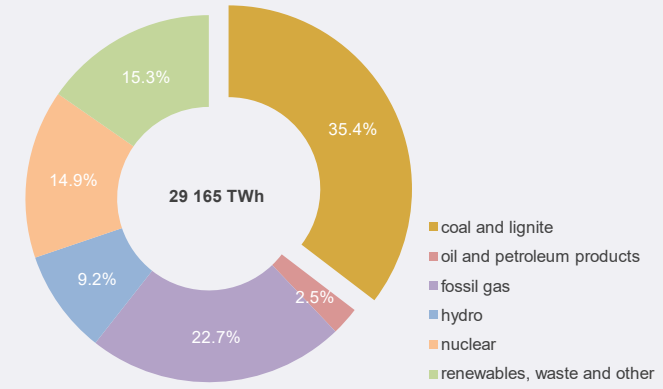


Source: Energy Institute, 2023 (excludes non-commercial biofuels)

Global energy mix and coal

World total primary energy supply in 2022 was 20 609 million tonnes of coal equivalent (Mtce) of which 26.7% came from coal. Coal is of particular significance for electricity generation. Over one third or 35.4% of global power generation and 17.1% of EU power generation in 2022 was based on coal.

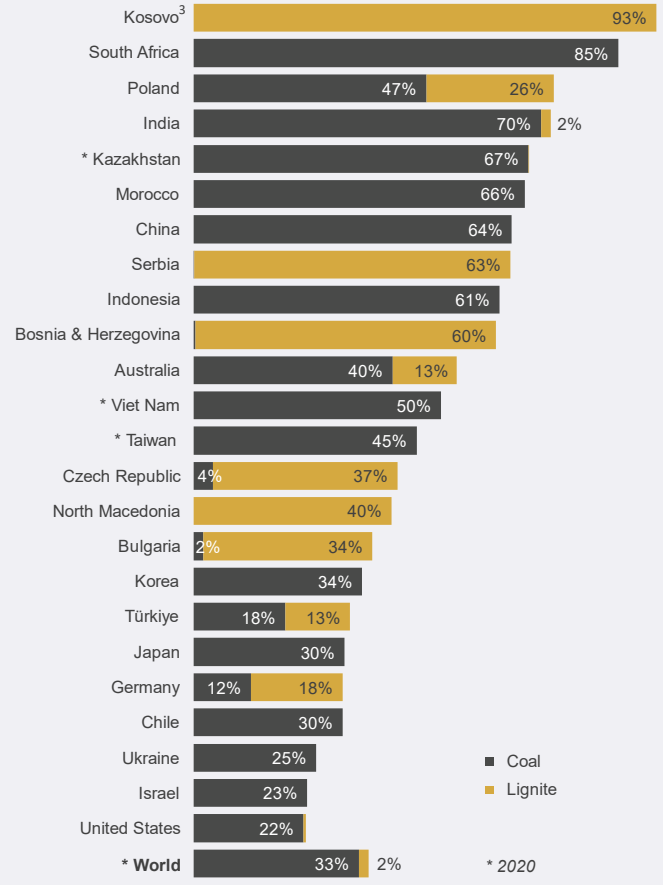
Figure 15
World electricity generation by fuel, 2022



Source: Energy Institute, 2023

According to ENTSO-E (2023), 443 TWh of net electricity generation in the EU came from solid fuels in 2022 (213 TWh from hard coal, 222 TWh from lignite and the remainder from oil shale and peat). Hard coal-fired power plants in the EU have a total net capacity of 80 GW and lignite-fired power plants add a further 49 GW. Individual countries have very different energy mixes for power generation, with coal being indispensable in many (Figure 16 and table on page 83).

Figure 16
Shares of coal- and lignite-fired power generation in gross power generation around the world, 2021



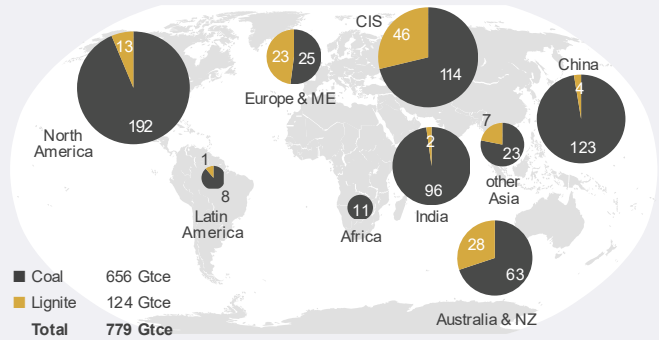
Source: IEA databases (including coal gases and coal products)

World coal resources

Coal and lignite are superabundant: total resources are estimated at 15 883 billion tonnes of coal equivalent (Gtce). Less than 2% of the initially in-place coal resources have been extracted. Current coal reserves amount to 779 Gtce – greater than the combined reserves of oil and gas, even when non-conventional oil and gas are included. In fact, coal reserves account for over half of all conventional energy reserves and are distributed more equally than those of oil, gas or uranium.

The world coal market is a freely traded commodity market, which – in contrast to oil and gas markets – is little influenced by geopolitics or the formation of cartels.

Figure 17
Global hard coal and lignite reserves, 31 December 2021



Source: BGR, 2023 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 in the EU. 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 gas, coal does not require large strategic stocks to safeguard against political risks.

Table 2
Conventional energy reserves in the European Union, 2021

	Gtce	share
Hard coal	23.5	56.7%
Lignite	16.0	38.6%
Oil	0.7	1.6%
Fossil gas	0.6	1.4%
Uranium	0.6	1.6%
Total	41.4	100.0%

Source: BGR, 2023 and own calculations

International coal market

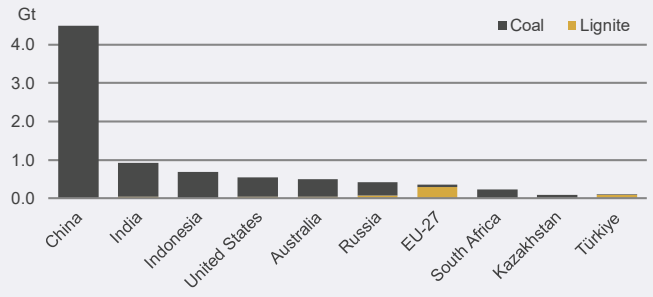
The largest coal producers in 2022 were China and India, followed by Indonesia and the United States. Australia was the fifth largest producer and is the world's largest exporter of steam and coking coal by value. The European Union was the seventh largest producer, being the world's largest producer of lignite by a wide margin. The top-10 producing countries – which includes Germany – accounted for 93% of total world production.

Table 3
Largest coal producers, 2022

	Country	Steam and coking coal (Mt)	Lignite (Mt)	Total (Mt)
1	China	4 495.8	0.0	4 495.8
2	India	868.1	47.6	915.7
3	Indonesia	684.5	0.0	684.5
4	United States	496.8	43.1	539.9
5	Australia	444.9	46.6	491.5
6	Russia	348.6	77.6	426.2
7	EU-27	54.6	294.3	348.9
8	South Africa	229.6	0.0	229.6
9	Kazakhstan	90.5	5.3	95.7
10	Türkiye	1.5	87.3	88.8
	others	256.9	110.8	367.8
	World	7 971.8	712.7	8 684.4

Sources: IEA Quarterly Coal Statistics, June 2023; and EURACOAL Market Report 2023 no. 1

Figure 18
Largest coal producers in 2022, billion tonnes



Sources: ibid.

Important exporters of steam coal and coking coal are Indonesia, Australia, Russia, the United States, South Africa and Colombia. Together, they accounted for 90% of all coal exports in 2022. The twenty-seven member states of the European Union accounted for 9.6% of global coal import trade and 5.5% of world coal consumption in 2022.

According to Eurostat data (Figure 19), Russia supplied more than half of the coal imported into the European Union in 2021, followed by Australia and the United States. Other important suppliers included Colombia, Canada and South Africa. New suppliers such as Kazakhstan and Mozambique have emerged, especially since August 2022 when EU sanctions put an end to Russian coal imports.

Table 4
Largest coal exporters, 2022

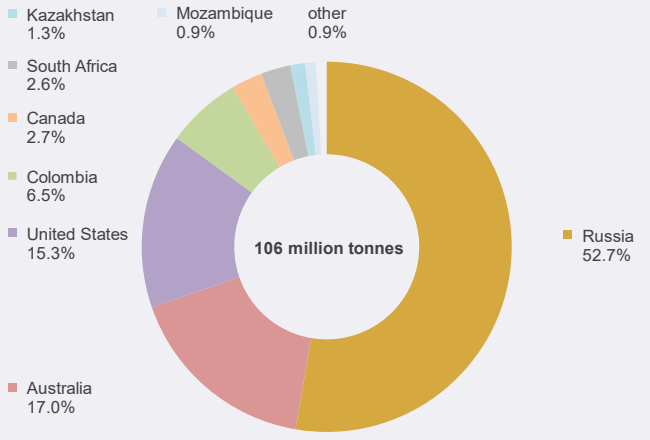
	Country	Coking coal (Mt)	Steam coal (Mt)	Total (Mt)
1	Indonesia	1.5	470.9	472.4
2	Australia	157.8	178.6	336.4
3	Russia	31.9	158.9	190.8
4	United States	41.4	30.8	72.2
5	South Africa	0.4	71.4	71.8
6	Colombia	2.2	53.7	55.9
7	Canada	28.1	8.2	36.3
8	Kazakhstan*	1.5	31.0	32.5
9	Mongolia*	17.0	14.7	31.7
10	Mozambique*	4.8	8.0	12.8
	others	13.4	10.0	23.4
	World	299.9	1036.2	1 336.2

Sources: IEA Quarterly Coal Statistics, June 2023; and
** McCloskey by OPIS databases*

Utility scale electricity generation, combined heat and power, and heat production at municipal plants are the main uses of coal in the European Union, accounting in 2022 for two thirds of all coal and lignite use on an energy basis. At 1.1 tonnes per person, the annual *per-capita* coal consumption of EU citizens matches the global average.

The top coal importing countries are China, India, Japan, Korea, Taiwan and Türkiye, together accounting for 61% of all coal trade in 2022. In the European Union, Germany and Poland were the biggest coal importers in 2022, followed by Italy, Spain, the Netherlands and France.

Figure 19
Coal imports into the EU by country of origin, 2021



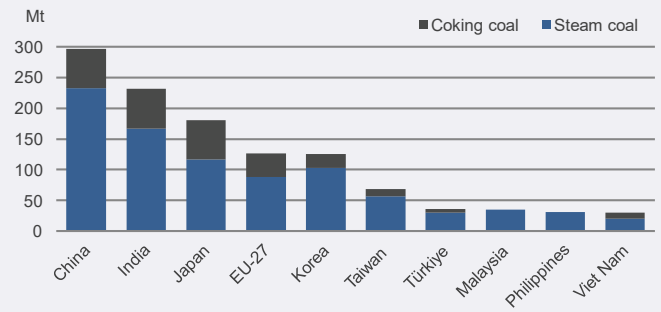
Sources: Eurostat nrg_ti_sff and nrg_te_sff databases, last updated 03.05.2023

Table 5
Largest coal importers, 2022

	Country	Coking coal (Mt)	Steam coal (Mt)	Total (Mt)
1	China	63.8	233.2	297.0
2	India	64.7	167.0	231.7
3	Japan	64.2	116.6	180.8
4	EU-27	38.3	88.5	126.8
5	Korea	22.3	102.8	125.1
6	Taiwan	11.1	57.0	68.1
7	Türkiye	5.0	30.5	35.6
8	Malaysia*	0.0	34.5	34.5
9	Philippines*	0.0	31.5	31.5
10	Viet Nam*	9.0	20.6	29.6
	others	24.0	137.5	161.5
	World	302.4	1 019.8	1 322.2

*Sources: IEA Quarterly Coal Statistics, June 2023; EURACOAL Market Report 2023 no. 1; and * McCloskey by OPIS databases*

Figure 20
Largest coal importers in 2022, million tonnes



Sources: ibid.

Global seaborne hard coal trade is estimated at 1 123 million tonnes in 2022, of which 851 million tonnes were steam coal and 272 million tonnes coking coal. Seaborne coal trade can be divided into Pacific and Atlantic markets, each with different supply patterns.

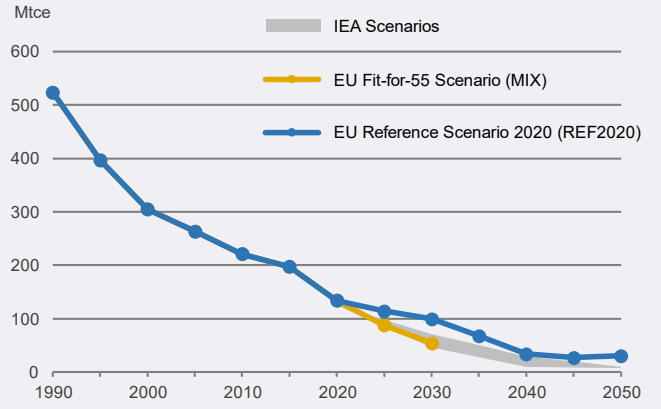
Figure 21
World traded coal flows in 2022

Source: VDKi, 2023

Global energy trends

Future world energy scenarios to 2050 from the International Energy Agency (IEA) and other respected bodies show only modest increases or even decreases in total primary energy consumption, with similar volumes of oil, coal and fossil gas in the energy supply mix but a growing share of renewables. In scenarios designed for low or net-zero CO_2 emissions, the share of renewables overtakes the combined share of conventional energy sources, including fossil, hydro and nuclear, while energy demand is curtailed below today's level.

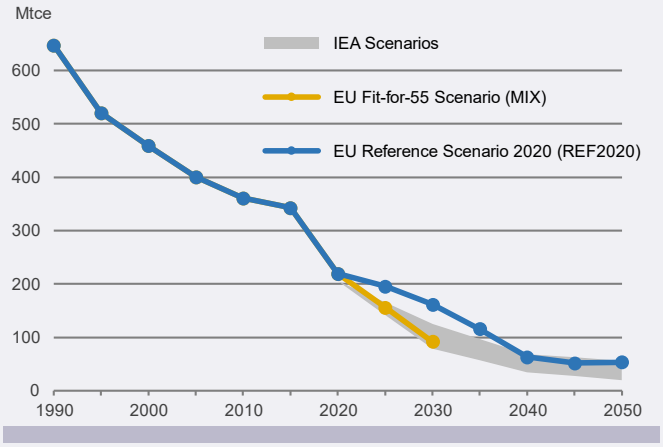
Figure 22
EU production of coal and lignite



Sources: European Commission, 2021b & 2021c; and IEA, 2022

Under the European Climate Law of 2021, the EU has agreed to reduce greenhouse gas emissions by at least 55% by 2030, compared with 1990 levels, and reach "climate neutrality" by 2050. Long-term projections by the European Commission show that residual man-made emissions must be balanced by enhanced removals, including carbon capture, use and storage (CCUS). Coal and lignite are expected to have a declining role: by 2050, total EU coal production might be just 38% of current Polish production.

Figure 23
EU consumption of coal and lignite

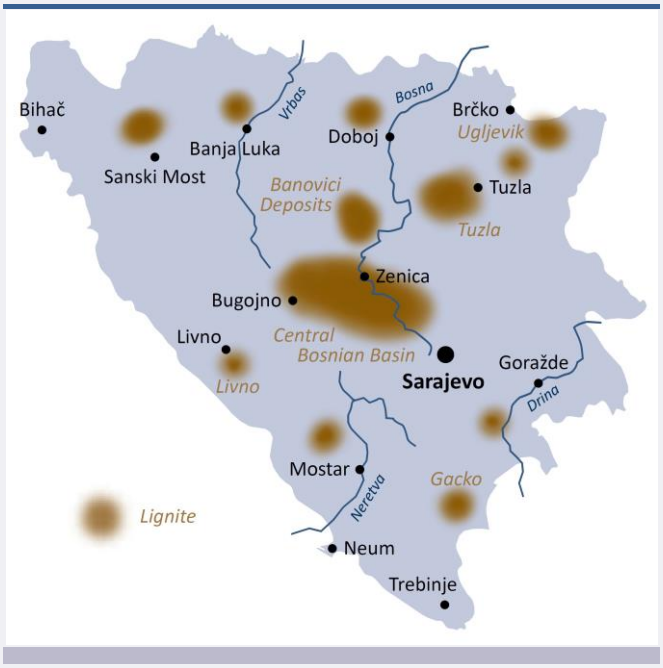


Sources: European Commission, 2021b & 2021c; and IEA, 2022

Bosnia and Herzegovina

Bosnia and Herzegovina has been a candidate for EU membership since December 2022. It shares most of its border with EU- and Schengen-member Croatia and exchanged 63% of its trade with the EU in 2022, followed by Serbia, China and Türkiye. Since a bloody civil war between 1992 and 1995, the country is divided administratively and politically in two parts of similar size: the Federation of Bosnia and Herzegovina and Republika Srpska. Coal plays a crucial role in its energy mix, accounting in 2021 for over one half of total primary energy supply and 60.4% of its electricity production, followed by 36.7% hydro and 2.1% wind. Bosnia and Herzegovina is a net electricity exporter (to Serbia, Croatia and Montenegro). In 2022, it exported 7.3 TWh and imported 4.3 TWh.

Bosnia and Herzegovina's total lignite resources are estimated at 5.3 billion tonnes, while the economically exploitable reserves are estimated at 2.3 billion tonnes. The largest coal deposits lie in the northeast of the country around Tuzla in the Kreka-Banovići coal basin. Bosnian lignite typically has a low calorific value of 9 100 kJ/kg (2 200 kcal/kg), a moisture content of 49%, an ash content of 13.8% and a high sulphur content (as-received values). In 2022, Bosnia and Herzegovina produced 13.3 million tonnes of lignite. This was mostly used to generate electricity at power plants near to coal mines. In addition, 1.3 million tonnes of coal were imported in 2022. The larger part of this was transformed into coke oven coke, of which 403 thousand tonnes were re-exported. Given the generally favourable coal market situation, the country also exported a record 832 thousand tonnes of lignite in 2022.



General data		2022
Population	million	3.2
GDP	€ billion	23.3
Per capita GDP	€/person	7 200

Federation of Bosnia and Herzegovina

ELEKTROPRIVREDA BOSNE I HERCEGOVINE (EPBiH) is a state-owned utility company in the Federation of Bosnia and Herzegovina with seven subsidiary coal mining companies: Rudnici „Kreka" (Šikulje and Dubrave opencast lignite mines and Mramor underground mine), RMU „Kakanj" (Vrtlište opencast mine, Haljinići underground mine and Begići-Bištrani underground mine which opened in July 2013), RMU „Zenica" (Stara Jama, Raspotočje and Stranjani underground mines), RMU „Breza" (underground mines at Sretno and Kamenice), RMU „Đurđevik" (Višća opencast brown coal mine and Đurđevik underground mine), and RMU „Abid Lolić" and RU „Gračanica" which operate opencast mines. The Livno (Tušnica) mine closed in 2015.

RMU BANOVIĆI operates two large opencast mines at Grivice and Turija, employing hydraulic shovels, draglines and 170-tonne trucks to mine a 12-metre seam. The Čubrić opencast mine was closed in 2011. Opencast mines at Banovići have an average overburden ratio of 5 cubic metres per tonne. The company also operates the partly mechanised Omazići underground coal mine. The 350 MW Banovići power plant proposed by RMU BANOVIĆI in 2015 did not materialise and the government's 2023-2030 draft energy and climate plan does not foresee any new coal-fired power plants.

Coal mines situated in northeast and central Bosnia serve the Tuzla and Kakanj power plants owned and operated by EPBiH. The 730 MW Tuzla power plant has three operational units and supplies heat to Tuzla and Lukavac as well as process steam to nearby industries 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 electrostatic precipitators. The application of the EU Large Combustion Plant Directive (LCPD), via its membership in the Energy Community, poses a challenge to the continuous operation of these units. Originally, it was planned to replace the existing units with two new 450 MW units. However, these units were not built due to political pressure, and all three units are threatened with premature closure. To meet EU

pollution standards, the 230 MW Tuzla 6 unit is being refurbished in 2023 by DONGFANG ELECTRIC CORPORATION and DONGFANG BOILER GROUP, together with the Bosnian company ITC GROUP Zenica. The 100 MW Tuzla 1 unit might be converted to fire biomass. 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. Similarly to the Tuzla plant, new units were planned but have not been built.

Republika Srpska

The Gacko coal mine and power plant in the south of the country as well as the Bogutovo Selo opencast mine and Ugljevik power plant in the east are operated by the state-owned ELEKTROPRIVREDA REPUBLIKE SRPSKE (EPRS). Other mines include Kamengrad mine and the Livno and Tušnica mines which supply Ugljevik power plant, although not all are in production. The Gacko and Ugljevik power plants, each of 300 MW, were commissioned in 1983 and 1985 respectively. In 2019, MITSUBISHI HITACHI POWER SYSTEMS and RUDIS of Slovenia completed a FGD retrofit project at Ugljevik power plant. Under a national emission reduction plan (NERP) agreed with the Energy Community, FGD at the Gacko plant will be needed from 2023. In the future, lignite for these plants could come from new opencast mines being developed by COMSAR ENERGY at Delići, Peljave-Tobut and Baljak and by EPRS subsidiary RUDNIK i TERMOELEKTRANA (RiTE) UGLJEVIK at Ugljevik-Istok. Plans to build an additional coal-fired power plant in the town of Ugljevik have been halted by a verdict of the District Court of Banja Luka annulling the environmental permit previously granted by the Ministry of Energy and the mining authority of Republika Srpska.

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 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. The UK-registered, Serbian-owned EFT GROUP owns the Stanari mine and power plant.

The 2023-2030 national energy and climate plan foresees the closure of 410 MW of coal-fired power plants and the construction of 2 GW of renewable energy capacity, of which 1.5 GW would be solar PV. Some coal-fired power plants would switch to biomass co-firing.

Bosnia and Herzegovina

Coal production, reserves and resources		2022
Brown coal and lignite saleable output	Mt	13.3
Brown coal and lignite reserves	Mt	2 264
Brown coal and lignite total resources	Mt	5 274

Saleable coal quality		
Brown coal net calorific value	kJ/kg	11 000 - 20 000
Brown coal ash content	% a.r.	24 - 42
Brown coal moisture content	% a.r.	6.6-18
Brown coal sulphur content	% a.r.	1.7-3.85
Lignite net calorific value	kJ/kg	9 000 - 12 500
Lignite ash content	% a.r.	13 - 19.5
Lignite moisture content	% a.r.	32 - 49
Lignite sulphur content	% a.r.	0.4 - 4.0

Coal imports / (exports)		2022
Hard coal	Mt	1.3 / (0.0)
Brown coal and lignite	Mt	0.0 / (0.8)

Primary energy production		2021
Total primary energy production	Mtce	7.5
Brown coal and lignite production	Mt / Mtce	12.8 / 4.5

Primary energy consumption		2021
Total primary energy supply	Mtce	10.5
Hard coal consumption	Mt / Mtce	1.5 / 1.1
Brown coal and lignite consumption	Mt / Mtce	13.2 / 4.6

Power supply		2022
Total gross power generation	TWh	16.3
Net power imports (exports)	TWh	(3.0)
Total power supply	TWh	12.1
Power generation from lignite*	TWh	11.1
Lignite power generation capacity	MW net	1 888

Employment		2022
Direct in coal mining and generation	number	13 350

** 2021*

Bulgaria

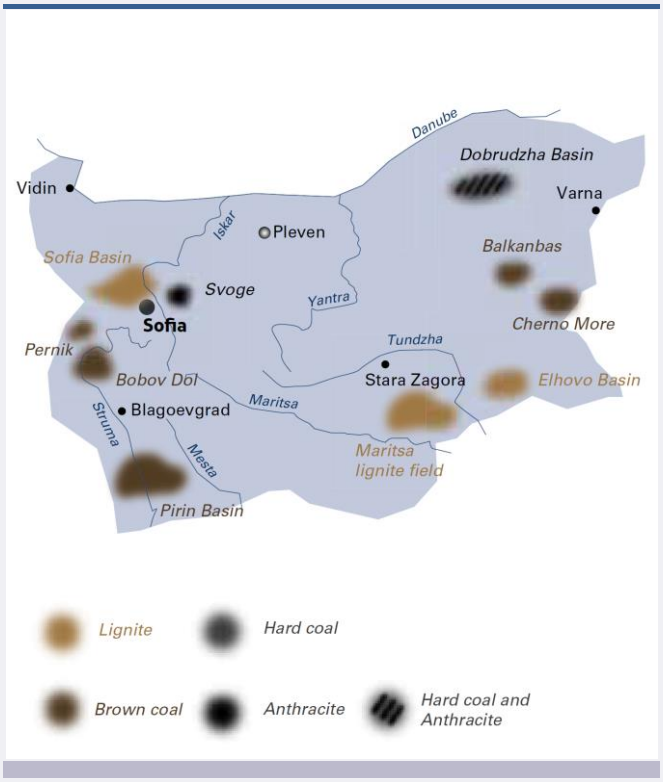
Since the global economic crisis of 2008, the Bulgarian economy has grown steadily, by up to 7% per year. In 2022, GDP growth was 3.9% and the unemployment rate was 2.7%. The national currency is pegged to the euro at a rate of 1.96 leva and Bulgaria intends to introduce the euro within the coming years which should further increase the country's attractiveness for foreign direct investment.

The Bulgarian mining industry is in a period of uncertainty and change as it faces the challenges of achieving the EU's ambitious decarbonisation targets. Nevertheless, with its large resource potential, the mining sector has been able to modernise by implementing environmental measures and investing in energy efficiency programmes. Priority investments are directed towards high-tech solutions and energy efficiency, all in compliance with the environmental requirements and standards of national and EU legislation.

In January 2023, the Bulgarian Ministry of Energy published a *Strategic Vision for Sustainable Development of the Energy Sector of the Republic of Bulgaria 2023-2053*. This envisages a phase-out of electricity production from coal and lignite by 2038, increased production from renewables and the roll out of electricity storage technologies. Based on this vision, the Bulgarian government is elaborating a new energy policy strategy to 2030 with a horizon to 2050. In September 2023, the government submitted territorial just transition plans for three coal mining regions to the European Commission. These were approved in December 2023.

Primary energy production totalled 19.3 million tonnes of coal equivalent in 2022, with lignite and brown coal having the highest share at 43.7%, followed by nuclear energy (31.9%) and renewables (22.9%). Non-renewable waste (0.8%), fossil gas (0.1%) and other sources accounted for the balance. Bulgaria's overall energy import dependency was 36.3% in 2021, far below the EU average of 57.1%.

Bulgaria has a diverse power generation mix, including conventional nuclear and thermal plants, alongside renewable energy sources (hydro, wind, solar and biomass). The power generation mix is dominated by thermal power plants using coal, followed by the 2 GW Kozloduy nuclear power plant on the Danube. Two new reactors are planned which would double the capacity of Bulgaria's only nuclear power plant. Gross electricity generation in 2022 was 50.5 TWh, 6.2% more than in 2021. The Bulgarian state uses the potential of indigenous coal to its maximum extent and in compliance with all environmental requirements. Thermal power plants using locally mined coal provided 43.1% of electricity production in 2022, a year when only thermal power generation grew – by 22.1% – while hydro and nuclear output fell.



General data		2022
Population	million	6.4
GDP	€ billion	85.8
Per capita GDP	€/person	13 300

MINI MARITSA IZTOK EAD (MMI) operates the largest lignite coal field in Bulgaria to supply lignite to thermal power plants for electricity generation and a briquetting plant. Brown coal is also mined in the Pernik and Bobovdol basins.

Saleable coal output in 2022 was 35.5 million tonnes, 25.5% more than in 2021. Most of the coal now produced in Bulgaria is classified as lignite (98%) and the remainder is brown coal (2%).

The Bulgarian energy sector is important for the country's energy-intensive industries and accounts for above EU-average shares in total employment and value added. The sector contributes to the socio-economic development and welfare of the coal mining municipalities.

Large investments in new capacity, the rehabilitation of old power plants and expansion of the electricity grid in recent years have allowed Bulgarian consumers to benefit from

reliable and affordable electricity. However, for electricity utilities, the regulated consumer tariffs are insufficient to cover new investments or even the cost of allowances under the EU emissions trading system, a situation exacerbated by the high number of consumers in arrears.

Lignite

With a total mining area of 240 square kilometres at the Maritsa Iztok (or Maritsa East) complex, MINI MARITSA IZTOK EAD (MMI) operates the largest mining site in southeast Europe and is the largest employer in Bulgaria. Lignite is mainly extracted in opencast mines where the total production of 34.3 million tonnes in 2022 was 104% of the production target. Including contracted quantities, the company delivered 15.5 million tonnes to the 1 620 MW Maritsa East 2 power plant owned by BULGARIAN ENERGY HOLDING, 9.9 million tonnes to the CONTOURGLOBAL 908 MW Maritsa East 3 power plant, 6.0 million tonnes to the AES 690 MW Galabovo power plant and 2.5 million tonnes to "BRICKEL" EAD for briquetting. A further 0.5 million tonnes were exported to Serbia. This was the first time in its 71-year history that MMI had exported coal outside the territory of its Maritsa Iztok complex.

The sale of Bulgarian coal outside the country is a major achievement for MMI and offers good prospects. In 2022, a contract was signed with the Serbian company VIROM GROUP to export 1.75 million tonnes of lignite to power plants near Belgrade at a price higher than that for deliveries to power plants in the Maritsa Iztok complex.

As a subsidiary of BULGARIAN ENERGY HOLDING, MMI plays an important role in ensuring national energy security. In the next few years, lignite produced by MMI will be used exclusively for thermal power generation whose share in the generation mix will remain stable. As there is no alternative to lignite in the immediate future, no significant reduction in lignite production or lignite-fired power generation is foreseen. Under the various new energy strategy scenarios, a decrease in lignite-fired power generation and consequent capacity closures are forecast after 2030 or when the new nuclear units are commissioned.

The selling price of lignite mined by MMI, despite being the lowest in the EU, will most probably remain unchanged in the years ahead. This has a negative impact on the company's ability to invest. Hence, the company will rely on European investment funds for its future development projects, including diversification projects such as a solar PV park on the spoil tip of a mine.

Private lignite mining companies accounted for small shares of national lignite production in 2022: STANYANTSI AD (0.7%) and BELI BRYAG AD (0.6%).

Brown coal

Bulgaria's brown coal deposits are mostly located in the western part of the country (the Bobov Dol, Pernik and Pirin coalfields and the Katrishte deposit) and near the Black Sea (the Cherno More coalfield where production ceased in 2016). In 2022, the production of brown coal accounted for 2% of total coal production. Two thirds were mined in the Bobov Dol basin and one third in the Pernik basin by two small private mining companies: VAGLEDOBIV BOBOV DOL EOOD and MINI OTKRIT VAGLEDOBIV EAD.

Bulgaria

Coal production, reserves and resources		2022
Brown coal saleable output	Mt	0.7
Brown coal reserves	Mt	190
Brown coal total resources	Mt	4 110
Lignite saleable output	Mt	34.8
Lignite reserves	Mt	2 089
Lignite total resources	Mt	4 489

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

Coal imports / (exports)		2022
Hard coal	Mt	1.3 / (0.0)
Lignite	Mt	0.0 / (0.5)

Primary energy production		2022
Total primary energy production	Mtce	19.3
Brown coal and lignite production	Mt / Mtce	35.5 / 8.4

Primary energy consumption		2022
Total primary energy supply	Mtce	27.6
Hard coal consumption	Mt / Mtce	0.7 / 0.5
Lignite consumption	Mt / Mtce	35.1 / 8.4

Power supply		2022
Total gross power generation	TWh	50.5
Net power imports (exports)	TWh	(12.2)
Total power supply	TWh	33.7
Power generation from hard coal	TWh	0.3
Power generation from lignite	TWh	21.8
Hard coal power generation capacity	MW net	356
Lignite power generation capacity	MW net	4 119

Employment		2022
Direct in brown coal and lignite mining	number	7 075
Direct in coal and lignite power generation	number	4 275

Czech Republic

The Czech Republic, like other countries, had to cope with the effects of Covid-19 and the subsequent energy crisis triggered by Russian aggression against Ukraine. After economic stagnation in the first half of 2023, the economy is expected to pick up with an annual growth rate of over 2%. Inflation is expected to fall below 3% and the unemployment rate should also remain below 3%. Among EU member states, the country has the highest share of industry (including construction) in GDP at 30.7%.

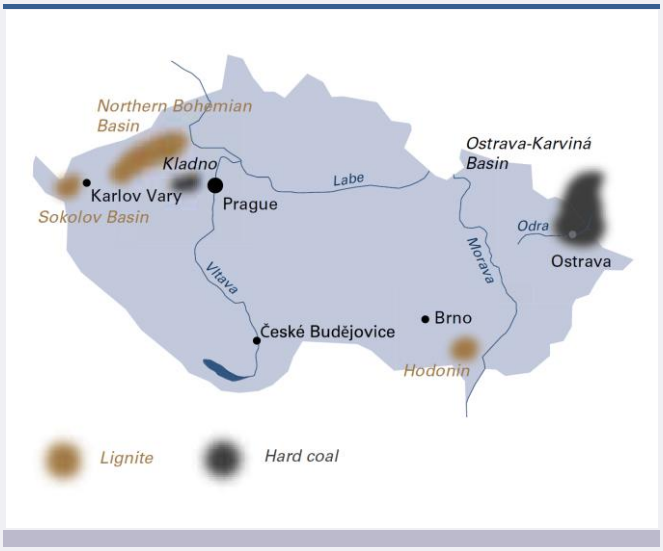
Coal is the only significant indigenous energy resource in the Czech Republic; economically recoverable coal reserves are estimated to total 568.4 million tonnes. Brown coal, with recoverable reserves of 562.7 million tonnes, is mainly produced in north-western Bohemia, while hard coal reserves (5.7 million tonnes) are mined in northern Moravia. Hard coal is consumed locally at heat and power plants or at steelworks.

Total energy supply was 59.4 million tonnes of coal equivalent (Mtce) in 2022, comprising: 32.3% coal (19.2 Mtce total of which an estimated 5.0 Mtce was hard coal and 14.2 Mtce was brown coal), 22.7% oil (13.5 Mtce) and 15.2% fossil gas (9.1 Mtce). The energy mix also includes nuclear energy with an 18.5% share in 2022 (11.0 Mtce), and non-renewable waste which accounted for 0.8% (0.5 Mtce). Biofuels, solar, hydro and wind power supplied the 13.1% (7.8 Mtce) of renewable energy. Electricity exports were the balancing -2.8%.

The Czech Republic's dependence on energy imports has been quite modest to date but is growing; 42.1% of energy demand was met by net imports in 2022. However, imports are structurally imbalanced with a nearly 100% dependency on imported oil and gas. A number of direct and indirect measures are being adopted to reduce dependence on energy imports, including increased energy efficiency, the promotion of renewable energy sources, and the efficient use of indigenous solid fuel resources, mainly brown coal.

In 2022, 43.8% of national gross electricity production of 84.8 TWh came from hard coal and lignite-fired power plants with a total net capacity of 8 450 MW. Fossil gas-fired power generation had a 5.1% share. Nuclear power plants supplied 36.6% of gross generation and 12.7% came from renewable energy sources including hydro. Pumped hydro and other sources, including plants running on gases from coke ovens and blast furnaces, accounted for the balance. After rapid growth from 2009 to 2011, output from solar PV has stagnated, with 2.6 TWh in 2022 when output from wind turbines was just 0.6 TWh.

There are five coal mining companies in the Czech Republic, namely OSTRAVSKO-KARVINSKÉ DOLY, the only hard coal producer, and four brown coal mining companies:



General data		2022
Population	million	10.8
GDP	€ billion	276.2
Per capita GDP	€/person	25 500

SEVEROČESKÉ DOLY, the biggest producer of brown coal – owned by ČEZ; VRŠANSKÁ UHELNÁ, with coal reserves to last until 2055, and SEVERNÍ ENERGETICKÁ – both part of SEV.EN ČESKÁ ENERGIE, and SOKOLOVSKÁ UHELNÁ, the smallest of the brown coal mining companies. All five are publicly listed or in private ownership. The majority state-owned utility company, ČEZ, is the largest coal consumer in Czechia and the most important supplier of electricity.

The Czech coal industry has played a significant role in the national economy for years and will undoubtedly continue to do so for years to come. In 2022, the share of coal in gross electricity production amounted to 44.1% (brown coal 40.6% and hard coal 3.5%). Even so, the Coal Commission has proposed to phase out coal in 2038, and the government manifesto recommends 2033. According to an ongoing update of the *State Energy Policy,* Czechia's future energy mix will be based on nuclear and renewable energy sources.

Hard coal

The Czech Republic has 5.7 million tonnes of economically recoverable hard coal reserves, with the largest deposits located in the Upper Silesian coal basin. Having 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 fifth (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 a deep mine: ČSM in Stonava, with two operations in the northern and southern districts. It is the last active deep mine in the country. According to the company's medium-term plan, ČSM will be operational until the end of 2025. In 2022, OKD's saleable output was 2.1 million tonnes, with a workforce of 2 569 own employees and 730 contractors.

The thickness of worked coal seams at the ČSM mine ranges from 1.5 to 6.5 metres. Production at OKD is mainly by longwall cutters with shearer loaders, combined with controlled caving. The last longwall working with a plough finished in 2021. Raw coal is washed in the coal treatment plant and sold as coking or steam coal, based on its quality.

Brown coal (lignite)

The Czech Republic has 562.7 million tonnes of exploitable brown coal reserves. In addition to a coal basin in North Bohemia and another basin near the town of Sokolov, there are coalfields in the south of the country, although these are not economically viable. Production of brown coal totalled 33.4 million tonnes in 2022 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 North Bohemian brown coal basin, which is located at the foothills of the Krušné hory mountains, along the border with the German state of Saxony, in the vicinity of the towns of Kadaň, Chomutov, Most, Teplice and Ústí nad Labem. The coal seams in this area lie at depths of up to 400 metres and are between 15 and 30 metres thick.

In the central part of the North Bohemian brown coal basin, brown coal is extracted by two mining companies: VRŠANSKÁ UHELNÁ (VUAS) and SEVERNÍ ENERGETICKÁ (SEAS). Both are members of the vertically integrated energy company SEV.EN ČESKÁ ENERGIE (SEV.EN) and together employ 2 700 people for coal production out of a total group workforce of 3 262 in 2022.

VUAS 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 2022, VUAS extracted 7.8 million tonnes of brown coal.

SEAS exploits the ČSA surface mine that produced 2.4 million tonnes in 2022. The end date for mining at the ČSA mine is currently planned for 2025 or 2026, depending on market demand and the exploitation rate. For the rehabilitation of the ČSA mine, the Green Mine project is being prepared with a strategic, long-term revitalisation plan for the large areas affected by the mine. This project will transform the mining district into a modern location with high-tech industrial zones, smart residential development, renewable energy sources and new business activities.

SEV.EN operates two brown coal-fired power plants, Elektrárna Počerady and Elektrárna Chvaletice. The 820 MW Chvaletice power plant is the younger of the two power plants and comprises four units that can generate electricity for baseload or for peak demand by operating in two-shift mode (12 hours per day) with output ranging from 100 MW to 820 MW.

The 1 050 MW Počerady power plant is the largest brown coal-fired power plant in the Czech Republic. The plant has five pulverised-fuel boilers connected to condensing turbines.

Both of the SEV.EN power plants have been certified to provide balancing services for electricity grid stability and also for so-called island-mode operation. In the event of an emergency, operating in island mode can prevent blackouts.

SEV.EN also operates two combined heat and power plants, Teplárna Kladno and Teplárna Zlín, with a total production capacity of approximately 600 MW electrical and 1 300 MW thermal. The Kladno plant is a major heat and power producer in Central Bohemia, supplying heat to households and industrial customers in the Kladno region from its five blocks. The plant also plays an important role in stabilising the Czech power grid as it provides balancing services and serves as a potential back-up power source for the Prague metropolitan area. The Kladno and Zlín plants have been upgraded to burn biomass in the form of wood chips in addition to brown coal. More than 90 000 MWh of electricity was generated in 2022 using green fuel, for which the electricity and gas market operator (OTE) issued guarantees of origin certificates, thus rewarding this environmentally friendly way of generating renewable electricity.

The brown coal mining company SEVEROČESKÉ DOLY (SD), based in the town of Chomutov, operates in the North Bohemian brown coal basin, northwest of Prague. SD extracts brown coal at two sites, namely the Tušimice mine and the Bílina mine. A total of 17.8 million tonnes was produced in 2022, giving SD a 53% share in national brown coal production.

The Tušimice brown coal mine is located between the towns of Chomutov and Kadaň. In 2022, the annual production amounted to 8.6 million tonnes. After blending at the Tušimice coal preparation plant, the majority of the coal produced is supplied to the 800 MW Tušimice and the 750 MW Prunéřov power stations operated by ČEZ.

The Bílina brown coal mine is located between the towns of Bílina and Duchcov. In 2022, 9.2 million tonnes of high-quality, low-sulphur brown coal were produced and delivered to the modern 660 MW Ledvice power station, CHP plants, district heating plants, industrial users and households. In 2022, the SD group had a total workforce of 4 344.

Located in West 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 2022, its output was 3.8 million tonnes. Brown coal from the Sokolov area is mainly used for heat and power generation. The company's coal gasification plant was closed in August 2020.

SU generates electricity and heat at its own CHP and GUD plants in Vřesová – they had a combined annual output of 1 500 GWh in 2022. 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 305 MW power plant Tisová generated 829 GWh of electricity and 548 TJ of heat in 2022.

Czech Republic

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	1.8
Hard coal reserves	Mt	1 401
Hard coal total resources	Mt	16 269
Brown coal saleable output	Mt	33.4
Brown coal reserves	Mt	2 087
Brown coal total resources	Mt	8 539

Saleable coal quality		
Hard coal net calorific value	kJ/kg	24 000 - 31 500
Hard coal ash content	% a.r.	8.1 - 22.0
Hard coal moisture content	% a.r.	10.5 - 13.0
Hard coal sulphur content	% a.r.	0.45 - 0.60
Brown coal net calorific value	kJ/kg	11 860 - 21 270
Brown coal ash content	% a.r.	5.6 - 29.1
Brown coal moisture content	% a.r.	25.5 - 36.0
Brown coal sulphur content	% a.r.	0.7 - 1.5

Coal imports / (exports)		2022
Hard coal	Mt	4.4 / (0.9)
Brown coal	Mt	0.0 / (1.0)

Primary energy production		2022
Total primary energy production	Mtce	36.1
Hard coal production	Mt / Mtce	1.8 / 1.6
Brown coal production	Mt / Mtce	33.4 / 14.7

Primary energy consumption		2022
Total primary energy supply	Mtce	59.4
Hard coal consumption	Mt / Mtce	5.6 / 5.0
Brown coal consumption	Mt / Mtce	32.6 / 14.2

Power supply		2022
Total gross power generation	TWh	84.8
Net power imports (exports)	TWh	(13.5)
Total power supply	TWh	63.4
Power generation from hard coal	TWh	3.0
Power generation from brown coal	TWh	34.4
Hard coal power generation capacity	MW net	1 200
Brown coal power generation capacity	MW net	7 250

Employment		2022
Direct in hard coal mining	number	3 299
Direct in brown coal mining and power generation	number	8 247

The company also pursues environmental activities, notably the reclamation of land affected by surface mining, as well as waste processing and disposal. SU's operations employed a total workforce of 1 203 in 2022.

Germany

Germany has the fourth largest economy in the world, after the United States, China and Japan, and accounts for one fifth of EU energy use. In 2022, Germany's gross domestic product was approximately €3.9 trillion. Adjusted for inflation, German GDP grew by 1.8% compared with the previous year. After the Covid-19 crisis and an economic downturn in 2020, it was hoped the German economy would recover. However, the war in Ukraine, rising energy prices, and record inflation combined to dampen economic growth in 2022. The unemployment rate in 2022 was 3.1%.

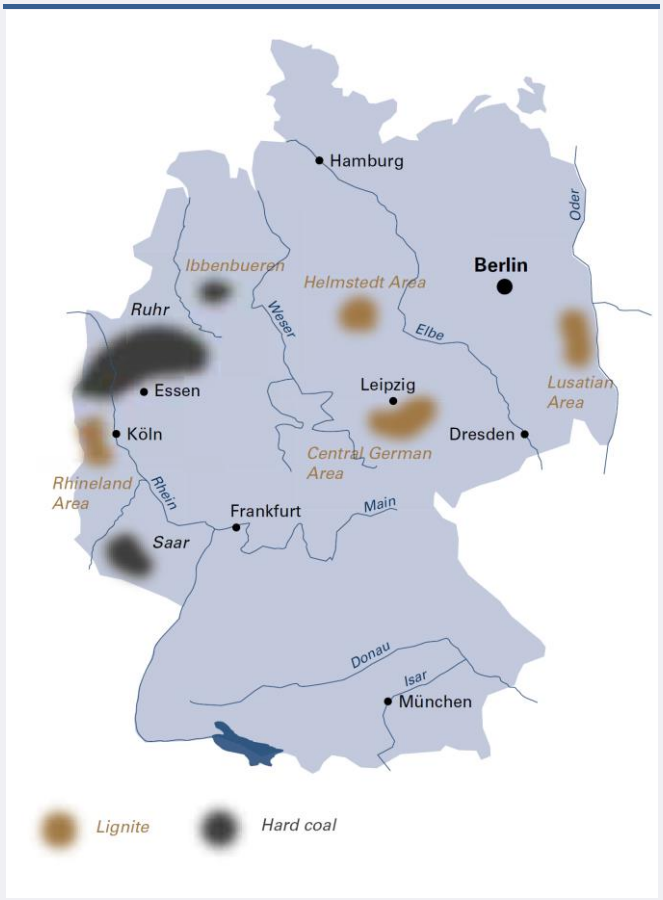
Germany has considerable reserves of lignite at 35.4 billion tonnes, making it an important indigenous source of energy. The last two hard coal mines were closed in 2018, following a political decision eleven years earlier to end subsidised German hard coal production.

In 2022, domestic primary energy production, excluding nuclear power generation, totalled 124.4 million tonnes of coal equivalent (Mtce), broken down as follows: 69.2 Mtce of renewable energy (55.6%), 40.7 Mtce of lignite (32.7%), 5.2 Mtce of fossil gas (4.2%), 2.5 Mtce of oil (2.0%) and 6.8 Mtce of other fuels (5.5%).

Germany's primary energy consumption was 401.6 Mtce in 2022. Oil accounted for the largest share (35.3%), followed by fossil gas (23.6%), coal (19.8%), renewables (17.2%) and nuclear power (3.2%). Within the figure for coal, hard coal accounted for 9.8% and lignite for 10.0% of total primary energy consumption. Germany depends heavily on energy imports, except in the cases of lignite and renewable energy. The country's overall energy import dependence was 72% in 2022, 100% in the case of hard coal.

Power generation is characterised by a diversified energy mix with hard coal and lignite being essential pillars. In 2022, Germany's gross power generation of 580.3 TWh was produced as follows: 43.2% from renewable energy sources, 32.7% from coal (of which 19.9% was from lignite and 12.8% from hard coal), 15.7% from fossil gas and oil, 6.0% from nuclear, and 2.3% from waste and other sources. In 2023, power generation from lignite is expected to be at least 20% lower due to a significant decline in domestic electricity consumption, a reduction in generation capacity as part of the gradual coal phase-out, an increase in electricity production from wind turbines and higher electricity imports.

Since 2011, the German government enacted several new or amended energy laws and other measures to foster change in the energy sector. This fundamental, long-term change is known as the *Energiewende* or "energy transition" to renewable energy sources and included the phase-out of nuclear power generation in Germany by the end of 2022. However, in response to the ongoing energy crisis, the lifetimes of the last three nuclear power plants were extended to mid-April 2023, reflecting the pressing need to ensure a stable energy supply during a challenging period.



General data		2022
Population	million	84.4
GDP	€ billion	3 876.8
Per capita GDP	€/person	46 000

On 3 July 2020, the German Bundestag passed the Coal-fired Power Generation Termination Act (KVBG – *Kohleverstromungsbeendigungsgesetz*) which came into force on 14 August 2020. This law outlines a roadmap for shutting down coal-fired power plants to achieve climate protection goals while ensuring energy supply. The roadmap is based on recommendations from the Growth, Structural Change and Employment Commission. It guarantees social support for coal regions and promotes new economic perspectives. Lignite use for power generation will be phased out gradually and end by 2038 at the latest, following a detailed plan. Hard coal power plants will close from 2020 to 2026 through tenders for compensation, and from 2027 to 2038 through mandated closures without compensation.

The coal phase-out plan includes mitigation measures for affected workers: adjustment payments for older employees until 2043, along with support for new qualifications. The federal government will invest up to €40 billion by 2038 for restructuring in the coal regions with new infrastructure, research institutions and development projects.

In December 2020, the European Commission informed the Federal Ministry for Economic Affairs and Energy (BMWi) that it would launch a state-aid investigation on the proposed compensation for lignite companies. BMWi subsequently notified the European Commission of the Coal-fired Power Generation Termination Act (KVBG). This procedure should complete by the end of 2023.

After complaints brought by climate activists, the Federal Constitutional Court ruled in April 2021 that parts of the Climate Protection Act of 2019 were not compatible with the Basic Law of Germany. According to the Court, the Climate Protection Act did not go far enough as it only set a greenhouse gas (GHG) emission reduction target for 2030. To protect the fundamental rights of future generations, it ruled that the legislature should set well-defined climate targets for the period after 2030. In June 2021, the German Bundestag revised the Climate Protection Act by adding the goal of climate neutrality by 2045 and increasing the GHG emission reduction target for 2030 from 55% to 65%. The energy and industrial sectors are expected to bear the largest shares of the emission reduction target. Here, the German Environment Agency (UBA – *Umweltbundesamt*) advocates for advancing the coal phase-out to 2030 instead of 2038 and for the faster roll out of solar and wind power. But while the energy sector is meeting its targets, other sectors lag behind. Nevertheless, in June 2023, the federal cabinet decided to amend the Climate Protection Act to eliminate mandatory sectoral emission targets; a cross-sectoral goal remains in effect.

The federal election in September 2021 resulted in a coalition of the centre-left SPD, the Greens, and the liberal FDP. The new government established even more ambitious climate goals to increase the share of renewables to 80% of gross electricity consumption by 2030 and to phase out coal “ideally by 2030”. As there is also expected to be a substantial rise in electricity consumption, an Immediate Climate Action Programme for 2022 was introduced to tackle these multiple challenges.

At the same time, the energy policy landscape has undergone a significant shift due to the war in Ukraine. This has led to increased energy prices, emergency measures, and embargoes on Russian coal and oil imports. To ensure energy security, a gas replacement reserve of coal and oil plants was introduced under the EKBG (*Ersatzkraftwerke-bereithaltungsgesetz*) alongside the temporary reactivation of lignite-fired power plants. The federal government amended the Energy Security Act (EnSiG), the Energy Industry Act (EnWG) and extended the Energy Security Transport Ordinance (EnSiTrV). Under the EnSiTrV, the rail transport of energy products can be prioritised. Recognising the need for economic stability, rising energy costs were tackled in December 2022 with price-control laws.

As per the Coal-fired Power Generation Termination Act (KVBG), the federal government committed to periodic assessments, beginning in August 2022 and including defined criteria with corresponding indicators. These will examine the impacts of the coal phase-out by 2038 on energy security, electricity prices, climate protection and social cohesion. However, due to the administrative workload prompted by the crises, the initial assessment was postponed. Furthermore, a new assessment objective has been introduced, namely an expert evaluation of the potential for a coal phase-out by 2030. An analysis of the supplementary measures needed to achieve this outcome is proposed. Moreover, a new investigation will determine whether a coal phase-out by 2030 would align with the climate protection targets for the energy sector set out in the Climate Protection Act.

Hard coal

Germany's consumption of hard coal in 2022 was 39.4 million tonnes of coal equivalent (Mtce), an increase on the previous year. Thus, the steady downward trend over several years was interrupted due to the direct and indirect consequences of the war in Ukraine and the strengthening economic recovery after the Covid-19 pandemic. Coal was able to help offset the decline in fossil gas supply. An additional challenge was the structural decline in nuclear power generation.

The most important coal-consuming sector is utility and industrial power generation: 20.3 Mtce in 2022. In contrast, the use of hard coal in the German steel industry was 18.2 Mtce. Other sectors, mainly the heating market, consumed 1.6 Mtce, a market which includes foundries, district heating plants, small businesses and households.

Since the end of hard coal mining at the end of 2018, the German hard coal market has been supplied by imports alone: 42.3 million tonnes in 2022, including 30.7 million tonnes of steam coal and 11.6 million tonnes of coking coal. Germany also imported 2.2 million tonnes of coke. With the war in Ukraine and trade embargoes, Russian coal imports fell to zero by the end of 2022, having accounted for as much as 50% of total coal imports in previous years. Other countries benefited from the fall of Russian coal imports: South Africa, Colombia and the United States.

The core activities of RAG, the former German hard coal mining company, are now: mine water management, repairing subsidence damage due to past coal mining, and the restructuring of former coal mining areas. The private RAG FOUNDATION, created in July 2007, is the owner of RAG and majority owner of EVONIK, a speciality chemicals company. The ongoing, post-mining liabilities are financed by the proceeds of the foundation which also promotes education, science and culture in the mining regions.

Brown coal and lignite

Lignite supply in 2022 totalled 39.9 Mtce with insignificant trade – exports of pulverised lignite and briquettes amounted to 0.9 Mtce.

Nearly 90% of lignite production is used for power generation (116.9 million tonnes in 2022), accounting for 19.9% of total power generation in Germany.

With the shutdown of the lignite power plants Neurath B, Niederaußem C, and Weisweiler E in the Rhineland at the end of 2021, in accordance with the Coal-fired Power Generation Termination Act (KVBG), a total of 900 MW of lignite power plant capacity was no longer available. The total lignite power plant capacity as of 1 January 2022 was 20 814 MW. In April 2022, another power plant unit (Neurath A) with a capacity of 300 MW was also decommissioned. Nevertheless, lignite was still able to make a significant contribution to power supply in 2022.

To ensure supply security in times of crisis, the government allowed the temporary return of coal power plants to the electricity market. The lignite power plants Jänschwalde E & F, Niederaußem E & F, and Neurath C, with a total capacity of 1.9 GW, are part of a new supply reserve created on 1 October 2022. Temporary market participation is possible until 31 March 2024 if gas supply alerts or emergencies are declared, based on the Supply Reserve Call Regulation (VersResAbV). Restarting the lignite power plants required extensive work and more staff to ensure the facilities were ready for extended operations at high load. Previously, three of the affected reserve power plants were to have been permanently shut down on 30 September 2022, and two more on 30 September 2023.

In the Rhineland, RWE POWER AG produced a total of 65.3 million tonnes of lignite in 2022 from three surface mines: Hambach, Garzweiler and Inden. Almost 90% of the lignite was consumed at the company's own power stations with a gross installed capacity of 10 416 MW (as of 1 January 2022), while 7.2 million tonnes were used for processed products.[2] In line with the KVBG, lignite briquetting in the Rhineland region ended on 31 December 2022. At the end of 2022, the Rhenish mining area had a total workforce of around 7 700.

RWE has reached an agreement with the federal and state ministries of economic affairs to terminate market-oriented lignite use by 2030. This political consensus has since been legally enshrined in the Coal-fired Power Generation Termination Act (KVBG). Accordingly, to secure power generation and displace gas use, Neurath D & E, originally slated for decommissioning by the end of 2022 and with a total capacity of 1 200 MW, will continue to operate until 31 March 2024, with an option for extension to March 2025.

[2] *Raw coal use for upgraded products without the quantities required for electricity and process steam generation at the refining sites.*

To secure power supply beyond 2030, the federal government can also decide in 2026 whether four lignite power plant units will be transferred to a reserve until the end of 2033. These include a 600 MW unit as well as the three most modern facilities with optimised technology (BoA), totalling around 3 600 MW. Should such a reserve be called into service, its fuel supply would require no changes to the planning approval for Garzweiler mine. Coal extraction would continue in parallel with ongoing land rehabilitation without altering land use or restoration activities.

In the Lusatian mining region, the Czech company EPH owns LAUSITZ ENERGIE BERGBAU AG (LEAG) and extracts lignite at the Jänschwalde and Welzow-Süd surface mines in Brandenburg, as well as at the Nochten and Reichwalde mines in Saxony, all with a total output of 48.5 million tonnes in 2022. Significantly more coal was extracted than initially planned, driven by a considerably higher demand from power plants and refineries due to high prices in the electricity and heating markets linked to the gas crisis and the war in Ukraine. The Jänschwalde surface mine is set to be phased out as planned by the end of 2023.

Lignite deliveries to power plants in Lusatia totalled 44.6 million tonnes in 2022. LEAG is the main operator of lignite-fired power plants in the mining area with a total gross capacity of 7 175 MW, including the Jänschwalde, Schwarze Pumpe and Boxberg power plants. At the end of 2022, LEAG had a total workforce of around 7 300.

The Central German mining area around Leipzig yielded a total of 17.0 million tonnes of lignite in 2022. The most important company in this area is MIBRAG, also owned by the Czech company EPH. It has two surface mines at Profen in Saxony Anhalt and Vereinigtes Schleenhain in Saxony. The company supplies lignite to its combined heat and power plant at Wählitz with a capacity of 37 MW, as well as to the larger LEAG/EnBW Lippendorf (1 862 MW) and Saale Energie GmbH Schkopau (980 MW) power stations. At the end of 2022, the Central German mining area had a total workforce of around 1 800.

Also in Central Germany, ROMONTA GmbH operates a surface lignite mine in Amsdorf, Saxony-Anhalt, exclusively for the material use of lignite, namely for the extraction of montan wax. Thanks to its special properties, montan wax is used primarily in specialty chemicals, *e.g.* for the production of high-tech plastics, for skincare and cosmetics products, as well as in cleaning agents and for the hydrophobic treatment of building materials. In addition, montan wax is used as a forming wax in investment casting and as an additive to modify the performance of asphalt and bitumen. Lignite production amounted to 458 thousand tonnes in 2022. The wax-free coal residue is currently still used in Amsdorf to generate process heat and electricity, but will not be used as a fuel at the site in the future. Alternative energy sources will be used to secure the heat supply for montan wax production.

Extraction of lignite from surface 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” mine site 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.

The coal phase-out has necessitated modifications to approved mining plans. A new balance among the various interests in the lignite mining areas, including agriculture, forestry, local authorities, water management, nature conservation and, last but not least, mining, had to be established.

The lignite industry itself is making significant contributions to the necessary conditions for the coal phase-out. German lignite mining companies RWE, LEAG, MIBRAG, and ROMONTA are heavily investing in renewables, energy storage and H_2-ready gas power plants. By 2030, the lignite regions alone are projected to add another 9 GW of installed renewables capacity. Additionally, plans are in place for 6 GW of H_2-ready gas power plants.

Other companies within the lignite industry are also adapting to the transition. This includes exploring new value chains, expanding business sectors, and investing in workforce development. The objectives are twofold: developing sustainable power generation projects and safeguarding employment within the lignite regions.

Oil shale

Germany has reserves of 150 million tonnes of oil shale in the Franconian Jura region of Bavaria, in northern Germany near Brunswick, and in Swabian Jura, Baden-Württemberg. Only the latter deposit (CV 3 000–4 000 kJ/kg) is exploited to supply a HOLCIM GROUP cement works at Dormettingen with around 0.5 million tonnes of shale each year. As cement making is carbon-intensive, with few renewable alternatives, there are no plans to end this oil shale use.

Germany

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	-
Hard coal reserves	Mt	-
Hard coal total resources	Mt	82 965
Lignite saleable output	Mt	130.8
Lignite reserves	Mt	35 400
Lignite total resources	Mt	71 900

Saleable coal quality		
Lignite net calorific value	kJ/kg	7 000 - 11 300
Lignite ash content	% a.r.	1.6-16
Lignite moisture content	% a.r.	48.0 - 62.0
Lignite sulphur content	% a.r.	0.15 - 2.1

Coal imports / (exports)		2022
Hard coal	Mt	42.3 / (1.0)
Lignite	Mt	0.0 / (0.0)

Primary energy production		2022
Total primary energy production	Mtce	124.4
Hard coal production	Mt / Mtce	0.0 / 0.0
Lignite production	Mt / Mtce	130.8 / 40.7

Primary energy consumption		2022
Total primary energy supply	Mtce	401.6
Hard coal consumption	Mt / Mtce	40.2 / 39.4
Lignite consumption	Mt / Mtce	130.9 / 39.8

Power supply		2022
Total gross power generation	TWh	580.3
Net power imports (exports)	TWh	(27.3)
Total power supply	TWh	532.3
Power generation from hard coal	TWh	74.1
Power generation from lignite	TWh	115.4
Hard coal power generation capacity	MW net	18 939
Lignite power generation capacity	MW net	18 550

Employment		2022
Direct in hard coal (post mining)	number	655
Direct in lignite mining	number	13 384
Other lignite-related*	number	3 822

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

Greece

The Greek economy has recovered strongly from the sovereign debt and Covid-19 crises, growing by 8.4% in 2021 and by 5.9% in 2022 with further growth forecast. A part of this recovery is based on a vibrant tourism sector, with estimates of its overall contribution to GDP ranging up to 33%.

At 80.0% in 2021, Greece's energy import dependency in total energy supply is well above the EU average of 57.1%. Lignite and coal accounted for 7.6% of energy supply in 2022. With a production of 2.4 Mtce in 2022, lignite is Greece's most important conventional energy resource, although the country also has modest oil and gas reserves. Oil accounted for 51.9% of total primary energy supply in 2022; Greece has a large refining industry which exports oil products. The production from renewable energy sources is growing, notably solar power, to account for 17.7% of supply in 2022.

Greek lignite resources are estimated to total 2 200 million tonnes. Lignite deposits are found in specific areas, with the most important deposits in the north of the country at Amynteon-Ptolemais and in the south at Megalopolis. PPC has mining rights covering around 1 000 million tonnes of which 550 million tonnes lie in the active mining areas of Ptolemais and Megalopolis. Other deposits are at Drama (900 million tonnes), Elassona (168 million tonnes) and Florina (112 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). 103 thousand tonnes of hard coal were imported in 2022, mostly for industrial use.

In 2022, Greek electricity production was 52.7 TWh, of which 19.1 TWh were generated at fossil gas-fired power plants, a share of 36.3% in total generation. 18.6 TWh (35.3%) came from new renewable energy sources, and 3.9 TWh (7.3%) from hydro. Lignite-fired power plants supplied 5.8 TWh (10.9%) while 5.1 TWh (9.7%) came from oil-fired plants, often on islands operating isolated systems.

In 2021, Greece reported net electricity imports of 3.7 TWh with the largest share coming from Bulgaria. In 2022, net electricity imports were 3.4 TWh. Since 2015, imports have increased significantly due to the greater penetration of variable renewable energy sources. In some months, electricity imports can reach up to 25% of supply.

Greek energy policy is focused on implementation of the European Green Deal for power generation and further promoting renewable energy sources as the dominant electricity generation technology. Policy towards the lignite sector addresses the decommissioning of lignite-fired power plants and the rehabilitation of lignite mine sites. Greece was the first country to submit territorial just transition plans which were approved with much praise by the European Commission on 16 June 2022.

General data		2022
Population	million	10.4
GDP	€ billion	206.6
Per capita GDP	€/person	19 900

Lignite

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

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). At less than 1%, the sulphur content is generally low.

Lignite is mainly mined by the PUBLIC POWER CORPORATION (PPC) exclusively in opencast mines. This company is the largest lignite producer in Greece and operates mines in Western Macedonia at Central Field and South Field – the West Macedonia Lignite Center (WMLC). PPC also operates an opencast mine in the Peloponnese region of southern Greece, in the Megalopolis Field – the Megalopolis Lignite Center (MLC).

Bucket-wheel excavators, spreaders, tripper cars and conveyor belts are used to mine and transport lignite at these sites. Hydraulic excavators and heavy trucks are used to remove the hard overburden found at some mines.

In 2022, lignite production in Greece was 14.3 million tonnes, mostly mined by PPC with 10.5 million tonnes extracted by the company at the West Macedonia Lignite Centre and 2.9 million tonnes at the Megalopolis Lignite Centre to give a total of 13.4 million tonnes. A few small, privately owned and operated lignite mines in West Macedonia produced an additional of 0.4 Mt in the same year. Operations at the West Macedonia Lignite Centre removed a total of 39.2 million cubic metres of overburden and interburden, corresponding to an overburden-interburden-to-lignite ratio of 3.7 cubic metres per tonne. At the Megalopolis Lignite Centre, overburden plus interburden removal was 7.7 million cubic metres for an overburden-interburden-to-lignite ratio of 2.6:1. The two mining centres and the head office in Athens employed during 2022 a total permanent workforce of 2 947.

Four lignite-fired power plants are owned and operated by PPC: the 1 595 MW Agios Dimitrios, the 660 MW Ptolemais Unit V, the 300 MW Megalopolis Unit IV and the 330 MW Meliti Unit. Ptolemais V is one of the most modern lignite-fired power plants in Europe, inaugurated in February 2023 following construction by TERNA SA and HITACHI POWER EUROPE. The long-term future of this plant is yet to be decided, with various plans to either convert it to fire fossil gas or hydrogen, or include it in a capacity mechanism.

In Greece, only small quantities of lignite are used outside of power generation: 14 268 tonnes were supplied to household users in 2022, while 2 503 tonnes were supplied for agricultural use as fertilisers. Over the coming years, the quantity for agricultural use is expected to increase as demand from several fertiliser companies grows.

Environmental protection is central to PPC's corporate strategy and especially its 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, animal sanctuaries and crop-testing areas. In 2022, an area of around 66 square kilometres has been fully restored.

Greece remains committed to phasing out lignite-based power generation by 2028 and to further increase the use of renewable energy sources. The goal of a complete decarbonisation of the Greek power system is reflected in the forecasts of the *National Energy and Climate Plan* (NECP – Government Gazette B' 4893 / 31.12.2019), a plan which also aims to ensure energy security across the whole country and grid stability. At the same time, the plan is aligned with the European Green Deal (COM(2019) 640) which targets net-zero greenhouse gas emissions by 2050.

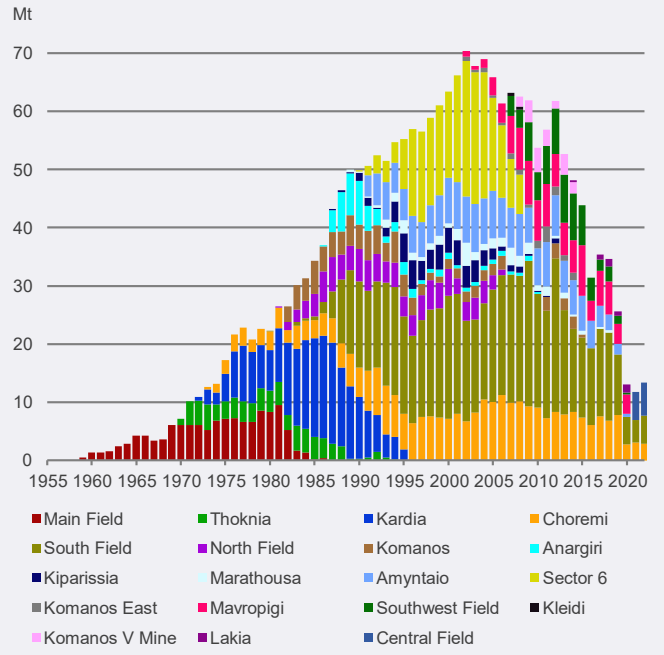
Land restoration and a 15 MW solar PV park near Ptolemais at the West Macedonia Lignite Centre – part of the 550 MW Kozani solar project

Just transition

Throughout this decarbonisation effort, a central priority is to ensure a just transition and development of the lignite mining areas of Western Macedonia and Megalopolis. The NECP is based on three pillars: employment protection, compensation for the socio-economic impacts of transition, and energy self-sufficiency for the lignite regions and the country at large.

The related *Just Transition Development Plan* of 2020 for the lignite areas is itself based on five pillars for development: clean energy, industry and trade, smart agriculture, sustainable tourism, and technology and education. This "master plan" includes enhanced incentives to attract inward investment, as well as specific uses for the tens of thousands of acres of land that will be released as lignite mining comes to an end.

Figure 24
Lignite production by PPC mines, 1958 to 2022



Source: PPC

The state-owned Hellenic Company for Just Development Transition SA (ΕΛΕ.Δ.Α.Μ.) or METAVASI, established by Law 4872/2021 and co-funded by the EU, operates in the public interest and is supervised by the government minister responsible for development and investments. The main scope of the company's activities is to co-operate with PPC and the Greek public to diversify economic activities in the affected areas. Activities are all implemented in accordance with the master plan and the *Territorial Just Transition Plans* accompanying the *National Strategic Reference Framework 2021-2027* (Act of the Council of Ministers No. 37 / 37.9.2021). More specifically, activities include:

- the reclamation and exploitation of land included in the *Lignite Phase-out Zones* whether these belong to the state or are to be acquired by PPC or third parties;
- the redirection/redesign of the business development prospects for these zones;
- attracting, soliciting, supporting, and promoting investments and investment partnerships; and
- providing support to facilitate business development and investment plans, and to promote entrepreneurship in the zones.

Greece

Coal production, reserves and resources		2022
Lignite saleable output	Mt	14.3
Lignite reserves	Mt	550
Lignite total resources	Mt	2 200

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)		2022
Hard coal	Mt	0.1 / (0.0)
Lignite	Mt	0.0 / (0.4)

Primary energy production		2022
Total primary energy production	Mtce	7.5
Lignite production	Mt / Mtce	14.3 / 2.4

Primary energy consumption		2022
Total primary energy supply	Mtce	29.5
Hard coal consumption	Mtce	0.1 / 0.1
Lignite consumption	Mtce	13.1 / 2.2

Power supply*		2022
Total gross power generation	TWh	52.7
Net power imports (exports)	TWh	3.4
Total power supply	TWh	52.9
Power generation from lignite	TWh	5.8
Lignite power generation capacity	MW net	2 001

Employment		2022
Direct in lignite mining	number	2 947
Other lignite-related**	number	776

** including small islands with independent diesel generators*
*** at PPC lignite-fired power plants*

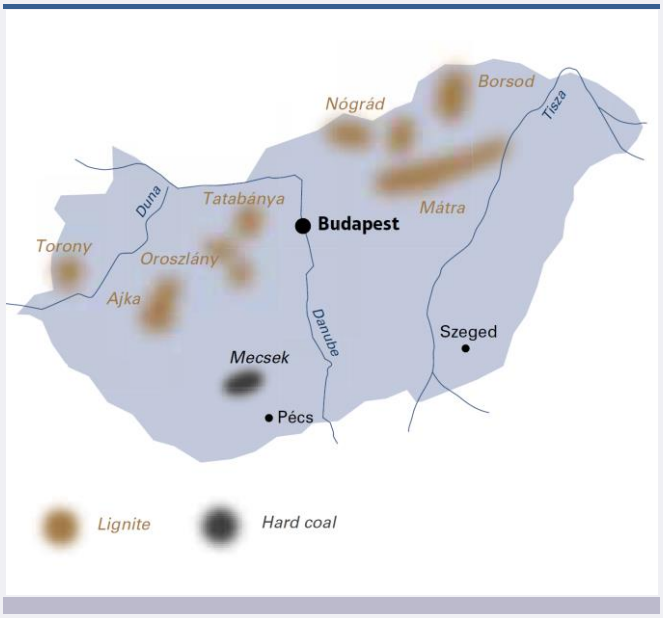
Hungary

Since 2013, Hungary's export-oriented economy has grown strongly thanks in part to significant corporate investments in the automotive equipment sector. The country enjoys almost full employment; the unemployment rate fell to 3.1% in 2022. Looking ahead, the government plans to boost its stake in "strategically important sectors" while a 2022 decree allows energy companies to be placed under government supervision in times of emergency. Due to its sparse energy and raw material resources, Hungary's import dependency (54.1% in 2021) is close to the EU average, with oil (86.9% import dependence) and fossil gas (67.2%) accounting for large shares of supply.

Total fossil energy resources in Hungary comprise about 10.7 billion tonnes of coal, 177 billion cubic metres of fossil gas and 18 million tonnes of oil. Lignite and brown coal account for about half of Hungary's total coal resources and are the most important indigenous sources of energy currently exploited.

Hungary's total energy supply in 2022 amounted to 36.5 Mtce. Fossil gas had the biggest share in this total (31.0%), followed by oil (30.6%), nuclear energy (15.6%), renewables and waste (13.9%) and coal (4.9%). Around 99% of hard coal is imported – 0.8 million tonnes in 2022. Hungary aims to increase the share of renewable energy in gross final energy consumption to 21% by 2030. In 2022, the share was 13.0%.

National electricity generation in 2022 totalled 35.8 TWh from an installed capacity of 10.6 GW. A net 12.2 TWh of electricity was imported. Nuclear energy from Hungary's sole nuclear power plant at Paks accounted for 44.2% of gross electricity production in 2022. This state-owned plant has four reactors with a combined gross capacity of 2 000 MW. As a result of a service lifetime extension programme agreed by the Hungarian parliament in December 2022, the four units at Paks will operate for another twenty years. Paks II (2 × 1 200 MW) has been approved for constructed on the same site; a construction licence was granted in August 2022 and the new units 5 and 6 are expected to start operation in 2032. Gas-fired generation also makes a major contribution to national electricity supply with a share of 24.7% in 2022. Electricity produced from coal, mostly lignite, had a share of 8.6% in gross electricity production in 2022, generated mainly by MVM MÁTRA ENERGIA ZRT which state-owned MVM purchased from OPUS GLOBAL in March 2020. Renewable energy sources had a share of 20.9%, mostly solar PV and biomass, followed by industrial and municipal wastes, and some hydro. A renewables support scheme adopted in June 2016, with feed-in tariffs and premiums, led to a surge in solar PV projects.



General data		2022
Population	million	9.6
GDP	€ billion	168.9
Per capita GDP	€/person	17 600

The second *National Climate Change Strategy*, approved by the Hungarian parliament in October 2018, targets a 40% reduction in greenhouse gas (GHG) emissions by 2030, compared with 1990, and a 52% to 85% reduction of gross GHG emissions by 2050. In June 2020, Hungary adopted a new law making the net-zero emission target by 2050 a binding obligation. The Ministry for Innovation and Technology (MIT) updated the *National Energy Strategy* with an outlook to 2040 in which a decarbonised electricity mix will be central to achieving climate targets while strengthening energy independence and security.

In July 2022, the Hungarian government launched a seven-point plan to further enhance energy security: an export ban on certain energy sources, increasing domestic fossil gas and coal production, re-starting the coal-fired Mátra power plant, extending the working hours of the Paks nuclear power plant, purchasing additional fossil gas for storage, and increasing regulated utility prices to better reflect market conditions. A new Ministry of Energy was established in December 2022 with responsibility for energy, environment and climate policies.

Lignite

Hungary's lignite and brown coal resources are concentrated in the Transdanubia region and in Northern Hungary. In 2022, Hungary's total lignite output was 4.9 million tonnes. Almost all of this was used for heat and power generation, with only small quantities supplied elsewhere, mainly to households.

Since the closure in 2014 of the Márkushegy underground mine in western Hungary, all lignite production has been at surface mines, principally the Visonta and Bükkábrány mines belonging to MVM MÁTRA ENERGIA (MÁTRA). The approved mining fields of these two opencast mines have about 770 million tonnes of lignite reserves.

In 2022, MÁTRA produced 4.9 million tonnes of lignite and removed over 30 million cubic metres of overburden – a stripping ratio of 6.1. The lignite is used in the company-owned power plant at Visonta which comprises four lignite-fired units and two topping gas turbines. Lignite from the Bükkábrány mine, some 50 kilometres from the power plant, is transported by rail while a conveyor belt links the plant to the adjacent Visonta mine. Besides lignite and fossil gas, biomass is co-fired to a fuel input level of around 10%.

The Mátra power plant at Visonta, located 90 kilometres north-east of Budapest, has a total capacity of 950 MW (2 × 100 MW units, 1 × 220 MW unit, 2 × 232 MW units, 2 × 33 MW gas turbines). The wet flue gas desulphurisation (FGD) system commissioned in 2000 is interesting as it is installed inside dry cooling towers and makes use of the natural draft to release flue gas high into the atmosphere. The plant is also fitted with selective, non-catalytic NOx reduction (SNCR) to further reduce pollutant emissions. Additional wet cooling cells have been added to units 4 and 5 to create a hybrid cooling system that improves efficiency.

As part of its development strategy, MÁTRA has created an industrial park at Visonta with many activities related to the power plant, such as block manufacture using bottom ash and fly ash, plasterboard production using gypsum from the FGD system, biomass fuel processing, a biodiesel/bioethanol plant, and a 16 MW solar PV park.

Looking to the future, in March 2023 MÁTRA issued a call for tenders for a 650 MW gas-fired CCGT. This is just one part of a major transformation of the Visonta site which the government approved in April 2022. MVM will develop two further solar PV parks with a total capacity of 200 MW on reclaimed areas at the lignite mines, and construct a 38-45 MW power plant fuelled with mixed household waste (RDF) and biomass. Support for this €1 billion investment comes from free allowances granted under Article 10c of the EU ETS Directive as well as from other public sources.

Hungary

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	-
Hard coal reserves	Mt	276
Hard coal total resources	Mt	5 351
Lignite saleable output	Mt	4.9
Lignite reserves	Mt	2 633
Lignite total resources	Mt	5 337

Saleable coal quality		
Hard coal net calorific value	kJ/kg	17 549
Lignite net calorific value	kJ/kg	6 742
Lignite ash content	% a.r.	23.0
Lignite moisture content	% a.r.	47.4
Lignite sulphur content	% a.r.	1.2

Coal imports / (exports)		2022
Hard coal	Mt	0.8 / (0.0)
Lignite	Mt	0.1 / (0.0)

Primary energy production		2022
Total primary energy production	Mtce	15.2
Hard coal production	Mt / Mtce	0.0 / 0.0
Lignite production	Mt / Mtce	4.9 / 0.8

Primary energy consumption		2022
Total primary energy supply	Mtce	36.5
Hard coal consumption	Mt / Mtce	0.8 / 0.7
Lignite consumption	Mt / Mtce	5.0 / 1.1

Power supply		2022
Total gross power generation	TWh	35.8
Net power imports (exports)	TWh	12.2
Total power supply	TWh	45.9
Power generation from lignite	TWh	2.9
Lignite power generation capacity	MW net	1 007

Employment		2022
Direct in hard coal mining	number	51
Direct in lignite mining	number	1 300
Other lignite-related*	number	700

* i.e. *in power generation at MÁTRA power plant*

Hard coal

PANNON HŐERŐMŰ ZRT owned by VEOLIA has extracted small quantities of coal from the Pécs-Vasas surface mine in Southern Transdanubia. This coal is officially classified as lignite due to its low calorific value.

Poland

The Polish economy has grown steadily since 1992, at annual rates far above EU averages. In 2022, GDP growth was 5.3% and, on a purchasing power parity basis, *per capita* GDP is now above 80% of the EU average. Unemployment has fallen steadily over recent years, to 2.9% in 2022 – less than half the EU average. Poland's population has been relatively stable over the last thirty years; emigration has been more than balanced by immigration from Ukraine.

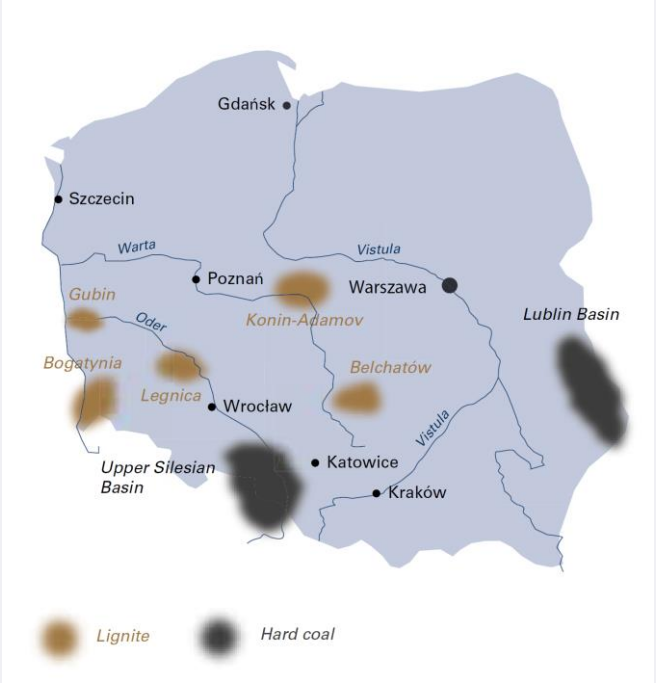
Coal is of strategic importance to the Polish economy. Compared with other EU member states, Poland has much larger reserves and makes good use of hard coal and lignite for electricity production with a 70.5% share in 2022 (126.7 TWh). Hard coal reserves total 4.3 billion tonnes, located mostly in the Upper Silesian and Lublin coal basins, while lignite reserves amount to 0.8 billion tonnes with a further 23.1 billion tonnes of resources.

At 40.6%, Poland's energy import dependency was well below the EU average of 57.1% in 2021. The country's total primary energy supply in 2022 was dominated by coal (42.1%), with oil (30.2%) and gas (14.5%) also taking significant shares, followed by biofuels and waste (10.8%), solar PV and wind (2.4%), and hydro (0.2%).

In 2022, total gross power generation was 179.7 TWh. Polish electricity exports have declined since 2015 and in 2022 Poland was a net exporter of 1.7 TWh. 78.9 TWh or 43.9% of Polish electricity production was generated at hard coal-fired power plants or from coal gases at coking works and steel plants. 47.8 TWh were generated at lignite-fired power plants, a 26.6% share. Power generated from wind grew to 19.8 TWh (11.0%); solar PV has grown strongly and accounted for 4.6% in 2022. Fossil gas (6.3%), oil (1.3%), biofuels (3.3%), hydro (1.1%) and waste were the other sources of electricity. In total, renewable energy sources had a 20.1% share of power generation.

Over recent years, Poland has commissioned the last of its coal- and lignite-fired power plants: PGE Opole units 5 and 6 (2 × 900 MW) in 2019, TAURON Jaworzno III (910 MW) in 2020 and the 490 MW lignite-fired unit 11 at the PGE Turów power station in 2021. With an otherwise ageing fleet and stricter EU emission standards, these new plants replaced older ones. In line with EU climate policy, the Polish government in September 2020 signed a social agreement with trade unions to phase out coal mining by 2049.

In the *Energy Policy of Poland to 2040* (PEP2040), published in November 2019 and adopted in February 2021, output from coal and lignite plants was expected to remain relatively stable, falling only slightly to 113 TWh in 2030 to take a



General data		2022
Population	million	36.8
GDP	€ billion	654.6
Per capita GDP	€/person	17 800

reduced, 56% share of a larger market. Renewables are forecast to grow to take a 32% share with the balance from new nuclear and gas-fired power plants.

For economic reasons, the government plans a restructuring of the coal and lignite sector. In April 2021, the State Treasury announced a plan to create the new National Energy Security Agency (NABE). This would integrate the coal and lignite assets of PGE, ENEA, ENERGA and TAURON POLSKA ENERGIA. PGE GiEK would have a special role as integrator. After this restructuring, NABE would own all lignite-fired power plants, related lignite mines, and all hard coal-fired power plants – so 55% of Polish electricity generation capacity – but no hard coal mines or district heating plants. Following national elections in October 2023, negotiations on the industry restructuring are expected to resume under the newly formed government.

Poland has no nuclear power generation, but operates one 30 MWth experimental reactor at Świerk-Otwock near Warsaw. PEP2040 calls for Poland to obtain 23% of its energy from renewable sources by 2030 with more solar PV and wind power, especially from the Baltic Sea, and the

commissioning in 2033 of Poland's first nuclear power plant at Lubiatowo-Kopalino or Zarnowiec in Pomerania, northern Poland, followed by more units to reach 9 GW for a total investment of PLN 140 billion (€32 billion). First contracts have been signed between a state-owned special purpose vehicle and US partners WESTINGHOUSE and BECHTEL for three AP1000 reactors, while in October 2022, KOREA HYDRO AND NUCLEAR POWER COMPANY (KHNP) signed a letter of intent with PGE and ZE PAK Group to replace existing lignite-fired power units at Pątnów with an APR1400 reactor, also by 2033. In April 2023, PGE and ZE PAK announced a PGE PAK ENERGIA JĄDROWA joint venture to develop the Pątnów nuclear plant.

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 89.7% 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.

More than half (58.6%) of Polish hard coal reserves are steam coal and 41.4% coking coal. All hard coal is deep mined at an average working depth of around 600 metres, with some mines over 1 000 metres. Mining is fully mechanised: over 90% of production is by longwall systems.

Since the beginning of the 1990s, the Polish mining industry has been going through a process of transformation. Hard coal production decreased from 177.4 million tonnes in 1989 to 52.8 million tonnes in 2022. Over the same period, employment in the Polish hard coal mining sector decreased from 407 000 to 72 911 employees at the end of 2022.

Despite the significant reduction of mining capacity over three decades, Poland remains by far the largest hard coal producer in Europe. The largest coal mining company, the Polish Mining Group (PGG – POLSKA GRUPA GÓRNICZA) was established in May 2016 to replace its predecessor, KOMPANIA WĘGLOWA (KW). PGG operates seven mines: KWK ROW (Chwałowice, Jankowice, Marcel and Rydułtowy mines), KWK Ruda (Bielszowice and Halemba mines), KWK Piast-Ziemowit, KWK Bolesław Śmiały, KWK Sośnica, KWK Staszic-Wujek and KWK Mysłowice-Wesoła. At the end of 2022, the company employed a total of 36 800 people.

Other leading coal mining companies are JASTRZĘBSKA SPÓŁKA WĘGLOWA (JSW) and LUBELSKI WĘGIEL „BOGDANKA" (LW „Bogdanka"). JSW is the EU's largest coking coal producer, with an output of 11.0 million tonnes of coking coal and 3.1 million tonnes of steam coal in 2022. Following its earlier privatisation in 2009, a majority (65%) of the shares in LW „Bogdanka" were acquired in 2015 by ENEA, a Polish power utility company, and so the state has a majority shareholding.

Other, smaller coal hard coal producers include: TAURON WYDOBYCIE with three mines, BUMECH's PG SILESIA mine, WĘGLOKOKS KRAJ with the Bobrek-Piekary mine, SILTECH mine, and the EKO-PLUS mine.

In 2022, steam coal output of 40.5 million tonnes accounted for the majority (76.6%) of hard coal production. Coking coal production reached 12.4 million tonnes, mainly by JSW.

Unprofitable mines or units of integrated mines have been transferred to SPÓŁKA RESTRUKTURYZACII KOPALŃ (SRK – Mines Restructuring Company) for their eventual closure. In 2022, there were ten mines in the decommissioning process managed by this restructuring company.

The Polish hard coal mining industry works to ensure the sector's profitability. This entails new investment in modernisation, matching production volumes to market demand, reducing costs and increasing productivity. However, structural changes have continued in line with the decision in November 2016 of the European Commission to allow state aid for the closure of uncompetitive coal mines. The European Commission concluded that this support would not unduly distort competition. On 15 April 2019, the Commission approved changes to the state aid programme for the Polish coal sector for the period from 2015 to 2023. And more recently, in 2021, Poland notified an update to the above-mentioned aid programme, including its extension to 2027.

Coal exporters and importers have an efficient infrastructure at their disposal in Poland, 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 can load capesize vessels. Hard coal exports from Poland totalled 5.4 million tonnes in 2022. Most of the shipments were transported overland to neighbouring EU member states, namely the Czech Republic, Slovakia, Austria, Germany and Hungary, while small volumes were transhipped via the Baltic ports. In 2022, WĘGLOKOKS exported 0.9 million tonnes of hard coal.

In 2022, hard coal imports reached a record 20.2 million tonnes, including 3.0 million tonnes of coking coal. The largest supplier was South Africa (3.4 million tonnes), with important quantities also from Australia (3.2 million tonnes), Kazakhstan (3.2 million tonnes), Colombia (2.7 million tonnes), Indonesia and other countries. Only 2.6 million tonnes were imported from Russia which had been the leading source of coal imports in previous years. From 16 April 2022 – ahead of the EU as a whole – Poland unilaterally banned the import of Russian energy raw materials into its territory. This decision was in response to Russian aggression against Ukraine and meant securing many new contracts with other coal exporters to Poland.

Irrespective of the large volume of coal imports in 2022, Poland aims to meet its demand for steam coal for power generation from domestic resources. Indigenous coal will be the foundation of Poland's energy mix and a key element of its energy security. At the same time, the forecast *increase*

in Polish power demand will be covered by sources other than conventional coal-fired power plants.

To expand the use of modern technologies, Główny Instytut Górnictwa – Państwowy Instytut Badawczy (GIG-PIB – the Central Mining Institute, a National Research Institute), the Poltegor Institute, Instytut Technologii Paliw i Energii (ITPE – Institute of Energy and Fuel Processing Technology) and Instytut Techniki Górniczej KOMAG (Institute of Mining Technology) undertake research, development and demonstration projects in co-operation with the coal and lignite mining industry. Notable projects, some supported by the EU Research Fund for Coal and Steel, include those aimed at methane management in underground coal mines and the ecological restoration of coal and lignite mine sites after mining has ceased.

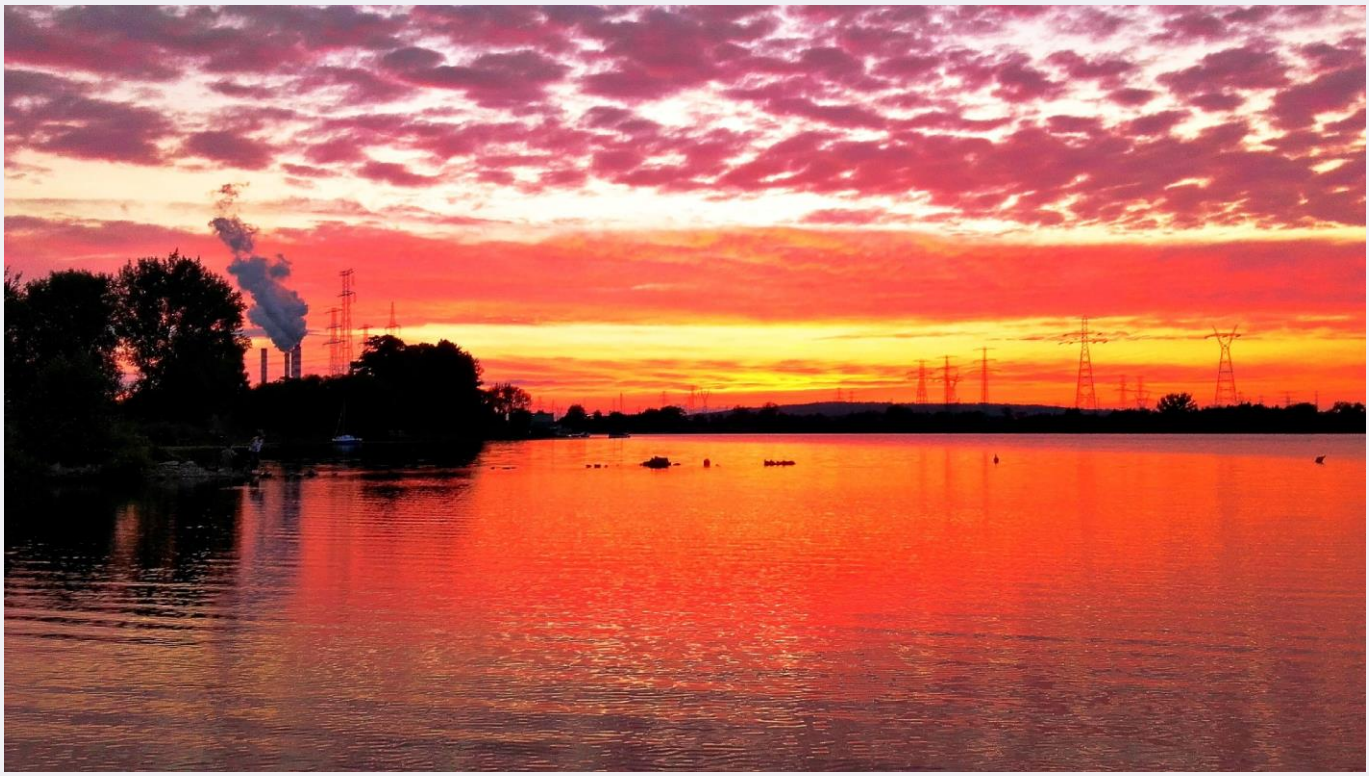
Lignite

Poland exploits its lignite deposits exclusively at surface mines. Two are located in central Poland and a third lies in the southwest of the country. In 2022, lignite production was 54.6 million tonnes, 99% of which was used by mine-mouth power plants which generated 47.8 TWh of electricity or 26.6% of Poland's total gross power generation.

The Bełchatów lignite basin, situated in the central part of Poland, incorporates two lignite fields: Bełchatów and Szczerców. In 2022, the Bełchatów mine produced 41.2 million tonnes of lignite or three quarters of Poland's total lignite production. Mining this lignite required the removal of about 96.3 million cubic metres of overburden, which equates to an overburden-to-lignite ratio of 2.3 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 2038. The lignite output is supplied entirely to the twelve units at a mine-mouth power station owned by PGE GiEK, with a total capacity of 5 298 MW – the largest in Europe. Electricity produced at this power station covers about 20% of national power demand. Built mainly between 1981 and 1988 and expanded with a new 858 MW unit in 2011, it generates the cheapest electricity in Poland.

In the Turoszów lignite basin, located in southwest Poland, reserves are estimated at 261 million tonnes. In 2022, Turów mine produced 9.9 million tonnes of lignite with a calorific value of 9 500 kJ/kg to supply the seven units at the 2 029 MW PGE GiEK Turów power station. From 2019 to 2021, units 1, 2 and 3 were modernised, increasing the capacity of each unit from 235 MW to 250 MW, while units 4, 5 and 6 are each 261 MW. In 2021, a new, 496 MW unit was put into operation. In 2022, approximately 21.5 million cubic metres of overburden were removed, giving a stripping ratio of 2.2 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 PGE GÓRNICTWO I ENERGETYKA KONWENCJONALNA (PGE GiEK), one of the seven companies in the majority state-owned Polish utility POLSKA GRUPA ENERGETYCZNA (PGE Capital Group). Headquartered in Bełchatów, PGE GiEK has operations in four voivodships. It is the leader in Polish lignite mining, with a share of 94% of total production, and is the biggest electricity producer in Poland, satisfying over 40% of national power demand.



The Pątnów-Adamów-Konin (PAK) lignite basin, located in central Poland between Warsaw and Poznań, has been producing lignite for over fifty years and accounted for around 5% of total Polish lignite production in 2022. The only active mining site in the PAK basin is the Konin mine belonging to ZESPÓŁ ELEKTROWNI PĄTNÓW-ADAMÓW-KONIN (ZE PAK Group) which was listed on the Warsaw stock exchange in October 2012. ZE PAK Group's mining assets are now concentrated in PAK KWB Konin SA which operates three mines: Tomisławice, Drzewce and Jóźwin II B (in the Pątnów IV field) that together produced 3.0 million tonnes of lignite in 2022, requiring the removal of 20.4 million cubic metres of overburden (a stripping ratio of 6.8 cubic metres per tonne). Working depths are between 25 metres and 80 metres. The extracted fuel has an average calorific value of 9 220 kJ/kg and is supplied to two mine-mouth power plants: Pątnów I with an installed capacity of 1 244 MW and Pątnów II (474 MW). The lignite units at Konin power plant have closed and, after conversions completed in 2012 and 2020, two 50 MW biomass units now operate. ZE PAK Group intends to cease lignite mining before 2025 and in August 2022 ended its mining operations at the Drzewce mine.

PAK KWB Adamów SA operated three surface mines, namely Adamów, Władysławów and Koźmin. All of these are now closed, the last in early 2021. In November 2023, ZE PAK Group and a consortium led by SIEMENS ENERGY agreed to build a 600 MW combined-cycle gas turbine (CCGT) plant at the Adamów site. This PLN 2.3 billion investment should be operational by early 2027.

The Sieniawa 2 lignite deposit in the Lubusz Voivodeship is exploited by the private company KWB SIENIAWA. In 2022, 531 thousand tonnes of lignite were mined, an increase of 47.9% compared with 2021.

The average productivity at Poland's lignite mines was 7 700 tonnes per man-year in 2022 and employment totalled 6 980 people. Poland's lignite mining areas can maintain their annual output at current levels of around 60 million tonnes; lignite is expected to play a stable and important role in Poland's energy supply until at least 2030. The Złoczew deposit has 611 million tonnes of exploitable reserves while the Ościsłowo deposit has 50 million tonnes and both are considered prospective by the government in its strategic forecast to 2040. A much larger deposit of 1 624 million tonnes lies at Gubin.

Poland

Coal production, reserves* and resources*		2022
Hard coal saleable output	Mt	52.8
Hard coal reserves	Mt	4 266
Hard coal total resources	Mt	64 616
Lignite saleable output	Mt	54.6
Lignite reserves	Mt	819
Lignite total resources	Mt	23 085

Saleable coal quality		
Hard coal net calorific value	kJ/kg	28 815
Hard coal ash content	% a.r.	16.7
Hard coal moisture content	% a.r.	10.0
Hard coal sulphur content	% a.r.	0.74
Lignite net calorific value	kJ/kg	7 400 - 10 300
Lignite ash content	% a.r.	6.0 - 12.0
Lignite moisture content	% a.r.	50.0 - 60.0
Lignite sulphur content	% a.r.	0.2 - 1.1

Coal imports / (exports)		2022
Hard coal	Mt	20.2 / (5.4)
Lignite	Mt	0.3 / (0.0)

Primary energy production		2022
Total primary energy production	Mtce	84.8
Hard coal production	Mt / Mtce	52.8 / 43.5
Lignite production	Mt / Mtce	54.6 / 15.4

Primary energy consumption		2022
Total primary energy supply	Mtce	148.0
Hard coal consumption	Mt / Mtce	65.5 / 54.2
Lignite consumption	Mt / Mtce	54.8 / 15.4

Power supply		2022
Total gross power generation	TWh	179.7
Net power imports (exports)	TWh	(1.7)
Total power supply	TWh	163.6
Power generation from hard coal	TWh	78.9
Power generation from lignite	TWh	47.8
Hard coal power generation capacity	MW net	20 925
Lignite power generation capacity	MW net	7 597

Employment		2022
Direct in hard coal mining	number	72 911
Direct in lignite mining and generation	number	6 980

** Source: Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy (PIG-PIB – the Polish Geological Institute, a National Research Institute) as at 31 December 2022*

Romania

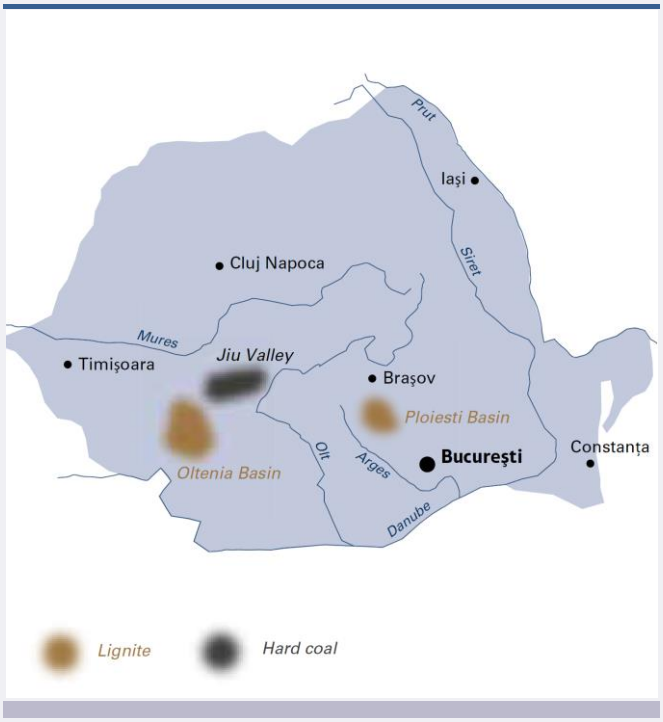
The Romanian economy has grown strongly since 2005: GDP has trebled and forecasts point to continued growth boosted by low tax rates. *Per-capita* GDP is less than half the EU average, although much closer on a purchasing power parity basis. In 2022, the unemployment rate was 5.5%. Romania has significant energy resources, including coal, lignite, fossil gas and oil. Almost 70% of the country's total primary energy supply is met from indigenous resources, well above the EU average of 42.9% in 2021. Coal and lignite accounted for 11.1% of energy supply in 2022.

Hard coal resources are estimated at 2 446 million tonnes of which 11 million tonnes might be economically recoverable. Proven reserves of lignite total 280 million tonnes within 9 920 million tonnes of remaining resources. Of these, 95% lie in the Oltenia mining basin where more than 80% can be surface mined. The remaining lignite deposits have low economic potential and so extraction in most other areas has stopped. The country has a long coal mining tradition, stretching back over 150 years. Today, Romania's entire hard coal and lignite output is used for heat and power generation.

The total net capacity of installed generation was 16 561 MW in 2022: coal and lignite 2 673 MW (16.1%), fossil gas 2 218 MW (13.4%), hydro 6 137 MW (37.1%), nuclear 1 300 MW (7.8%) and renewables 4 233 MW (25.6%), mostly wind turbines and solar PV. Peak demand in 2022 was 9 211 MW on 13 January, indicating a healthy generation margin.

In 2022, gross electricity production in Romania was 56.0 TWh: 25.0% from hydro, 19.8% from nuclear, 18.7% from coal and lignite, 18.7% from fossil gas and fuel oil, and 17.9% renewables and waste. Net electricity imports were 2.2 TWh in 2021 and reversed to 1.2 TWh net exports in 2022. Exports peaked at 11.2 TWh in 2015 but have since collapsed as the additional cost of allowances under the EU emissions trading system (ETS) has made non-EU power generation more competitive.

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). It is government policy to construct these reactors by 2031 and refurbish the two existing units for a 30-year life extension.



General data		2022
Population	million	19.1
GDP	€ billion	285.9
Per capita GDP	€/person	15 000

Romania has established an energy policy framework in line with EU law to regulate the production of gas, coal, lignite, oil and nuclear energy, as well as the promotion of renewable energy sources. Indeed, Romania's recovery and resilience plan foresees the phasing out of coal and lignite-fired electricity generation by 2032 to meet the requirements of the European Climate Law and related legislation.

In November 2018, the Romanian government published the *Romanian Energy Strategy for 2019-2030 in view of 2050* with the stated priority of maintaining a diversity of indigenous energy sources. To that end, the government plans to stimulate investments in energy exploitation and infrastructure. It envisages the development of the national gas transmission system along the Bulgaria-Romania-Hungary-Austria (BRUA) corridor and the development, on Romanian territory, of the Southern Transmission Corridor for Black Sea gas. The utilisation of existing cross-border pipelines will be enhanced: with Ukraine to the northwest (Medieșul Aurit) and east (Isaccea), to the west with Hungary, to the south with Bulgaria and to the northeast with Moldova.

In its *National Energy and Climate Plan*, Romania sets a target to increase the overall share of renewables in gross final energy consumption to 30.7% by 2030 (in 2021, the share was 23.6%). It also aims, with energy efficiency measures, to restrict primary energy consumption in 2030 to 45.1% below earlier projections.

Lignite

COMPLEXUL ENERGETIC OLTENIA (CEO) or Oltenia Energy Complex is Romania's largest producer of coal-based energy with an installed gross capacity of 2 295 MW. The company is responsible for 99% of national lignite production – 18.2 million tonnes in 2022. Its mines and power plants provide direct jobs for over 10 000 people.

Lignite mining has offered Romania a competitive advantage with the use of modern technologies and skilled labour to provide low-cost, baseload electricity. Reserves of lignite are concentrated in a relatively small area of 250 square kilometres where lignite is mined at ten surface mines. All these mines have scheduled closure dates (see box).

Lignite mines provide a long-term, secure supply for the Turceni (990 MW) and Rovinari (990 MW) power plants owned by CEO. Further to the south lies the 315 MW CEO Ișalnița power plant, also lignite-fired, and the 300 MW Craiova II owned by SOCIETATEA ELECTROCENTRALE CRAIOVA. The cost of EU ETS emission allowances places a heavy burden on the operation of these plants – more than the combined costs of labour and fuel.

Planned closure dates for Romania's lignite power plants

- Husnicioara and Lupoaia: 31 December 2022
- Jilţ Sud and Nord: 31 December 2023
- Tismana: 31 December 2024
- Alunu, Berbeşti and Roşiuţa: 31 December 2025
- Roşia-Peșteana and Pinoasa: 31 December 2030

In January 2022, the European Commission approved state aid of up to €2.66 billion for CEO to restructure and diversify its energy mix with eight solar PV parks of 725 MW total capacity and two gas power plants (475 MW at SE Turceni and 850 MW at SE Ișalnița). In July 2023, contracts worth €995 million were agreed with TINMAR ENERGY and OMV PETROM for the solar parks and the Turceni CCGT plant. Financial support will come from the EU ETS Modernisation Fund – 70% of the investment costs for the PV parks and 50% for the Turceni gas plant – as well as from other public sources. The parks will be built on mine waste tips and power plant ash heaps. Also in the approved restructuring plan is flexibility for CEO to increase lignite production and delay some plant closures. Romania's energy minister signed a similar agreement in June 2023 to replace the Craiova lignite plant with a 295 MW gas plant.

Hard coal

The COMPLEXUL ENERGETIC HUNEDOARA (CEH) or Hunedoara Energy Complex is a state-owned electricity and heat producer headquartered at Petroşani in the Southern Carpathians. In insolvency since 2019, CEH owns four underground hard coal mines in the Jiu Valley (Lonea, Livezeni, Vulcan and Lupeni which supply coal to the 150 MW Paroşeni and 1 075 MW Mintia-Deva power plants) and runs the Prestserv mines rescue station. The company accounts for less than 1% of Romanian electricity generation and had 2 045 employees at the end of 2022. An Iraqi company – MASS GROUP HOLDING – bought the Mintia-Deva site after the coal plant's closure in July 2021 and plans to develop a large replacement gas plant. The Norwegian company ARBAFLAME proposes a biomass conversion for the Paroşeni plant.

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	-
Hard coal reserves	Mt	11
Hard coal total resources	Mt	2 446
Lignite saleable output	Mt	18.2
Lignite reserves	Mt	280
Lignite total resources	Mt	9 920

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

Coal imports / (exports)		2022
Hard coal	Mt	0.6 / (0.0)
Lignite	Mt	0.0 / (0.2)

Primary energy production		2022
Total primary energy production	Mtce	31.8
Hard coal production	Mt / Mtce	0.0 / 0.0
Lignite production	Mt / Mtce	18.2 / 4.0

Primary energy consumption		2022
Total primary energy supply	Mtce	45.1
Hard coal consumption	Mt / Mtce	0.6 / 0.5
Lignite consumption	Mt / Mtce	18.0 / 3.9

Power supply		2022
Total gross power generation	TWh	56.0
Net power imports (exports)	TWh	(1.2)
Total power supply	TWh	51.7
Power generation from hard coal	TWh	0.2
Power generation from lignite	TWh	10.3
Hard coal power generation capacity	MW net	176
Lignite power generation capacity	MW net	2 497

Employment		2022
Direct in hard coal mining	number	2 045
Direct in lignite mining and generation	number	12 894

Serbia

At the heart of the Balkans, Serbia is well located for services and trade: the Morava Valley is the easiest land route from Europe to Türkiye and beyond. Since 2012, Serbia has been a candidate for EU membership; trade with the EU accounted for 58.8% of the country's total trade in 2022.

For energy, Serbia relies on lignite and small quantities of imported coal: 43.3% of its total energy supply of 23.0 million tonnes of coal equivalent in 2021. The country's electricity generation is based on lignite – 62.3% of 38.2 TWh gross generation in 2021 – and hydro (31.3%), recently complemented by wind power (2.8%). Serbia trades electricity with all its neighbours and is often a net importer, 0.7 TWh in 2021 and 2.6 TWh in 2022.

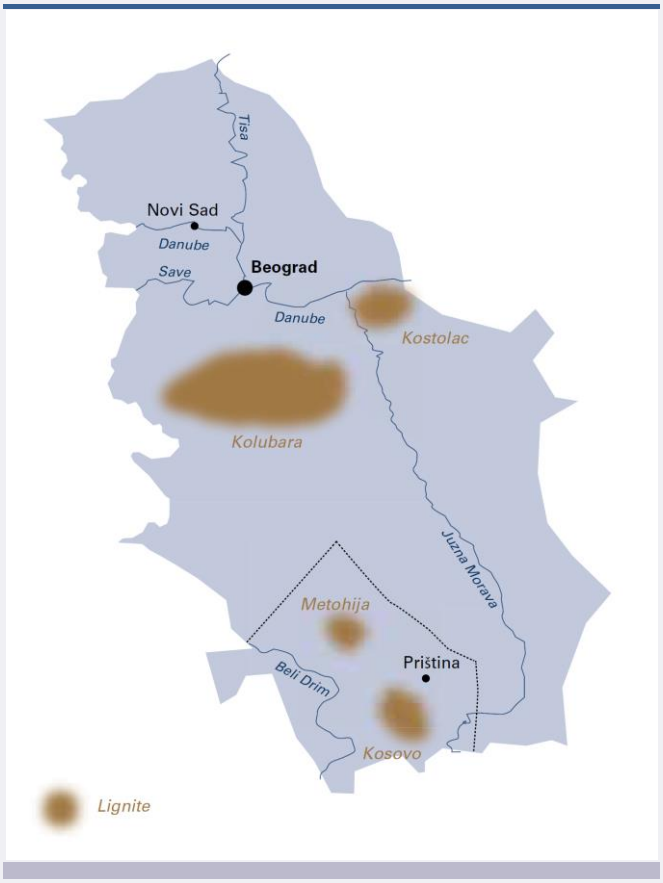
To increase power sector efficiency, the Serbian government has gradually introduced competition since adopting the *Energy Law 2004*. Opening of the electricity market will continue until it is fully opened in line with the country's ratification of the Energy Community Treaty in 2006.

According to Serbia's draft national energy and climate plan, the country will increase the share of renewable energy sources in electricity generation to 49.1% by 2030, requiring 75 GW of new renewables capacity. Serbia also considers nuclear power plants, including small modular reactors.

Serbia has very substantial lignite resources which are easily accessible for exploitation. Its lignite reserves are estimated to be 7.1 billion tonnes; in Europe, only Germany and Türkiye have larger reserves. Additionally, there are 13.1 billion tonnes of lignite resources. Deposits are located in two main coal basins, Kolubara and Kostolac. In 2022, Serbia mined 35.1 million tonnes of lignite and imported a further 2.2 million tonnes. Hard coal imports stood at 204 thousand tonnes.

The 100% state-owned ELEKTROPRIVREDA SRBIJE (EPS or Electric Power Industry of Serbia) is a vertically integrated utility company with the EPS Distribution LLC Belgrade subsidiary. EPS has eight divisions for electricity and coal production, including electricity supply which is the company's main activity. The production, processing and transport of coal, electricity generation, distribution system operator, renewable energy production, and the raising of steam and hot water in cogeneration plants are all performed by EPS. Since June 1999, EPS has not been able to operate its facilities in Kosovo[3].

In 2023, the Serbian government transformed EPS into a private joint stock company. For the time being, the state retains a 100% shareholding. With 20 481 employees, excluding workers from Kosovo[3], and over 3.4 million



General data		2022
Population	million	6.7
GDP	€ billion	60.4
Per capita GDP	€/person	9 100

consumers, EPS is the largest company in Serbia. The installed capacity of EPS power plants totals 7 391 MW comprising 4 079 MW of lignite-fired power plants, three gas- and oil-fired combined heat and power plants totalling 297 MW (the biggest at Panonske), and 3 015 MW of hydro plants.

Investment in new renewable energy sources is growing. EPS already operates the 158 MW Čibuk 1 and the 104.5 MW Kovačica wind farms, both located near Belgrade and partly financed by the European Bank for Reconstruction and Development. In the Kostolac lignite basin, other projects should complete in 2024: the 66 MW Kostolac wind farm and the 10 MW Petka solar PV park, as well as solar PV panels on the roof of the Nikola Tesla A lignite-fired power plant. Further such 10 MW solar PV projects are planned at Nikola Tesla B and on the ash heaps at Kolubara A and Morava coal power plants.

Lignite

Production of lignite, with an average calorific value of 7 200 kJ/kg, takes places at surface and underground mines in the Kolubara and Kostolac coal basins.

The 600 square kilometre Kolubara coal basin lies in the western part of Šumadija. There, Field B, Field E, Field G, Tamnava-West and Radljevo surface mines account for around 75% of Serbian lignite production. Lignite is supplied by rail to the Kolubara thermal power plant (TPP) at Veliki Crljeni, TPP Nikola Tesla A and B at Obrenovac about 40 kilometres from the mines, and TPP Morava at Svilajnac. Together, these three thermal power plants comprise ten units with a total capacity of 3 166 MW. Lignite from the surface mines is processed in coal preparation plants at Vreoci and the Tamnava-West mine.

In the Kolubara coal basin, surface mine Field E, with 400 million tonnes of lignite reserves, is progressively being developed as a replacement for Field D. The mine's planned annual output is 12 million tonnes. Field G surface mine extension was opened in 2017 with 36.5 million tonnes of good quality lignite reserves. In 2019, the new Radljevo surface mine with 350 million tonnes of lignite reserves opened after many months of overburden removal. The relocation of infrastructure to serve these new mines in the Kolubara basin was completed early in 2019.

Lignite mined in the Kostolac basin, from the 50 square kilometre Drmno coal deposit in the eastern part of the basin, accounts for the remaining 25% of Serbian lignite production and is supplied to the 310 MW Kostolac A and 700 MW Kostolac B power plants.

In 2022, EPS extracted 34.6 million tonnes of lignite in the Kolubara and Kostolac basins and removed 106 billion cubic metres of overburden, with overburden-to-production ratios of 2.7 cubic metres per tonne in Kolubara and 4.0 cubic metres per tonne in Kostolac. In addition, EPS purchased coal from underground mines operated by state-owned PEU "RESAVICA" U RESTRUKTURIRANJU, producing up to 500 thousand tonnes per year and employing 3 565 workers as at December 2022.

In December 2014, a loan agreement was signed by the Serbian government with the EXIM BANK OF CHINA to finance 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 in progress and the new unit should be operational by September 2023. The new unit will help secure Serbia's electricity supply while respecting EU environmental law.

When Kostolac B3 comes online, the older units of Kolubara A and Morava will be decommissioned. By 2028, Kostolac A and the oldest two units at Nikola Tesla A should

also be decommissioned. By then, a new 300 MW gas-fired power plant is scheduled to be online. Kolubara B should be co-fired with 30% biomass with Nikola Tesla A3-A6 continuing on 100% lignite. EPS has invited tenders for a new 630 MW pumped-storage hydro plant at Bistrica. This €1.2 billion project could partly replace Nikola Tesla A3-A6 sometime after 2031. Until 2025, annual demand for lignite from the Kostolac basin should remain at 7.3 to 8.0 million tonnes. Consumption of lignite from Kolubara is expected to decrease. With this emissions reduction strategy, Serbia should comply with the EU carbon border adjustment mechanism to be phased in from 1 January 2026.

To comply with EU environmental standards, EPS has invested heavily in power plant modernisation and environmental protection projects, particularly at its thermal power plants where flue gas desulphurisation, electrostatic filters, ash and slag transport, and wastewater treatment projects have been completed. By the end of 2025, EPS plans to have invested more than €850 million in its facilities in order to improve efficiency and environmental protection. About €650 million will be invested in air pollution control equipment to further reduce emissions of sulphur dioxide, oxides of nitrogen and fine particulates.

Serbia

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	-
Hard coal reserves	Mt	402
Hard coal total resources	Mt	855
Lignite saleable output	Mt	35.1
Lignite reserves	Mt	7 112
Lignite total resources	Mt	20 186

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

Coal imports / (exports)		2022
Hard coal	Mt	0.2 / (0.0)
Lignite	Mt	2.2 / (0.0)

Primary energy production		2022
Total primary energy production*	Mtce	15.0
Lignite production	Mt / Mtce	35.1 / 9.1

Primary energy consumption		2022
Total primary energy supply*	Mtce	23.0
Hard coal consumption	Mt / Mtce	0.2 / 0.2
Lignite consumption	Mt / Mtce	37.1 / 9.6

Power supply		2022
Total gross power generation	TWh	36.0
Net power imports (exports)	TWh	2.6
Total power supply	TWh	34.9
Power generation from hard coal	TWh net	0.7
Power generation from lignite	TWh net	21.5
Hard coal power generation capacity	MW net	486
Lignite power generation capacity	MW net	5 661

Employment		2022
Direct in lignite mining and power generation	number	16 700

** 2021*

Slovakia

The double pressure of Covid-19 and the energy crisis meant Slovak economic growth slowed; GDP in 2022 was €109.6 billion, a growth of 1.1%. With population stable at 5.4 million, *per-capita* GDP was €20 200. The country's strong automotive sector is deeply integrated with Germany's and both face the challenge of adapting to new technologies.

The Slovak Republic's total energy supply in 2022 was 23.8 million tonnes of coal equivalent. It has no significant exploitable fossil energy reserves beyond coal, although there is large potential for gas storage. Overall and thanks to nuclear power, the country had an energy import dependence of 52.5% in 2021, below the EU average. In recent years, there has been debate on the exploitation of a uranium deposit at Kurišková.

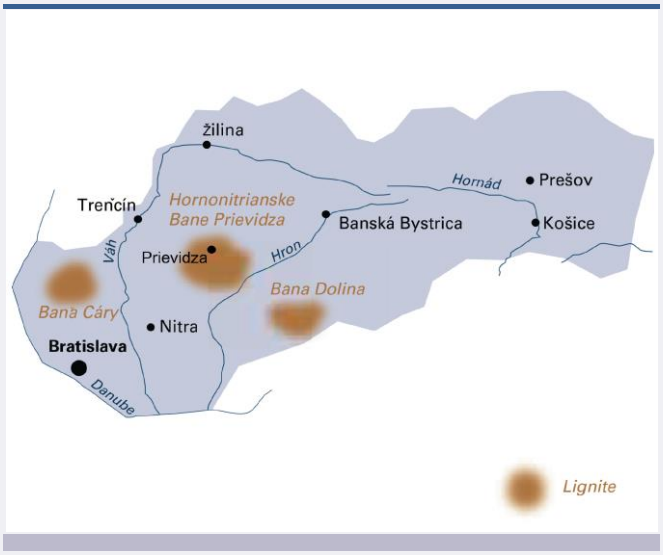
Slovak gross electricity production in 2022 was 26.8 TWh, with nuclear power having the largest share at 59.3%, followed by hydro at 13.3%. Fossil gas use for power generation was 7.8% in 2022. Hard coal, including coke oven gas, and lignite accounted for 7.7% of generation. Bioenergy (5.6%), solar PV (2.4%), oil (1.9%), waste (0.5%) and pumped hydro accounted for the balance.

At the end of 2022, the installed nuclear power generation capacity in Slovakia was 1 750 GW. In spring 2023, the third block of the Mochovce nuclear power station was commissioned, with generation starting at 25% of its 440 MW capacity before rising to 75% in July 2023.

Slovakia was a net importer of electricity in 2022, with 16.7 TWh mostly from Czechia and Poland. Exports were 15.3 TWh, mostly to Hungary and Ukraine. When Mochovce 3 reaches full output, Slovakia will become a net exporter of electricity and fossil fuels' share of generation will fall below 10% (compared with 17.4% in 2022).

Two gas-fired power stations are in operation: the 350 MW Malženice CCGT commissioned in 2011 near the town of Trnava, 60 kilometres from Bratislava, and the 4 × 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.

For the Vojany power plant and industrial applications, 2.9 million tonnes of hard coal were imported, mainly from Poland, Czechia, South Africa, Canada and Mozambique. The biggest consumer of coking coal and coke is U. S. STEEL KOŠICE.



General data		2022
Population	million	5.4
GDP	€ billion	109.6
Per capita GDP	€/person	20 200

Lignite

Slovakia's lignite resources, estimated at just over one billion tonnes, include 44.5 million tonnes classified as mineable reserves which are exploited by HORNONITRIANSKE BANE PRIEVIDZA (HBP). The average net calorific value of these reserves is 9 000 kJ/kg. There is an insignificant hard coal deposit in eastern Slovakia which is not exploitable.

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

In 2022, HBP produced 870 thousand tonnes of lignite and an additional 436 thousand tonnes were imported. In 2023, HBP planned to mine around 700 thousand tonnes of lignite. As the country is preparing to end coal production and use,

several mines have already closed: Cigeľ in October 2017, Handlová in September 2021 and Čary in October 2022 after HBP's BAŇA ČÁRY company suspended operations due to the complex geological condition found 180 metres undergound. The last remaining mine, Nováky, closed in December 2023.

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 conventional longwalls. HBP also operates a mines rescue station, which serves all mining districts in Slovakia, and owns BANSKÁ MECHANIZÁCIA A ELEKTRIFIKÁCIA NOVÁKY (BME), a mining and construction equipment manufacturer.

In line with the *Territorial Just Transition Plan for Slovakia*, adopted by the European Commission in November 2022, HBP focuses on renewable energy projects, indoor and outdoor agricultural production, thermal and ground water resources management, and mining heritage. Projects include greenhouses heated by geothermal energy from warm mine waters and solar PV parks with battery storage on brownfield mine sites.

After the 486 MW Nováky lignite-fired heat and power plant (Elektráreň Nováky – ENO) closed in December 2023, a 98 MW_{th} district heating boiler and two small turbogenerators (28 MW_e + 18 MW_e) remain. The only other coal power plant comprises the remaining two 110 MW units at Elektráreň Vojany I (EVO I) in the southeast of the country. The plant was designed to fire Russian semi-anthracite coal, but has trialled alternative solid fuels. This necessary fuel switching would build on the operator's experience with co-firing wood chips since 2009. The Nováky and Vojany I plants are operated by SLOVENSKÉ ELEKTRÁRNE which is majority-owned by a 50:50 consortium of ENEL of Italy and EPH of Czechia, with the state holding a minority 34% share.

Slovakia

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	-
Hard coal reserves	Mt	-
Hard coal total resources	Mt	19
Lignite saleable output	Mt	0.9
Lignite reserves	Mt	45
Lignite total resources	Mt	1 073

Saleable coal quality		
Lignite net calorific value	kJ/kg	10 600
Lignite ash content	% a.r.	<25
Lignite moisture content	% a.r.	<35
Lignite sulphur content	% a.r.	<2.5

Coal imports / (exports)		2022
Hard coal	Mt	2.9 (0.0)
Lignite	Mt	0.4 (0.0)

Primary energy production		2022
Total primary energy production	Mtce	9.8
Lignite production	Mt / Mtce	0.9 / 0.3

Primary energy consumption		2022
Total primary energy supply	Mtce	23.8
Hard coal consumption	Mt / Mtce	2.9 / 2.9
Lignite consumption	Mt / Mtce	1.3 / 0.5

Power supply		2022
Total gross power generation	TWh	26.8
Net power imports (exports)	TWh	1.4
Total power supply	TWh	25.3
Power generation from hard coal	TWh	1.1
Power generation from lignite	TWh	1.0
Hard coal power generation capacity	MW net	220
Lignite power generation capacity	MW net	486

Employment		2022
Direct in lignite mining	number	1 251
Other lignite-related*	number	300

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

Slovenia

Since its foundation in 1991, the Republic of Slovenia has enjoyed steady economic growth. After a period of strong growth from 2014, the economy slowed in 2019. The country's primary energy consumption grew until 2008 when the trend reversed. In 2022, total primary energy supply was 9.1 million tonnes of coal equivalent.

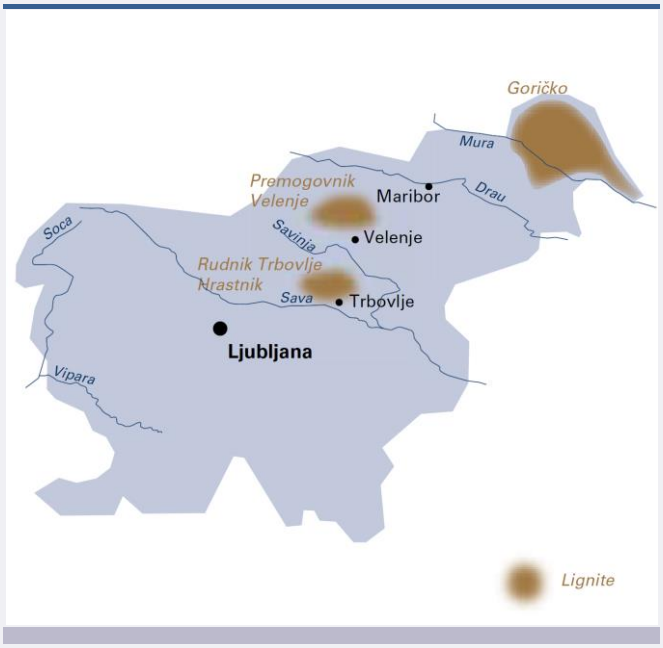
Resources of lignite and brown coal in Slovenia are estimated to be 1 244 million tonnes, lying at Velenje (346 million tonnes), Zasavje (68 million tonnes) and Goričko (830 million tonnes), with mineable reserves accounting for 100 million tonnes of the total resources. In 2022, 52.3% of the country's primary energy requirements were met by imports. Indigenous lignite production and coal imports accounted for 11.8% of primary energy supply in 2022. Oil had a share of 37.3%, nuclear 22.3%, renewable sources 11.4%, fossil gas 10.4%, hydro 4.1%, waste 0.8% and electricity imports accounted for the remainder.

The key elements of Slovenian energy policy are closely aligned with EU priorities, such as a national plan for renewables and a plan to improve energy efficiency. In the area of climate policy, Slovenia adopted a strategic framework for climate change adaptation in December 2016. In the long term, coal and lignite are expected to be partially replaced by renewable energy sources, fossil gas and biomass. PREMOGOVNIK VELENJE will continue its lignite production until 2033 under current plans as lignite is needed to maintain a well-balanced energy mix for security of supply reasons.

At 41.2% in 2022, nuclear power accounted for the largest share of gross electricity generation in Slovenia, followed by hydro (23.1%) and lignite (23.0%). Other sources had rather small shares, dominated by solar (4.7%). Over 70% of Slovenia's electricity generation is from zero-carbon sources.

Lignite

Only one lignite deposit is exploited in Slovenia, at Velenje in the north of the country. In 2022, 2.4 million tonnes of lignite were produced. Velenje mine is the only coal mine in Slovenia and all 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 in the Šaleška dolina valley and boasts one of the thickest-known lignite seams in the world, at more than 160 metres.



General data		2022
Population	million	2.1
GDP	€ billion	57.0
Per capita GDP	€/person	27 000

The company's long-term strategy is to operate the mine until 2033, as it is likely to remain Slovenia's only exploited indigenous energy resource. The Velenje coal mine belongs to the state-owned HOLDING SLOVENSKE ELEKTRARNE (HSE) who also owns the 1 029 MW Šoštanj (TEŠ) thermal power plant as well as hydro power plants.

Imported coal is mostly used at ENERGETIKA LJUBLJANA's Termoelektrarna Toplarna Ljubljana (TE-TOL) heat and power plant in Ljubljana. The company covers over 48% of the capital's household demand for heat.

Taking into consideration the increasing demand for electricity, the risks of energy import dependence and the abundant coal reserves at Velenje, HSE commissioned a new 600 MW unit at Šoštanj thermal power plant in 2015. 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 has had a very positive economic and environmental impact in Slovenia by ensuring stable electricity prices and lower emissions.

PREMOGOVNIK VELENJE is a technologically well-developed and strongly integrated company with almost 150 years of operation 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" has been proven to be the most effective method for extracting thick coal seams. PREMOGOVNIK VELENJE continues to develop this method to improve its productivity even more.

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, North Macedonia, Montenegro, Serbia and Türkiye).

PREMOGOVNIK VELENJE is also a partner in many EU-funded research and innovation projects which aim to develop clean coal technologies and safer mining solutions, as well as to execute transition projects that aim to repurpose end-of-life underground coal mines to create new green and quality jobs.

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 dolina 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 Velenje coal mine.

Slovenia

Coal production, reserves and resources		2022
Lignite saleable output	Mt	2.4
Lignite reserves	Mt	100
Lignite total resources	Mt	1 244

Saleable coal quality		
Lignite net calorific value	kJ/kg	10 650
Lignite ash content	% a.r.	16
Lignite moisture content	% a.r.	35
Lignite sulphur content	% a.r.	1.6

Coal imports / (exports)		2022
Hard coal	Mt	0.4 / (0.0)
Lignite	Mt	0.0 / (0.0)

Primary energy production		2022
Total primary energy production	Mtce	4.5
Lignite production	Mt / Mtce	2.4 / 0.9

Primary energy consumption		2022
Total primary energy supply	Mtce	9.1
Lignite consumption	Mt / Mtce	2.5 / 0.9

Power supply		2022
Total gross power generation	TWh	13.6
Net power imports (exports)	TWh	1.4
Total power supply	TWh	14.0
Power generation from lignite	TWh	2.8
Lignite power generation capacity	MW net	981

Employment		2022
Direct in lignite mining	number	1 196
Other lignite-related*	number	2 300

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

The energy transition brings new challenges in Slovenia and elsewhere. As recognised in the European Green Deal, a just transition should be ensured in those regions affected by structural change brought about by any reductions in coal mining or coal-fired power generation. In January 2022, the Slovenian government adopted a national strategy for phasing out coal and restructuring the coal-intensive regions in accordance with the principles of a just transition. This strategy stipulates that Slovenia will cease using coal for the production of electricity by 2033 at the latest. It is planned to replace coal mainly with renewable energy sources. With that objective in mind, it will be necessary to adopt regulations for the gradual closure and restructuring of Velenje mine in line with a green energy transition and the sustainable economic development of the region.

Türkiye

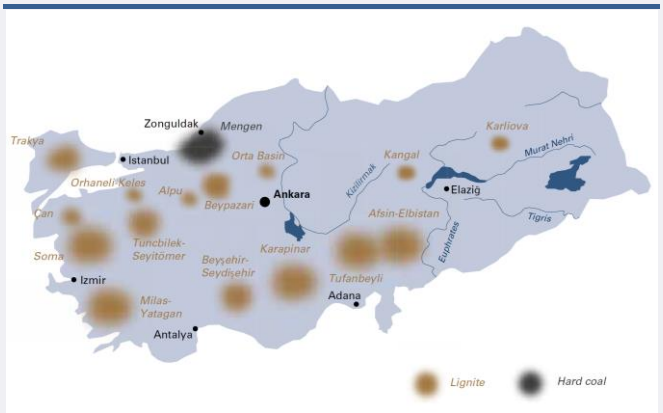
Türkiye is a candidate for EU membership and its economy benefits from access to the EU single market through the 1995 Customs Union agreement. Privatisation has created a buoyant energy sector. Total primary energy supply was 227.2 Mtce in 2021 with coal and lignite accounting for 25.6% – bringing diversity to an energy mix that was 72.4% dependent on net imports. With *per-capita* energy use in Türkiye still comparatively low at 1.9 tonnes of oil equivalent (toe) compared with an EU-average of 3.2 toe, energy demand is expected to grow with the economy.

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.

Coal is the second most important source of electricity generation, at 31.0% in 2021; fossil gas-fired power plants contributed 32.3%, hydro 16.8%, wind 9.4% and solar PV 4.2%. Turkish coal-fired power plants had an installed capacity of 21.8 GW at the end of 2022 (21% of total). Hard coal-fired power plant capacity was 10.4 GW and the capacity using domestic lignite was 11.4 GW.

The first 1 200 MW unit at the Akkuyu nuclear power plant on the Mediterranean coast was inaugurated in April 2023; three more units should be completed there by 2026. The 4 800 MW Akkuyu plant is built, owned and operated by a Turkish subsidiary of ROSATOM and the state-owned electricity supplier EÜAŞ will buy around half its output under a 15-year contract. The proposed 5 200 MW Sinop and 5 300 MW Igneada nuclear power plants, both on the Black Sea coast, would likely be based on other reactor designs.

Türkiye has the world's sixth largest lignite reserves. Total coal resources are estimated at 1.3 billion tonnes of hard coal and 16.3 billion tonnes of lignite. Turkish lignite production and electricity generation from lignite and hard coal have increased steadily. Between 1990 and 2022, lignite production doubled while hard coal imports increased sixfold to 34.7 million tonnes. Turkish energy policy would see this trend continue, offering opportunities for foreign direct investment (FDI) in the modernisation and expansion of the Turkish coal sector. 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 several private companies, some under contract to the state-owned companies.



General data		2022
Population	million	85.3
GDP	€ billion	862.3
Per capita GDP	€/person	10 100

Coal also plays a role in residential heating. The Turkish government distributes annual coal allowances to poorer households, even in regions with access to fossil gas.

Türkiye forecasts growing energy needs. Currently, almost all oil, gas and hard coal are imported (93%, 99% and 97% respectively) mostly from the Middle East and Russia, leading to a large trade deficit. Turkish energy policy focuses on boosting indigenous energy supply, modernising energy system infrastructure, and improving the functioning of the energy market. The *Eleventh Development Plan 2019-2023* prioritises expanding lignite production and lignite-fired power generation, exploiting fossil gas reserves, constructing new nuclear power plants and deploying more renewables. The plan calls for the further liberalisation of the Turkish energy market, limiting the share of state-owned enterprises. The *National Energy Plan 2022* aims to meet the country's 2053 net-zero emission target. The share of coal in primary energy consumption should be limited to 21.4% by 2035 which would still result in an absolute increase of coal use to 62.7 Mtce with an installed coal plant capacity of 24.3 GW.

Türkiye aims to become a hub in the fossil gas market. The TurkStream pipeline from Russia opened in January 2020 and can carry 31.5 billion cubic metres (bcm) annually, with half destined for the European market. In 2020, Türkiye also imported 11.1 bcm from Azerbaijan via the Trans Anatolian TANAP and Baku-Tbilisi-Erzurum (BTE) pipelines. Newly discovered gas fields in the Black Sea and the Mediterranean Sea could significantly lower Türkiye's import dependence.

Türkiye ratified the Paris Agreement on 6 October 2021, and its national targets allow an 86% rise in greenhouse gas emissions from 499 $MtCO_2e$ in 2020 to 929 $MtCO_2e$ in 2030 before falling to net zero by 2053. Through research and development, Türkiye promotes clean coal technologies, CCUS, coal-based chemicals such as ammonia, synthetic diesel and alternative gases. A *Hydrogen Technologies Strategy and Roadmap* was launched in January 2023.

Hard coal

Türkiye's hard coal deposits are in the Zonguldak basin, between Ereğli and Amasra on the Black Sea coast in northwest Türkiye. Total hard coal resources in the basin are estimated to be over one billion tonnes, of which reserves are estimated to be 550 million 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 Türkiye where hard coal is extracted and it has a very complex geological structure which makes mechanised coal production difficult; hence, coal production is labour intensive and subsidised.

The state-owned TTK operates five deep mines in the Zonguldak coal basin and produced 1.1 million tonnes of saleable coal in 2022, supplying the 300 MW Catalağzı thermal power plant owned by BEREKET ENERGY and other customers. Including private mines, hard coal production in Türkiye totalled 1.4 million tonnes in 2022. In the same year, Türkiye imported 34.7 million tonnes of hard coal for thermal power plants, steel production, industry and domestic heating purposes – mostly from Colombia and Russia, with smaller quantities from the United States, Australia, Canada and South Africa (Türkiye did not join the EU ban of 2022 on Russian coal imports).

Türkiye has embarked on an ambitious programme to build new power plants with the latest supercritical and circulating fluidised bed (CFB) boiler technologies to burn mainly lignite and imported coal. The second unit at AKSA ENERJI's 270 MW Bolu-Göynük plant started operation in 2016, while ENERJISA ENERJI completed its 450 MW Tufanbeyli CFB plant in Adana province. Two 700 MW supercritical units at EREN ENERJI's 2 790 MW ZETES power station were also completed in 2016 at Zonguldak, running on imported coal. Private investment into the Turkish energy sector often includes foreign companies in joint ventures, such as the 1 320 MW İsken-Sugözü coal power plant in partnership with STEAG and the 1 320 MW Emba Hunutlu coal power plant, opened in 2022 as a joint venture with SHANGHAI ELECTRIC POWER. The government intends to increase the share of domestic companies in both the power generation and mining sectors.

Lignite

Lignite is Türkiye's most important indigenous energy resource, with total resources of 16.3 billion tonnes and 11.0 billion tonnes of reserves. 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 deposits are up to 58 metres thick and economic reserves are estimated to be around 7 billion tonnes. The Soma basin is the second-largest lignite mining area in Türkiye. 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).

The scale of Türkiye's surface mining operations allows lignite to be produced at a relatively low cost, making it competitive with imported energy resources. In 2022, lignite output was 80.9 million tonnes, including from underground mines in the Soma, Tunçbilek and Beypazarı basins. Among the proposed new lignite mines in Türkiye, those in Thrace, Eskişehir-Alpu and Afyon-Dinar would be underground, and those in Konya and Karamanmaraş would be opencast.

The Turkish government promotes more private ownership in the coal-mining sector and encourages domestic coal production by tendering the licences held by public companies for non-producing blocks. Some of these tenders grant the right to mine coal subject to the construction of an adjacent power plant. By 2021, five new licenses were awarded. All coal plants can benefit from capacity payments and voluntary power purchase agreements with EÜAŞ for a proportion of their output if using domestic coal.

Looking to the future, TKİ works in collaboration with TÜBİTAK, the Turkish Scientific and Technical Research Council, and other international partners on research projects in the fields of lignite drying, coal gasification, coal-biomass co-combustion and liquid fuels production, some projects partly supported by the European Union.

Asphaltite

At Silopi near the Iraqi and Syrian borders, a third CFB unit at CINER GROUP's 405 MW asphaltite-fired power plant was commissioned in 2015 by CHINA NATIONAL MACHINERY ENGINEERING CORPORATION. In 2022, 1.5 million tonnes of asphaltite were mined. The national institute TurkStat includes asphaltite production data within lignite production.

Türkiye

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	1.4
Hard coal reserves	Mt	550
Hard coal total resources	Mt	1 337
Lignite saleable output	Mt	80.9
Lignite reserves	Mt	10 975
Lignite total resources	Mt	16 259

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

Coal imports / (exports)		2022
Hard coal	Mt	34.7 / (0.7)

Primary energy production		2021
Total primary energy production	Mtce	66.0
Hard coal production	Mt / Mtce	1.2 / 1.0
Lignite production	Mt / Mtce	72.7 / 23.5

Primary energy consumption		2021
Total primary energy supply	Mtce	227.2
Hard coal consumption	Mt / Mtce	38.1 / 33.9
Lignite consumption	Mt / Mtce	86.5 / 24.2

Power supply		2022
Total gross power generation	TWh	326.0
Net power imports (exports)	TWh	2.7
Total power supply	TWh	313.9
Power generation from hard coal	TWh net	66.5
Power generation from lignite	TWh net	46.3
Hard coal power generation capacity*	MW net	10 374
Lignite power generation capacity*	MW net	11 437

Employment		2022
Direct in hard coal mining	number	8 528
Direct in lignite mining	number	44 457

** As at December 2022, 67 "coal" power plants were operating in Türkiye: 46 lignite-, 4 hard coal-, one asphaltite-, and 16 imported coal-fired power plants. The capacity of the four power plants using domestic hard coal is included here in the lignite capacity figure.*

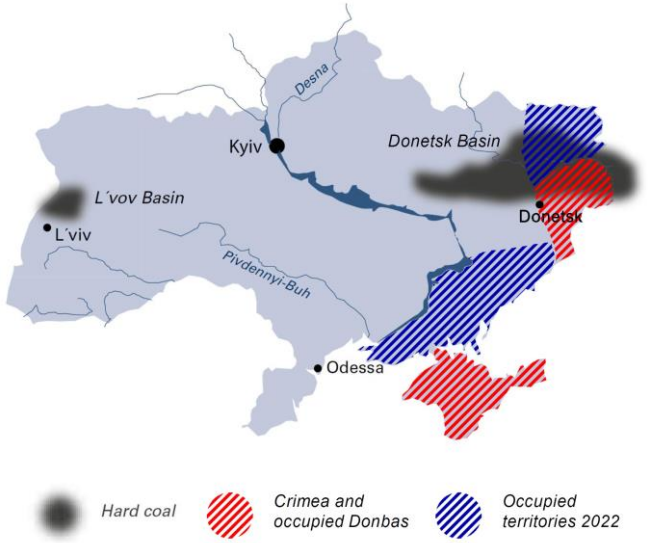
Ukraine

The war of aggression against Ukraine by the Russian Federation has devasted a peaceful country that was enjoying a period of impressive economic growth. The costs of war and the occupation of large parts of its territory mean that Ukraine's GDP shrank by 30.3% in 2022, despite foreign currency inflows and assistance from Western partners. An exchange rate freeze helped curb inflation. At the end of 2022, the unemployment rate was 28.3% or 4.5 million people, while 11.7 million had migrated abroad, including some skilled workers and professionals.

Since the 19th century, Ukraine has been an important centre of heavy industry in Eastern Europe, notably the coal, steel and non-ferrous metals industries of the Donbas region. Despite partial occupation since 2014 and the destruction of industrial facilities – including coal mines, power plants and, during summer 2022, the massive Azovstal steelworks – a significant industrial base remains elsewhere in the country. Government loans and credit lines have helped companies restore damaged power generation and transmission infrastructure, but the destruction by Russia of, for example, the 335 MW Kakhovka hydropower plant in June 2023 is irreparable.

Faced with systematic, large-scale attacks on its power infrastructure since the fourth quarter of 2022, electricity generation from the country's four nuclear power plants has been crucial, accounting for over half of the estimated 112.7 TWh total generation. The 6 000 MW Zaporizka NPP is the largest, with six of the country's fifteen VVER reactors, but is occupied by Russian forces and under constant threat – cooling water from the Kakhovka reservoir has been lost. In 2021, nuclear accounted for 86.2 TWh or 57.5% from plants owned by ENERGOATOM which is set in 2023 to become an independent, but still 100% state-owned, joint-stock company. Coal was the second most important electricity source, at 37.0 TWh (24.7% of 150.0 TWh total generation in 2021), followed by gas at 9.9 TWh (6.6%), hydro (6.9%), wind (1.9%) and solar (1.7%), with oil and biomass together accounting for less than 1%. New renewables capacity (wind, solar PV, biomass and small hydro) was 9.9 GW prior to the Russian invasion and while a quarter is damaged or non-operational, new wind capacity continues to be built such as the 498 MW Tiligulska wind farm near Mykolaiv in southern Ukraine. By 2030, renewables capacity could grow to 30 GW. At the same time, it is likely that EU emission limits assumed in the National Emission Reduction Plan will have to be relaxed at existing thermal plants as investment in pollution control equipment is impossible under martial law.

In March 2022, the Moldovan and Ukrainian power systems were desynchronised from the Russian-dominated IPS/UPS grid and connected to the synchronous grid of Continental Europe. By March 2023, the transmission capacity had increased to 850 MW from Poland/Romania to Moldova/Ukraine and 400 MW in reverse.



General data		2022
Population (including refugees)	million	41.0
GDP	€ billion	151.5
Per capita GDP	€/person	4 700

Ukraine has considerable reserves of coal and lignite, estimated at 32.0 billion tonnes in the Donetsk coal basin (by far the most significant), the Dnipro and Lviv-Volyn coal basins, as well as the Dnipro-Donetsk and Transcarpathian coal basins. It ranks sixth in the world after the United States, China, India, Australia and Russia in terms of proven hard coal reserves of which steam coal accounts for 70% and coking coal 30%. Exploitable reserves are competitive with imported coal.

The country also has large gas reserves estimated at over one trillion cubic metres – second only to Norway in Europe. These lie onshore, mainly in the Dnipro-Donetsk basin, offshore under the Black Sea, and as shale gas in the Donetsk and Kharkiv oblasts (Yuzivska gasfield) and in the Lviv and Ivano-Frankivsk oblasts (Olesska gasfield). Efforts to exploit these reserves were set back by the war, but a programme of deep drilling at the Machukhske gasfield in the Poltava oblast promises gas from almost 6 000 metres, adding to other conventional, shallower production which totalled 17.5 bcm in 2022.

In April 2023, the Cabinet of Ministers approved a new *Energy Strategy 2050* which aims to develop nuclear power generation for a 50% share and renewables for the other 50% to achieve carbon neutrality in the energy sector by 2050.

Hard Coal

Hard coal deposits in Ukraine 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. In 2018, coal was mined at forty-seven mines, of which forty-two produced G-grade bituminous coal. The rest produced K-grade coking coal and Zh-grade bituminous coal.

Total run-of-mine coal production in 2022 was 26.1 million tonnes (saleable production is reported in the table below), with 17.5 million tonnes from the mines of Ukraine's largest private energy company, DTEK. Other private mines produced 6.4 million tonnes while state-owned mines had an output of 2.2 million tonnes. Of these three groups, only DTEK managed to increase production since Russia's full-scale invasion.

Since spring 2014, Russia's invasion left Ukraine with little control over its coal-mining assets in the occupied territories of Donetsk and Luhansk oblasts where all anthracite mines are located. Production data for the lost coal mines in Donbas is not known, but some coal is likely exported via Russia and Georgia's breakaway region of Abkhazia. In response, the consumption of G-grade coal has grown as power plants designed for anthracite (A/T grade) have been converted to use G-grade coal whose production is less at risk from hostilities.

Since the start of the war in 2014, Ukraine became a hard coal importer. In 2022, 4.7 million tonnes were imported: 2.9 million tonnes of coking coal and 1.8 million tonnes of steam coal. Ukraine currently bans the export of thermal coal for security reasons.

DTEK operates four thermal power plants: the 510 MW Dobrotvirska power plant, the 1 200 MW Ladyzhinska power plant, the 2 181 MW Burshtynska power plant and the 1 532 MW Kurakhivska power plant which has been heavily damaged by shelling. The company lost control over the Luhanska and Zaporizka coal power plants which are in the occupied territories, but still controls two coal-fired power plants using G and A/T grade coal: the 610 MW Prydniprovska power station and the 915 MW Kryvorizka power plant. State-owned CENTRENERGO also owns two coal-fired power plants using G and A/T grade coal: the 1 700 MW Zmiivska power plant (only one unit operating) and the 1 225 MW Trypilska power plant which does not operate as of 2023 due to heavy damage. The third coal plant operator, DONBASENERGO had to close its single 880 MW Slovianska coal power plant due to war damage.

Coal is sold under contract by mining enterprises to consumers, and through DERZHVUGLEPOSTACH which was established by the government to trade coal produced at state-owned coal mines. The bulk of the saleable output from state-owned coal mines is distributed at fixed prices.

Ukraine

Coal production, reserves and resources		2022
Hard coal saleable output	Mt	21.2
Hard coal reserves	Mt	32 039
Hard coal total resources	Mt	81 045
Lignite saleable output	Mt	-
Lignite reserves	Mt	2 336
Lignite total resources	Mt	7 717

Saleable coal quality		
Hard coal net calorific value	kJ/kg	19 250 - 28 500
Hard coal ash content	% a.r.	5.0 - 35.0
Hard coal moisture content	% a.r.	5.0 - 16.0
Hard coal sulphur content	% a.r.	0.8 - 5.0

Coal imports / (exports)		2022
Hard coal	Mt	4.7 / (0.7)

Primary energy production		2021
Total primary energy production	Mtce	78.1
Hard coal production	Mt / Mtce	23.0 / 17.3

Primary energy consumption		2021
Total primary energy supply	Mtce	126.0
Hard coal consumption	Mt / Mtce	35.1 / 29.7

Power supply		2022
Total gross power generation	TWh	112.7
Net power imports (exports)	TWh	(2.0)
Total power supply	TWh	110.7
Power generation from hard coal	TWh	24.8
Hard coal power generation capacity	MW net	18 587

Employment		2022
Direct in hard coal mining	number	58 809
Other coal-related*	number	6 882

** at DTEK coal-fired power plants*

Thus, loss-making mines are cross-subsidised by profitable mines, although losses are not fully covered. The 2022 budget envisaged financial support for Ukraine's state-run mines of UAH 3.2 billion under the *Coal Industry Restructuring* programme and UAH 1.0 billion under a liquidation programme for uncompetitive coal mining companies. Private companies sell coal at market-based prices determined by supply and demand, having regard to international coal market prices.

Lignite

During the 1990s, Ukraine produced 35 million tonnes of lignite from the Olexandria and Mokra Kalyhirka deposits in the Kirovohrad and Cherkasy oblasts near the Dnipro River. Production in recent years has been minimal or zero.

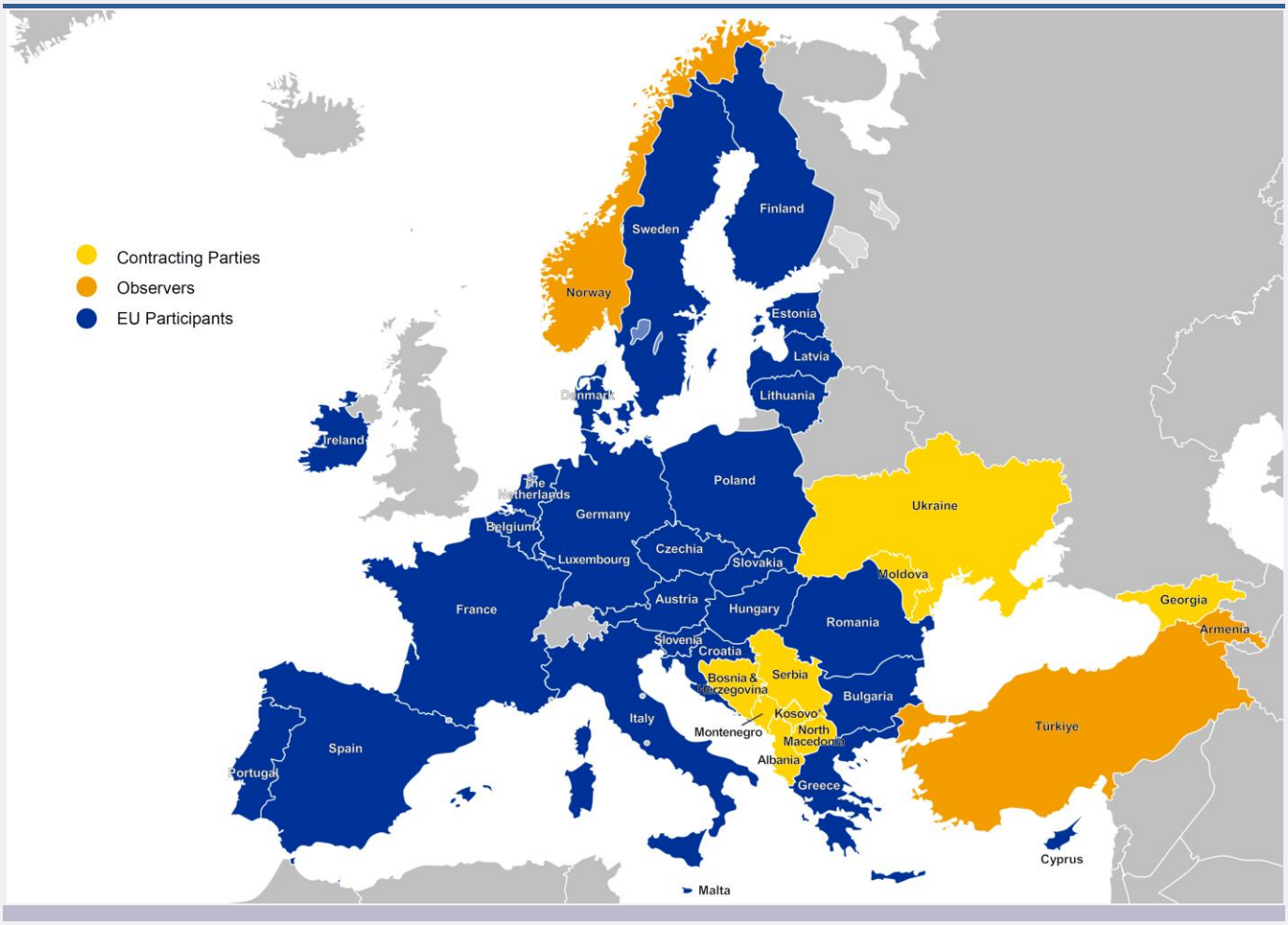
Other EU Member States and Energy Community stakeholders

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 nine contracting parties and three observers to the Energy Community. Given that the UK and Morocco are well interconnected with EU member states, these two, coal-using countries are included. Finally, Kaliningrad is synchronised with the Russian and Belarusian grid (IPS/UPS) via the Baltic States, at least until 2025, and has its own unique energy security challenges as an isolated enclave.

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 interconnected networks. 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. More recently, the Energy Community has provided dedicated support to Ukraine and runs its own Just Transition Initiative for contracting parties.

The Energy Community offers opportunities to owners of coal-fired power plants in Southeast Europe who have access to what is the world's largest electricity market. At the same time, plant owners are required to make very substantial investments in pollution control equipment to meet stringent EU emissions legislation.

Figure 25
EU member states and Energy Community stakeholders



Source: Energy Community. Map adapted from Energy Community Map.svg by BegbertBiggs, used and relicensed by EURACOAL under CC BY 4.0.

** See footnote 3 on page 77.*


RÓMAN II
RÓMAN II

Armenia

Since 2018, the South Caucasus country of Armenia has co-operated with the European Union via the EU-Armenia Comprehensive and Enhanced Partnership Agreement (CEPA) which came into force in 2021. In 2022, the EU was Armenia's second most important trading partner, after Russia which supplies oil, gas, coal and nuclear fuel.

The country generates electricity at gas-fired power plants, accounting for 44.1% of the 7.7 TWh total generation in 2021, at the Sevan-Hrazdan, Vorotan and other hydro plants (28.7%) and at the 440 MW Metsamor nuclear power plant (26.0%) located 30 kilometres from the capital Yerevan. Solar PV accounted for the balance.

Armenia has six major coal deposits with estimated total resources of 317 million tonnes. Only the Jajur deposit has officially approved reserves of 355 thousand tonnes. However, no deposits have been exploited in recent years. In 2022, Armenia imported a few thousand tonnes of coal from Russia for use in industrial applications.

Austria

Austria's developed economy includes a large industrial sector – around one quarter of GDP. Germany is its largest trading partner but since the fall of the Iron Curtain, Austria has increased trade with other countries under the former Habsburg monarchy.

Thanks to its geography, Austria has good hydro resources and generated 50.1% of its electricity at hydropower plants in 2022, mostly at run-of-river plants. The second-largest source of electricity was fossil gas (15.1%) while the rest was covered by renewables, mainly wind (10.5%) and biofuels (6.8%), but also solar PV (5.5%). Electricity is traded with all neighbouring countries and in 2022 Austria was a net importer of 8.7 TWh, meeting 12.6% of demand.

The Baumgarten gas distribution hub is one of Europe's most important trading points, distributing Soviet, then Russian gas to Western European customers. This role has continued during Russia's war on Ukraine and the ensuing EU sanctions against other Russian energy commodities.

Although no longer exploited, Austrian lignite resources total 333 million tonnes, lying mainly in western Styria near Graz. During the monarchy, energy demand was met with coal from Moravia and Silesia. After each world war, hard coal and lignite mining was expanded to replace production lost elsewhere; lignite output peaked at over 6 million tonnes in 1963 when 100 thousand tonnes of hard coal were also mined. With increasing trade and more oil and gas use, Austria's underground coal mines became uncompetitive and closed during the 1960s. After more than two centuries, coal mining ended in 2006 with the re-cultivation of Oberdorf opencast lignite mine.

Austria imports hard coal for industrial uses – 2.5 million tonnes in 2022. The integrated steel works operated by VOESTALPINE at Linz is the biggest consumer. Production of coke for steelmaking – 1.3 million tonnes in 2022 – satisfies about two-thirds of demand. Before the EU ban on Russian coal imports from August 2022, Austria imported from there but now relies only on suppliers in Poland, Australia and the United States.

VERBUND's 225 MWe Mellach CHP plant supplying Graz with district heating used coal until March 2020. Plans to reopen it during the energy crisis were abandoned in January 2023.

Baltic States

The neighbouring Baltic States of Estonia, Latvia and Lithuania are all in the eurozone and Schengen area. To their south, the Russian enclave of Kaliningrad Oblast borders Lithuania and Poland. The Baltic States are among Europe's fastest-growing economies, but face unique market-access challenges due to their location. The three countries are electrically linked to the BRELL network which includes Belarus and Russia. By 2025 or earlier, they will synchronise with the continental European electricity grid – a move approved by the European Network of Transmission System Operators (ENSTO-E) in May 2019. Four DC interconnectors connect the Baltic States to Poland, Sweden and Finland: 500 MW LitPol, 700 MW NordBalt, 350 MW Estlink 1 and 650 MW Estlink 2. As of 2021, the European Commission considered all three states to be "coal-free", although all use small quantities of coal for industrial purposes. Estonia also mines oil shale, a solid fossil fuel used in a similar way to coal.

Russia exports coal from Ust-Luga, 120 km west of St. Petersburg and the largest port for coal in the region, although ice can hinder operations there as well as at St. Petersburg and Vyborg (Vysotsk) ports. A project to expand Primorsk port to handle 25 million tonnes of coal per year is underway. Until 2022, alternative routes for Russian coal exports included the Baltic Coal Terminal at Ventspils in Latvia with an annual capacity of 6.0 million tonnes and the 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.

Estonia is unique in using indigenous oil shale for its energy supply. It enjoyed an energy import dependency of just 1.5% in 2021, by far 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 combusted in much the same way as coal – either as a pulverised fuel in older boilers or in modern circulating fluidised-bed boilers (CFBs). In 2022, oil shale contributed 57.0% to Estonia's gross electricity generation, followed by biomass (17.0%), wind (7.5%) and solar PV (6.7%).

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.

Estonia's accessible oil shale reserves total approximately 1.5 billion tonnes. In 2022, 10.6 million tonnes of oil shale 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. In underground mines, traditional room-and-pillar mining methods are used. To improve recovery rates and reduce production losses, EESTI ENERGIA plans to test a 700-metre long-wall mining face at one underground mine.

At the beginning of the century, oil shale production was trending upwards to meet growing demand for oil products produced from oil shale. In response, the Estonian government set in 2018 an annual limit for oil shale mining of 20 million tonnes. Estonia plans to further increase the share of renewable energy sources and evaluates the possibility of building a nuclear power plant. The country aims to cease electricity production from oil shale by 2035, to phase out oil shale in energy production by 2040 and to reach climate neutrality by 2050.

Around 55% of oil shale production is used for electricity and heat generation, notably at the EESTI ENERGIA Narva energy complex, comprising the 1 015 MW Eesti power plant, the 215 MW Balti power plant which also supplies heat to the town of Narva and the adjacent 272 MW Auvere CFB power plant which runs on oil shale, biomass, peat and oil shale gas.

The environmental issues associated with oil shale exploitation are complex. With 45% incombustibles, the quantities of ash to store or recycle are large. All operational pulverised-fuel boilers have been upgraded to comply with the EU Industrial Emissions Directive. 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 deNOx systems. Although Estonia has decided to stop producing electricity from oil shale within the next decade, in 2022 the demand for electricity from oil shale increased due to the energy crisis. Compared with 2021, one third more oil shale was mined and 42% more electricity produced from oil shale.

5 659 people are employed in the Estonian oil shale industry, of which around 2 475 are employed at mines.

Latvia used to be an important transit country for shipping Russian coal to other EU member states. Since the EU ban of August 2022 on Russian coal imports, only Kazakh and Kyrgyz coal has been transhipped. Latvia generates most of its electricity at hydropower plants, 55.0% in 2022, followed by fossil gas at 24.2% and 20.7% renewables. Latvia imported 45 thousand tonnes of hard coal in 2022.

Lithuania, with the highest population and energy demand of the Baltic States, depends on imports to meet three quarters of its energy needs. Its energy mix is dominated by imported oil and fossil gas, with only 295 thousand tonnes of imported coal in 2022.

The closure of the Ignalina nuclear power plant at the end of 2009 left a power generation gap in the Baltic region. This could have been filled by the proposed Visaginas nuclear power plant, but Lithuanians voted against this project in a 2012 referendum. Ever since, Lithuania has relied upon electricity imports: 8.6 TWh net in 2022 to meet 70% of demand. The remaining 30% was met mainly by renewables and hydropower.

Since 2014, the Klaipėda LNG terminal has been a hub for LNG trade in the Baltic region and ended the region's dependence on Russian pipeline gas. This floating storage and regasification unit (FSRU) with an annual capacity of 4 billion cubic metres might be expanded in the future.

The **Kaliningrad** enclave is dependent on imported energy from the rest of Russia, although power is generated locally: at the 900 MW Kaliningradskaya 2 gas-fired power plant completed in 2010, the 160 MW Mayakovskaya and 160 MW Talakhovskaya gas plants completed in 2018, the 455 MW Pregolsky gas plant completed in 2019 and the backup 195 MW Primorskaya coal-fired power plant completed in 2020. Fossil gas is supplied via a single pipeline from Russia or via the Marshal Vasilevskiy LNG floating storage and regasification unit (FSRU) commissioned in 2022. The 174 million cubic metre (mcm) underground gas storage facility created in salt caverns provides security and will be expanded to hold 800 mcm by 2025.

In 2025, when the Baltic States synchronise with the Continental Europe Synchronous Area, Kaliningrad will operate as an isolated system. In May 2019, Kaliningrad's power grid was temporarily run in isolation to demonstrate its readiness.


1382
1382

Although construction stopped in June 2013 of the new 2 400 MW Baltiyskaya nuclear power plant at Neman close to the Lithuanian border, it would remain a viable project if customers for its electricity could 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, although in 2017 the pressure vessel for unit 1 was sent to replace a damaged vessel at the 2 400 MW Ostrovets 2 nuclear power plant in Belarus. Lying 50 kilometres from Vilnius, the Ostrovets plant is fully commissioned and operational after the second unit was connected to the grid in May 2023.

While the EU has imposed extensive sanctions on Russia, transit of goods between Russia and Kaliningrad, including coal, are exempt if they do not exceed the previous three-year average.

Belgium

Belgium's gross electricity generation in 2022 was 95.9 TWh of which 45.7% was nuclear (12.8% lower than 2021 when nuclear power generation reached an all-time-record high of 50.3 TWh), 25.2% renewables, 22.9% fossil gas and 2.4% coal. Belgium is a net exporter of electricity and carries power flows from Germany and the Netherlands to France and the United Kingdom. In 2003, the government decided to end nuclear power generation by 2025. In 2022 and 2023, the 1 GW Doel 3 and 1 GW Tihange 2 units were duly closed. However, the energy crisis reopened this decision and in 2023 the government agreed with ENGIE to continue operation of the newest units (1 GW Doel 4 and 1 GW Tihange 3) until 2035.

In the 19th century, the Walloon coal mines of southern Belgium fuelled the country's industrial expansion. By 1917, coal mining had started in the north-east, around Limburg. National coal production peaked at 30 million tonnes in 1952 and was maintained at this level until the late 1950s. Output gradually declined as the Walloon and Limburg mines closed: Eisden mine in 1987 and Belgium's last colliery at Heusden-Zolder in 1992. Remaining coal resources are an estimated 4 100 million tonnes.

Coal imports totalled 3.2 million tonnes in 2022, mostly from South Africa and the United States (more coal was imported into Antwerp port for onward delivery to customers in other countries). Coal provided 5.4% of Belgium's primary energy supply in 2022, 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.

Cyprus

Cyprus imports small quantities of hard coal – 80 thousand tonnes in 2022 – for use mainly by VASSILIKO CEMENT WORKS. Given the rising cost of EU ETS allowances, the company is actively looking at alternative fuels. For its electricity needs, Cyprus is reliant on imported fuel oil for power generation (83.2% in 2022), with the remainder being met by solar PV, wind and some biogas. A national target for renewable energy would see this share double to 30% by 2030 with a network of state-owned energy storage systems. Cyprus exerts no control over the northern territories administered by the Turkish Republic of Northern Cyprus which relies mainly on fuel oil and diesel for electricity generation. Electrically isolated, Cyprus promotes the 2 GW EuroAsia Interconnector to link Greece, Cyprus and Israel via a 525 kV HVDC (high voltage, direct current) submarine cable. A contract for the Cyprus-Greece section was awarded in July 2023. Also, the proposed 1 900-kilometre EastMed gas pipeline between Cyprus, Israel and Greece would connect Eastern Mediterranean gas fields to strengthen EU energy security. A shorter, 300-kilometre pipeline to Cyprus could be built more quickly, with the promise of future hydrogen transport to help secure public funding.

Denmark

With rising oil and gas production from the North Sea, Denmark became energy self-sufficient in 1999 and, in 2004, a net exporter of primary energy. Since then, production has steadily declined by 80% to 90% such that Denmark can no longer be considered a major oil or gas producer. Denmark returned to being a net energy importer in 2013 and, at around 50%, its energy import dependency is now near the EU average.

Danish energy supply changed significantly with efforts to promote renewable energy, combined heat and power (CHP) and energy efficiency. The remarkable growth of wind energy – 19.0 TWh or 54.2% of total generation in 2022 – means renewables are expected to supply more than 100% of the country's power needs by 2030. At least 90% of district heating is to come from non-fossil energy sources by 2030 as part of the government's long-term goal for climate-neutrality by 2050.

In 2022, 81.1% of gross electricity generation came from renewable sources, mostly wind and biomass. The relatively high use of onshore (4.6 GW) and offshore (2.3 GW) wind turbines enhances electricity supply security but poses balancing challenges. The Danish power system has connections to Norway, Sweden, Germany and the Netherlands, with the 325-kilometre, 700 MW COBRAcable

operating since 2019, and the new 760-kilometre 1.4 GW Viking Link to the UK to open at the end of 2023. Denmark's electricity imports in 2022 were 18.8 TWh or 1.4 TWh net of exports to account for 4.0% of supply. As part of the integrated Nordic electricity market, Denmark's thermal 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 3.2 GW; most are fuelled with biomass. The majority state-owned ØRSTED runs Asnæs (26 MW), Avedøre (806 MW), Esbjerg (373 MW) and Studstrup (362 MW) power plants. Most units at these plants can burn biomass – wood pellets or straw – the result of ØRSTED's bio-conversion programme for all its coal- and gas-fired CHP units. Following an order from the Danish authorities, ØRSTED has delayed its target to end coal use by one year to 2024.

Amager power plant is owned by a subsidiary of Copenhagen's municipal heat and power company, HOFOR ENERGIPRODUKTION. In 2010, the 68 MW coal-fired unit 1 dating from 1971 was converted to biomass. Then, in 2020, HOFOR commissioned the stylish 150 MW BIO4 unit. The whole power plant now runs on wood pellets. At Odense, the 409 MW Fyn power plant includes a straw-fired boiler and a coal-fired unit, with the latter set to close by 2025. Finally, since 2015, the 410 MW Nordjylland plant has been owned by the local municipality's utility company, AALBORG FORSYNING.

Avedøreværket and Nordjyllandsværket 3 remain among the world's most efficient coal-/biomass-fired power plants. Their high-temperature, high-pressure, supercritical boilers and steam turbines result in an electrical generation efficiency of 47% and, with heat supply, their overall efficiency can exceed 95%.

Denmark has no indigenous coal resources. In 2022, the country imported 1.9 million tonnes of coal, mostly from South Africa, Colombia and Australia. Almost 90% of this coal was used for electricity and heat generation with cement production and food processing being the other main uses. Having peaked in 1984 at 96%, the share of coal in power generation fell to 12.6% in 2022 (4.4 TWh) and will be gradually phased out before 2030 in line with government policy.

Finland

Even though it has no oil, gas or coal resources, Finland had an energy import dependency of just 38.3% in 2021 – well below the 57.1% EU average. Finnish energy policy maximises energy-supply diversity. Over one third of electricity production was from nuclear in 2022 and Finland's fifth nuclear reactor, the 1 600 MW EPR operated by TVO at Olkiluoto, began full commercial operation on 16 April 2023. However, in June 2015, TVO shareholders resolved not to proceed with plans for a second new unit at Olkiluoto.

Locally produced peat is used as a fuel, mostly at dedicated district heating plants and at combined heat and power (CHP) plants. Peat accounted for 3.0% of gross electricity generation in 2022. In its territorial just transition plan approved by the European Commission in December 2022, Finland will halve the energy use of peat by 2030 (*c.f.* 2018-2020). Consumption in 2022 was 3.7 million tonnes with stock drawdown adding significantly to production.

Finland is one of the world leaders in bioenergy. Renewable energy sources provided two-thirds of total primary energy production and accounted for 53.6% of power supply in 2022. Nevertheless, coal and fossil gas remain important fuels for CHP and district heating plants, although coal's share in conventional generation is falling. In 2022, gross electricity generation from coal was 6.2 TWh (8.6% of total), with an important contribution from the 565 MW Meri-Pori coal power plant at Tahkoluoto in Pori. In total, coal-fired generation capacity was 1.7 GW in 2022. 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 4.0 million tonnes in 2022: 2.6 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 also used by the paper and cement industries. All coal is imported, steam coal entirely from Russia in the past and now from Australia, Colombia and the United States. Coking coal arrives from North America and Australia.

Finland's *National Climate and Energy Strategy* accounts for the country's special features, including its cold climate, long transport distances, extensive energy-intensive industry and domestic raw material resources, especially forest biomass. To implement the strategy, the government has taken many measures, in particular on energy efficiency, energy saving and electrification. Finland aims to increase the share of renewable energy in final consumption to 50% by 2030 and become carbon neutral by 2035. As the share of renewable energy increases, the government wants to diminish the shares of peat and fossil fuels, in particular coal which is heavily taxed for heating use (220 €/tonne). In May 2019, the Finnish parliament approved a ban on coal-fired power generation from 1 May 2029, except when used as an emergency backup fuel, and a €90 million subsidy for companies that phase out coal by 2025.


R1

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. Remaining coal resources in France are estimated to be 160 million tonnes of hard coal and 114 million tonnes of lignite.

In 2022, coal imports amounted to 7.8 million tonnes, including 3.5 million tonnes of coking coal from Australia and the United States. Coal can be delivered through the ports of Dunkerque, Le Havre, Rouen, Montoir and Fos-sur-Mer, as well as via the ARA ports. Coal consumption was 8.1 million tonnes in 2022, of which an estimated 1.6 million tonnes were consumed for power generation.

Gross power generation in France was 474.8 TWh in 2022, with 62.1% of this total generated at nuclear power plants. Conventional thermal power generation contributed 12.2%, hydro 9.6%, wind 8.0% and solar PV 4.1%. Coal-fired power generation accounted for 1.3% of the total while the overall share of renewables was 23.9%.

In its *Programmation pluriannuelle de l'énergie* published in November 2018, the French government announced an end to coal-fired power generation by the end of 2021. Today, the only large coal power plants in France are located adjacent to the port at Cordemais (2 × 600 MW) and at Saint-Avold in Lorraine where the 600 MW Émile-Huchet unit 6 must remain operationally available until the end of 2024, according to a government decree of August 2023. By 2025, EDF plans to convert its Cordemais plant to fire biomass while EPH plans a 20 MW biomass plant at Émile-Huchet. RTE, the French power transmission system operator, considers the Cordemais plant to be essential for electricity supply security in western France and EDF has been allowed its limited operation on coal until 2026. EDF's 600 MW Le Havre coal plant was closed in April 2021 and is being demolished. EPH-owned GAZEL ENERGIE operated the now closed 600 MW Gardanne unit 5 in Provence until late 2020. At Gardanne-Meyreuil, GAZEL ENERGIE operates a 150 MW circulating fluidised bed unit converted in 2017 from coal to biomass and known as "Provence 4 Biomasse". The company hopes to expand its activities at Gardanne to include the production of green hydrogen and e-fuels, as well as district heating and a sawmill. These plans are a response to a March 2023 decision of the Conseil d'État to annul the plant's operating licence, citing an inadequate impact assessment that did not consider *indirect* impacts on regional forestry.

There are three 100 MW coal-fired power plants in French overseas territories: one in Guadeloupe (Le Moule) and two in Réunion (Le Gol and Bois-Rouge). During sugar campaigns, these plants also use renewable bagasse and each is being equipped to run on imported biomass in place of coal.

The French steel industry consumes important volumes of coal – around 5.6 million tonnes at integrated steel works in 2021. ARCELORMITTAL plants at Dunkerque and Fos-sur-Mer are the biggest coal consumers in this sector.

Georgia

Lying in the Caucasus region between Europe and Asia, Georgia has a pro-European foreign policy and applied for EU membership in March 2022. Georgia's economy is open and liberalised, ranking seventh in the World Bank "doing business index". Russian forces occupy about one-fifth of its territory – Abkhazia and parts of South Ossetia – over which the Georgian government has no control.

Georgia relies mainly on hydropower for electricity generation: 80.5% of the 12.6 TWh total in 2021, followed by imported fossil gas at 18.8% and little else. Georgia is a net importer of electricity with exports to Türkiye lower than imports from Russia.

In the Tkibuli-Shaori and Tkvarcheli deposits, Georgia has coal reserves of 201 million tonnes plus resources of 700 million tonnes. 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. Following the "Rose Revolution" of 2003 and conflict with Russia in 2008, the small coal industry was revitalised.

In 2022, 148 thousand tonnes of brown coal were produced from two underground mines at Tkibuli in west-central Georgia and 104 thousand tonnes of hard coal imported mainly for industrial use. Coal provided 4.2% of Georgia's total primary energy supply of 7.6 million tonnes of coal equivalent in 2021. Fossil gas was the main primary energy source (45.6%), followed by oil products (26.0%) and renewables (21.5%). Wood is used extensively, mainly for space heating, water heating and cooking.

SAKNAKHSHIRI (Georgian Coal), a subsidiary of STEEL INTERNATIONAL TRADE COMPANY, owns and operates the Dzidziguri and Mindeli mines at Tkibuli with licensed resources of 331 million tonnes. These supply cement works at Kaspi and Rustavi, a small 13 MW coal power plant at Tkibuli, as well as the ferroalloy industry. In 2019, DMT presented a report with recommendations to improve safety at the mines which then employed 1 400 workers.

Instead of the previously proposed 150 MW Tkibuli and 300 MW Gardabani coal power plants, a 460 MW combined cycle gas turbine plant was built at Gardabani in the southeastern Kvemo Kartli province by ÇALIK ENERJI (unit 1 in 2015) and CHINA TIANCHEN ENGINEERING CORPORATION (unit 2 in 2020). Plans will see its capacity doubled and tenders were invited for unit 3 in June 2023. The Georgian government will also focus on securing private

investment to construct new hydro plants, increase thermal power generation efficiency and diversify fossil fuel supply sources and routes.

In occupied Abkhazia, the Turkish operator TAMSAŞ produced good quality coal at an opencast mine in the Tkvarcheli coalfield, once the largest coal mine in the Caucasus region. Exploitation stopped in 2018 as the deeper parts of the 20 million tonne reserve became uneconomic. The Jukmuri coal terminal at Ochamchire has been greatly expanded to handle transhipments. The occupied region of South Ossetia does not generate electricity but relies on transmission from Russia.

Ireland

The Irish economy has grown remarkably since the 2008 global financial crisis, partly thanks to Ireland's attractiveness as the European base for some major multinational companies. Among EU member states, Ireland's *per-capita* GDP is second only to Luxembourg. Energy use has grown to support an increasingly services-based economy, but is still below the pre-crisis level of 2007. Energy production has also grown with strong growth of wind power over the last two decades and fossil gas since the Corrib gas field began production in December 2015. Although Ireland's import dependency fell to 77.9% in 2021, its coal and oil needs must all be imported.

Coal imports totalled 1.5 million tonnes in 2022, all steam coal and mostly from Colombia. As well as power generation, coal is used in Ireland for household heating and cement production. In 2022, Ireland also used 1.0 million tonnes of harvested peat, this being two-thirds less than in 2018 and much of it from stocks. Peat now accounts for a minor 2.5% of primary energy supply.

BORD NA MÓNA, once Ireland's leading peat producer and distributor of peat briquettes for residential heating, stopped peat harvesting in 2020. Some small producers and informal "turf cutters" remain, but there is political pressure to end peat sales.

Since 2001, peat-fired power plants were supported by a public service obligation as their use of indigenous fuel contributed to electricity supply security. However, this support expired 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 set a 30% biomass dilution target for peat used as a fuel. For example, the 120 MW Edenderry power plant was designed and built to fire peat, but is now co-fired with a mixture of peat and biomass from forests and energy crops. In 2022, 0.7% of Irish electricity was generated from peat and 1.5% from biomass. Once peat stocks are exhausted, only biomass will be fired at power plants.

Ireland has one 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 diversification 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 2025. Indeed, the Irish government's policy is to cease using coal for electricity generation by 2025. However, Moneypoint is Ireland's largest energy store, with a capacity to stock sufficient coal for three months' operation (*c.f.* five days at Ireland's fossil gas plants). The power plant remains important for national energy security and fuel diversity.

Fossil gas was the dominant fuel for power generation in 2022 with a 48.8% share of generation, followed by wind (33.1%) and coal (7.7%). Although a single electricity market covers the Republic of Ireland and Northern Ireland, and the 500 MW East-West and 500 MW Moyle interconnectors link this to the UK mainland, the island market is quite isolated. With wind power generation growing strongly, the island grid increasingly relies on conventional power plants during periods of low wind and high demand. A third HVDC interconnector is under construction – the 500 MW Greenlink scheduled to complete in 2024 – while the 575-kilometre, 700 MW HVDC Celtic Interconnector to France is scheduled to complete in 2026 as Ireland's first, direct connection to the synchronous grid of Continental Europe.

Italy

Italy has the third highest GDP in the European Union: €1.9 trillion in 2022. The country has a strong manufacturing base and enjoys a significant trade surplus. Public debt reflects a high level of government spending and means the economy suffers from structural problems which successive governments have aimed to resolve.

Coal accounts for a small part of Italy's primary energy supply at 5.1% of the 206.5 million tonnes of coal equivalent total in 2022. As in all other EU member states, oil and gas are important, and especially so in Italy where they account for three quarters of energy supply. The country has no nuclear power. 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. Renewables and waste make up the remaining share of energy supply. Overall, this energy mix means Italy has a high import dependency – 74.7% in 2022.

The only coal reserves and resources in Italy lie in the Sulcis-Iglesiente basin, in south-west Sardinia, totalling an estimated 10 million tonnes. Mining activities were stopped there in 1972, but restarted in 1997 with many environmental

improvements. In accordance with EU state-aid rules, CARBOSULCIS, owned by the Regional Government of Sardinia, closed Monte Sinni, the last mine at Nuraxi Figus, in December 2018. The agreed closure plan foresees site restoration and redevelopment by 2027.

For electricity generation, Italy is very dependent on fossil gas: 49.8% of the 284.0 TWh total gross generation in 2022. New renewables accounted for 25.4%, with solar PV, wind and biofuels all important. Hydro's share was 10.0%. The next largest source of electricity generation in 2022 was coal at 8.5%, with oil and waste accounting for the remainder.

After growing strongly under five *Conto Energia* schemes which ended in 2013 and other green subsidies, the share of new renewables (solar PV, wind and biofuels) stagnated over the eight-year period to 2022 at around 20%. Net electricity imports of 43.0 TWh in 2022 met 13.5% of gross electricity supply.

In 2022, Italy imported 11.8 million tonnes of coal: 9.0 million tonnes of steam coal and 2.8 million tonnes of coking coal for steelmaking. The main supply countries were South Africa, Indonesia, the United States and Australia. Coal imports into Italy 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 near Genoa owned by TIRRENO POWER, the closure of a further five coal power plants (A2A's 680 MW Brindisi Nord and 70 MW Brescia plants and ENEL's 640 MW "Andrea Palladio" at Fusina near Venice, 600 MW "Eugenio Montale" at La Spezia and 75 MW "Pietro Vannucci" Bastardo near Perugia in Umbria), as well as difficulties at the ACCIAIERIE D'ITALIA steel plant in Taranto which is majority owned by ARCELORMITTAL.

Mainland Italy has three coal-fired power plants totalling 4 300 MW: ENEL Torrevaldaliga Nord (1 980 MW) on the coast at Civitavecchia near Rome, ENEL Brindisi Sud "Federico II" (1 980 MW), and A2A Monfalcone (336 MW) near Trieste. Following their modernisation and conversion from fuel oil to coal, Italy has some of the best-performing coal-fired power plants in Europe. The Torrevaldaliga Nord power plant attains a net efficiency of 45%, thus matching the world-leading performance of plants in Japan. In line with the country's draft updated Integrated National Energy and Climate Plan (*PNIEC*) submitted to the European Commission in June 2023, the closure of Italy's remaining coal-fired power plants will be delayed until 2026 (and later for power plants located on Sardinia). Emphasis will instead be placed on the development of renewable energy sources, flexible generation supported by capacity market auctions, grid development and more energy storage systems.

The closure of the two coal-fired power plants on Sardinia (EPH 640 MW Fiumesanto and ENEL 490 MW Sulcis "Grazia Deledda") depends on completion of the western section of the 970-kilometre 1 GW Tyrrhenian Link connecting the Italian mainland with Sicily and Sardinia. The Italian TSO, TERNA, awarded contracts for this €3.7 billion interconnector in 2023 with completion scheduled for 2028.

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. Luxembourg continues to enjoy strong economic growth and at €121 132 in 2022 has the world's highest *per-capita* GDP.

With an energy-import dependence of 92.5% in 2021, Luxembourg is among the most import-dependent EU member states, after Cyprus and Malta. The country has only one major power generation site: the RWE-operated 1 300 MW Vianden pumped-storage hydro plant. A 385 MW combined-cycle gas turbine plant at Esch-sur-Alzette operated by TWINERG was prematurely closed in 2016 for economic reasons and fully demolished in 2019. Luxembourg thus generates only one third of its electricity needs from mainly renewable sources (excluding pumped hydro) and imports the rest. It is well connected with and integrated into the German bidding zone.

The steel industry's conversion to electric-arc furnaces (ARCELORMITTAL steel works at Esch-Belval and Differdange) has practically eliminated Luxembourg's coal use and means the sector accounts for around 35% of total electricity demand. Coal is used today mainly to produce cement at the CIMALUX Rumelange plant. All coal is imported – 72 thousand tonnes in 2022 – and makes only a small contribution to the country's primary energy supply. Yet, in 2021, Luxembourg had the EU's highest *per-capita* greenhouse gas emissions at 20.9 tCO_2e/cap – higher than the United States.

Malta

Malta has no fossil energy production and reports no coal consumption. Until 1995, coal was imported for power generation. The closure of two old, oil-fired power plants, the conversion of another to gas and the commissioning in 2017 of the 205 MW Delimara 4 combined cycle gas turbine plant at Marsaxlokk mean that Malta's CO_2 emissions have fallen by around 40% over the last decade. Liquified natural gas (LNG) is imported via a floating facility adjacent to the power plants and accounted for 84.5% of power generation in 2022. The proposed 159-kilometre Melita TransGas Pipeline would replace this LNG and end Malta's isolation from the EU gas network but must be "hydrogen-ready" if it is to secure public funding. The balance of power generation comes mainly from solar PV. To further diversify electricity supply, the 120-kilometre 200 MW Malta-Italy Interconnector was commissioned in 2015 and a second one to Sicily is planned.

Moldova

The Republic of Moldova, a candidate for EU membership since 2022, now trades more with the European Union than elsewhere: 49.3% of total trade in 2022, followed by Ukraine (12.3%) and Russia (10.8%).

The unrecognised breakaway state of Transnistria lies across the Dniester River on the country's eastern border with Ukraine and supplies most of Moldova's electricity from the 2 520 MW Cuciurgan thermal power plant on the shores of Cuciurgan reservoir. In 1990, over 4 million tonnes of coal were consumed there, but since the late 1990s the station has used virtually no coal. The four operational units (out of twelve) run now on imported Russian gas, although coal and oil are kept as reserve fuels. The plant is owned by MOLDAVSKAYA GRES, a subsidiary of the Russian company INTER RAO UES.

The remaining supply of electricity is covered by two gas-fired combined heat and power (CHP) plants in Chișinău (64 MW + 240 MW), a 20 MW CHP plant in Bălți, CHP plants at sugar refineries and two hydro power plants: the 48 MW Dubăsari plant and another 16 MW plant at Costeşti.

The dependency on Russian-occupied Transnistria for power has been a significant challenge. Moldova also relied on electricity imports from Ukraine which stopped in 2022 resulting in several blackouts. In March 2022, the Moldovan and Ukrainian power systems were connected to the synchronised grid of Continental Europe. There is no direct interconnector linking Moldova to Romania; all flows go via Ukraine. The long-planned Bălți-Suceava power line could improve energy security.

Moldova does not produce coal or lignite. It imports small quantities of hard coal for use by industry and in heating plants – 127 thousand tonnes in 2022. Coal represents less than 2% of total energy supply.

Morocco

Although not a European country, Morocco has been connected to the synchronous grid of Continental Europe via an 800 MW interconnector to Spain since 1997. In 2019, the Spanish and Moroccan governments agreed to add a third, 700 MW interconnector by 2026. A 1 000 MW Portugal-Morocco interconnector is also proposed. More speculatively, the Xlinks project would link Morocco to the United Kingdom with twin 3 800 km, 1 800 MW HVDC subsea cables.

Morocco was a net importer of electricity in 2022 but had been a net exporter in earlier years. The country generated 66.5% of its electricity at coal-fired power plants in 2021, a share that has increased steadily from 45.6% in 2010. Other important sources are new renewables (16.3%), and oil and gas (11.3%). Morocco plans to increase its renewable electricity production.

Coal mining in Morocco started in 1934 in the Jerada basin and continued until 2000, with only some artisanal mining since then. The country has total coal resources of 136 million tonnes of which 14 million tonnes are considered exploitable. Morocco imported 10.9 million tonnes of coal in 2021 mostly from Russia and mostly for power generation.

TAQA owns and operates the 2 056 GW Jorf Lasfar coal-fired complex in the Doukkala-Abda region comprising six units the last of which was commissioned in 2014. Also on the coast, SAFI ENERGY COMPANY operates the 1 386 MW Safi coal plant on behalf of owners ENGIE, NAREVA and MITSUI. Its two supercritical units were completed in 2018. The state-owned ONEE operates the coastal 600 MW Mohammedia and the inland 515 MW Jerada coal-fired power plants.

With Morocco's increasing demand for electricity and opportunities to export power, coal will likely remain essential for the country even as the share of renewables grows. The government has committed not to build any new coal plants, but its modern coal plants could still be operating in 2050.

The Netherlands

The Netherlands is the EU's seventh most populous member state and ranks fifth by GDP. In 2022, 39.2% of its electricity was generated from fossil gas, followed by wind (17.6%), coal (14.3%), bioenergy (8.3%), solar PV (14.0%), waste (2.1%), nuclear (3.4%) and oil (1.3%). The Netherlands trades electricity with all its neighbours, including Denmark, Norway, and the United Kingdom via subsea DC interconnectors.

The Netherlands reports 3 247 million tonnes of coal resources. Hard coal mining dominated the South Limburg area of the Netherlands from the late 19th century 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. Coal mining in the Netherlands ended in 1974 when the private Oranje-Nassau Mine I and Julia coal mines closed. Emma mine, the last state-owned mine, was closed in 1973.

From around 1915, lignite was extracted at opencast mines near the towns of Eygelshoven and Hoensbroek. The deposits are located on the northwest fringe of the large Rhenish lignite basin to the west of Cologne in Germany. Lignite mining ended in 1968 with the closure of the Carisborg site.

The Netherlands is home to the main ports for the transhipment of coal imports into Europe. The ports at Amsterdam and Rotterdam, along with Antwerp port in Belgium, together make up the ARA trading area for imported steam coal and coking coal in northwest Europe.

In 2022, 8.6% of the Netherlands' primary energy supply was provided by coal, all imported. The country imported 9.0 million tonnes: 4.8 million tonnes of steam coal and 4.2 million tonnes of coking coal. Since the EU ban on Russian coal, the main supplier countries were Colombia, South Africa, the United States and Canada.

Most imported coal is used for coal-fired power generation: coal took a 14.3% share of the 121.8 TWh gross electricity generation in 2022, including the use of coke oven gas and blast furnace gas at steelworks. Dutch coal power plants are modern: UNIPER's 1 070 MW Maasvlakte 3 plant in the Rotterdam area, ONYX POWER's 736 MW Rotterdam plant, commissioned in early 2015, and RWE's 1 560 MW Eemshaven plant near Groningen. All three employ the latest supercritical steam technologies to achieve high energy efficiencies. Only one older coal plant operates at Geertruidenberg, the 600 MW Amer plant owned by ESSENT, a subsidiary of RWE, after the 630 MW Hemweg 8 near Amsterdam closed in 2019. To fulfil the ambitious targets of Dutch climate policy, many coal power plants co-fire biomass.

Under the Climate Act of 2018, the Netherlands has committed to reduce its greenhouse gas emissions by 49% by 2030 and by 95% by 2050, compared with 1990 levels. In its Climate Agreement of June 2019, the coalition government agreed to phase out coal-fired electricity generation by 2030, with the first plant closed before 2020 and the three most modern plants by 2030. A carbon tax is used to create a floor price for the EU ETS starting at €30 per tonne of CO_2 in 2021 for industry and rising by €11.55 each year on emissions that exceed EU benchmarks (lowest 10th percentile) and subject to government evaluation in 2025. The floor for electricity generators started at €16.40 in 2020 and rises to €31.90 by 2030. A production capacity cap of 35% on coal-fired power generation was lifted in June 2022, less than six months after its introduction, amidst the ongoing energy crisis in Europe.

The Dutch government has supported CCS demonstration projects, including the ROAD project and the Porthos project which aims to store 2.5 million tonnes of CO_2 annually from Rotterdam industry in depleted North Sea gas fields. Two other projects (Athos and Aramis) are currently under development.

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 demonstrated the single-step HIsarna DRI process to reduce CO_2 emissions from steelmaking through a more efficient direct reduction of iron ore than the usual blast furnace / basic oxygen furnace. A larger demonstration at Jamshedpur in India is considered while TATA STEEL in the Netherland pursues hydrogen-based DRI.

The Dutch government plans to double offshore wind capacity to 21 GW by 2030, cut emissions from coal-fired power plants to zero by 2030, increase extraction from smaller North Sea gas fields, but close the Groningen field by 2024. In addition, it has proposed two new nuclear power plants, alongside more CCS projects and electrolysers for hydrogen production (8 GW by 2032).

Norway

Norway, Europe's northernmost country, opted to stay out of the European Union by referenda in 1972 and 1994, but supplies significant volumes of oil and fossil gas to the union. In 2022, 24.4% of EU gas imports came from Norway which is the world's fourth largest gas exporter after Russia, the United States and Qatar. Hydro power plants accounted for 91.6% of Norway's gross electricity generation in 2021 and the country is a significant net exporter of electricity – 17.6 TWh or 11.1% of gross production in 2021 – being well connected to European markets via the Nordlink and North Sea Link interconnectors to Germany and the UK, each with a capacity of 1.4 GW.

In 2022, Norway produced 117 thousand tonnes of hard coal and imported 814 thousand tonnes for use in the metallurgical industry, chemicals production and cement manufacture. 84 thousand tonnes of coal were exported in 2022.

Norway has access to deposits of good quality, high calorific value coal at Svalbard lying within the Arctic Circle where remaining resources are estimated to total 86 million tonnes, with 2 million tonnes of reserves. Annual coal production there peaked at 4.0 million tonnes in 2007.

Coal mining on Spitsbergen, the largest and only permanently populated island of the Svalbard archipelago, has served multiple government goals, not all related to energy. Without continued peaceful economic activity on Spitsbergen, Norwegian sovereignty might be weakened by foreign economic activity as the Svalbard Treaty of 1920 grants rights to all forty-six signatories. The state-owned STORE NORSKE SPITSBERGEN KULKOMPANI (SNSK) was established in November 1916 and now operates one drift mine employing around 40 people: the Gruve 7 room-and-pillar mine in the valley of Adventdalen near Longyearbyen. The company's Svea Nord longwall mine located 60 kilometres south of Longyearbyen stopped production in 2016, while the new Lunckefjell mine northeast of Svea closed in 2015 after being in operation for only a few months. After producing a total of 32 million tonnes, both

sites have been fully restored back to pristine wilderness, with no visible evidence of mining. In contrast, many other historic coal mines on Spitsbergen are protected by law. There is no road connection between Longyearbyen and Svea, so all personnel were transported by snow-mobile in the winter or by plane – the last flight out was on 1 August 2022.

Spitsbergen's 10 MW coal-fired combined heat and power plant takes coal from Gruve 7 and a decision to end coal use in autumn 2023 and replace the plant was finally taken in 2022. A 2018 report for the Norwegian Ministry of Petroleum and Energy examined the alternatives, including LNG, wood pellets, solar PV or an underwater cable from the mainland. At NOK 35 billion, the latter option would be very expensive and require backup. Meanwhile, the state-owned utility, Statkraft, proposed shipping compressed green hydrogen or ammonia to Spitsbergen. During winter, Longyearbyen's 2 400 inhabitants require energy to survive. Hence, the decision to switch from coal to an existing, diesel plant previously held in reserve was taken for existential reasons rather than climate protection. Supply security will be ensured with a new 7 MWh battery – sufficient for one hour – which began commissioning in June 2023. To reduce energy demand, heat meters are being encouraged. Thanks to high coal prices, the closure of Gruve 7 has been delayed to summer 2025. Its output will be exported, including to CLARIANT, a maker of speciality chemicals in Germany.

The Russian government has also made a decision on the coal mine it owns and operates according to the Svalbard Treaty at Barentsburg, 55 kilometres to the west of Longyearbyen. ARKTIKUGOL will reduce its annual output from 120 thousand tonnes to 40 thousand tonnes by 2032.

Political guidance for SNSK's operations is laid down in a government White Paper (No. 22 to the Storting, 2008-2009), establishing that its coal mining operations are important for maintaining a Norwegian community in Longyearbyen. In accordance with official policy for state-owned companies (Meld. St. 6 (2022-2023)) and specific direction to SNSK in 2021, the company's operations should be "future-oriented and sustainable". Today, the company has operations in mining, property, logistics, energy and infrastructure, cultural heritage and tourism. To bring in revenue from tourists, Gruve 3 which closed in 1996 has re-opened as a museum with underground tours.

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

Portugal

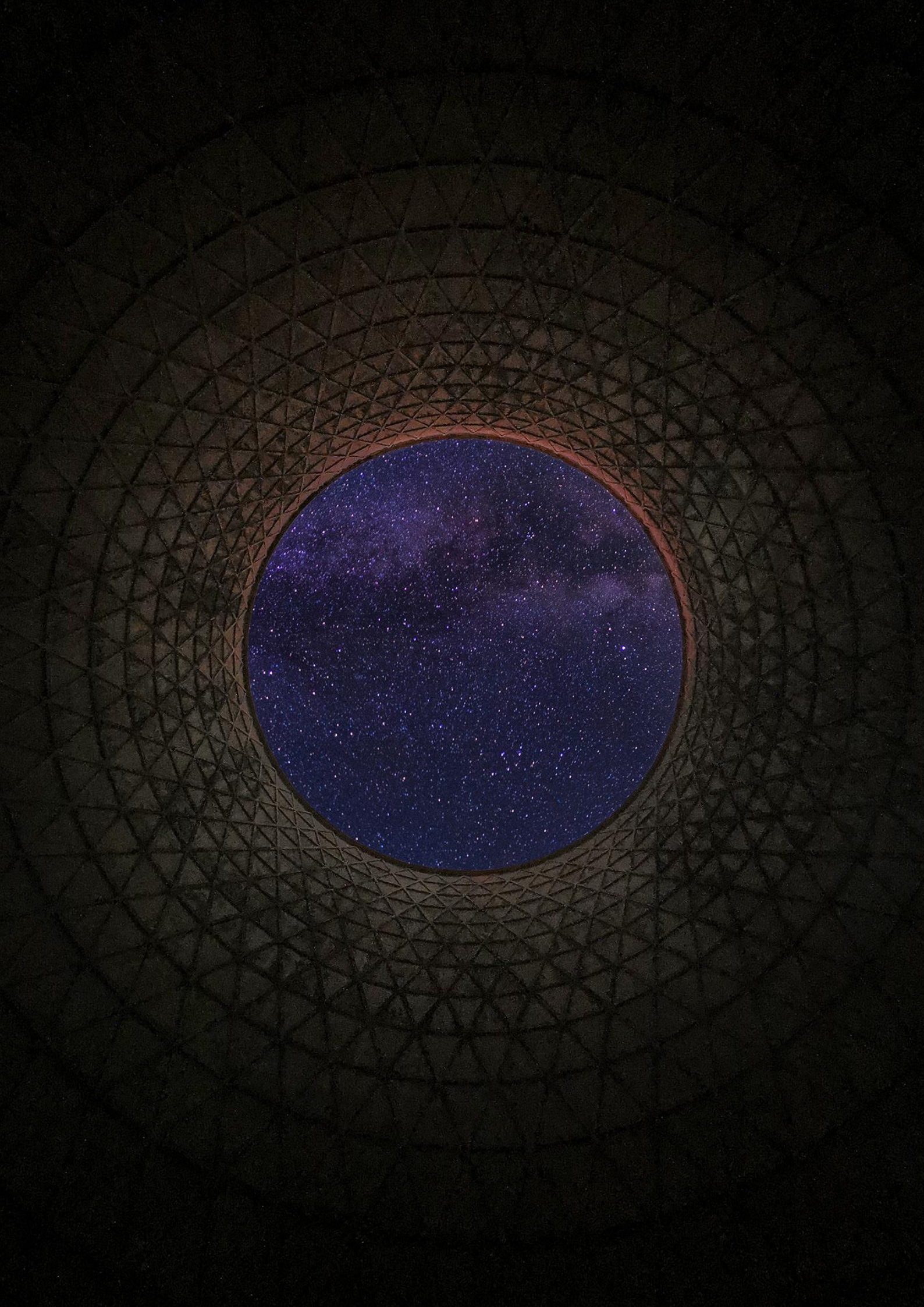
Portugal has limited indigenous fossil energy resources, leading to a 69.0% energy-import dependence in 2021. Its last coal mine, Germunde in the Castelo de Paiva region, was closed in 1994, leaving behind national reserves of 3 million tonnes. The country also has lignite resources of 66 million tonnes.

In 2022, 56.6% of Portugal's electricity production came from renewable energy sources: hydro, wind, biofuels, solar PV, geothermal and wave. Nevertheless, conventional thermal power generation remains crucial to cover those periods when wind power is not available and to balance the annual variations in hydro power production on the Iberian Peninsula. Coal-, oil- and gas-fired power generation together accounted for 38.3% of gross electricity production in 2022. Coal's share of gross generation was 1.6% in 2021, but none in 2022.

Imported coal accounted for 5.5% of total primary energy supply in 2019 with 2.6 million tonnes coming from Colombia and the United States. By 2020, imports had collapsed to 5.4 thousand tonnes and were just 2.6 thousand tonnes in 2022. Most of this coal was consumed at Portugal's two coal-fired power plants: ENERGIAS DE PORTUGAL (EDP) Sines (1 256 MW) and TRUSTENERGY Pego (628 MW) dating respectively from the 1980s and the early 1990s. The Pego plant was a child of electricity market liberalisation; its 28-year power purchase agreement with EDP, originally awarded to TEJO ENERGIA, expired on 30 November 2021.

In 2021, Portugal stopped coal-fired electricity production. Back in 2016, the Portuguese government announced its commitment to retire all coal-fired power plants by 2030. This date was brought forward to 2023 in Portugal's *National Energy and Climate Plan 2021-2030* submitted to the European Commission in December 2019. A ban on natural gas-fired power generation from 2040 is also foreseen in the plan.

Portugal passed a Green Taxation Law in 2014 to align energy taxes with climate goals. A carbon tax on fossil fuels was introduced in 2016 on top of the country's existing petroleum and energy products tax (ISP – *Imposto Sobre produtos Petrolíferos e energéticos*). The government has revised this carbon tax to drive greenhouse gas emission reductions, notably in 2018 with the progressive elimination by 2022 of the ISP and carbon tax exemptions for coal use in power generation. Given this burden, the Sines coal power plant closed in January 2021 and the Pego plant in November 2021. Shareholders in the Pego plant (ENGIE, MARUBENI and ENDESA) considered converting the plant to biomass, but in March 2022 ENDESA was awarded the site's connection rights for a project incorporating solar PV, wind, large battery storage and hydrogen electrolysers.



Southeast Europe

The countries of Southeast Europe not covered in earlier chapters include Albania, Croatia, Kosovo[3], North Macedonia and Montenegro.

Albania has been a candidate for EU membership since 2014 and formal accession negotiations began in July 2022. The EU accounts for 59% of the country's external trade.

With few fossil energy resources but a *per-capita* annual energy consumption of only one tonne of coal equivalent, Albania had a low import dependency of 23.8% in 2021. Hydropower is the country's major exploited energy resource; hydro plants with a total capacity of 2.2 GW generated 99.5% of Albania's electricity in 2021. Electricity trade with Greece, Montenegro and Kosovo is important. The government's policy is to increase hydro and solar PV capacity, decarbonise other sectors and increase electricity trade. This will be helped by the completion in 2024 of the 400 kV east-west transmission corridor between Bulgaria, North Macedonia, Albania, Montenegro and Italy.

Albania has coal reserves of 522 million tonnes, all classified as lignite: 85% in the Mëzezi and Valiasi deposits near the capital city, 9.2% in the Moravë and Gorë-Mokra deposits near Korçë-Pogradec, and 4.4% in the Memaliaj deposit north of Tepelenë. The Valiasi deposit in the Tirana region is the largest. During the 1980s, annual coal 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.

In 2022, Albania mined 379 thousand tonnes of coal at the country's two remaining licenced mines. A total of 256 thousand tonnes of coal and lignite was used for industrial applications, including at the Antea cement works, while 210 thousand tonnes were exported.

The opening in November 2020 of the Trans Adriatic Pipeline (TAP) from Azerbaijan was expected to herald coal-to-gas switching. However, the recent energy crisis led to some reconsideration of indigenous coal; a license to reopen the Kolonjë mine was granted in November 2022.

Croatia became the newest member state of the European Union on 1 July 2013 and the newest member of the eurozone and Schengen area on 1 January 2023. While the economy is dominated by services, with tourism accounting for 22.2% of its €66.9 billion GDP in 2022, the country also boasts a sizeable industrial sector (19.5% of GDP).

Depending on water availability, up to one half of Croatia's electricity can be generated at hydropower plants, 47.5% in 2021 but only 38.4% in 2022 when the rest came from fossil gas (24.7%), coal (11.0%) and a growing share of renewables, mainly wind. At the UNFCCC COP26 conference in Glasgow, the government announced a phase-out of coal-fired power generation by 2033. The Krk LNG terminal which opened in January 2021 may allow a shift from coal- to gas-fired generation. Electricity is imported from Slovenia and Bosnia and Herzegovina.

Croatia's last coal mine, at Raša, was closed in 1999 and the country has relied on imports since then. These totalled 639 thousand tonnes in 2022. Coal is mainly used at the 210 MW Plomin B power plant which is 100% owned by HRVATSKA ELEKTROPRIVREDA (HEP). The older Plomin A unit was closed in 2017 after plans to modernise it were abandoned for environmental and economic reasons. The proposed 500 MW Plomin C unit was cancelled in 2016. Alternative fuels, such as biomass and waste, could allow Plomin A to reopen and a life extension at Plomin B. The HOLCIM GROUP cement plant at Koromačno is another big user of coal and also uses ash and gypsum byproducts from Plomin. The EU-funded KOdeCO project aims to capture and store carbon dioxide from this plant.

Kosovo's[3] €9.0 billion economy and population of 1.8 million mean its per-capita GDP of €5 100 in 2022 is among the lowest in Europe. In December 2022, Kosovo applied for EU membership. Rich in natural resources, mining has played an important role in Kosovo. It has large lignite resources, totalling 10.8 billion tonnes, of which 1.6 billion tonnes are economically exploitable reserves. These 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 2022 was 8.3 million tonnes.

For electricity, Kosovo was 93.4% dependent on lignite in 2021, with the rest coming from hydro plants, including from the 32 MW hydro plant at Ujman/Gazivoda, and other smaller plants including wind turbines.

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

[3] This designation is without prejudice to positions on status and is in line with UN Security Council Resolution 1244 (1999) and the International Court of Justice opinion on the 2008 Kosovo declaration of independence.

In December 2014, a successful bid for the new 500 MW "Kosova e Re" thermal power plant (a.k.a. Kosova C) was submitted by CONTOUR GLOBAL to the Kosovo Ministry of Economic Development. However, CONTOUR GLOBAL withdrew their proposal in 2020. The *Energy Strategy of the Republic of Kosovo 2022-2031* includes a coal phase-out by 2050 and increases in wind and solar while ruling out new hydropower. The two units at Kosovo B should be upgraded by 2026 to operate as a baseload plant and a single unit at Kosova A will be modernised as a backup, leaving the decision on whether to modernise or close the other units until 2024.

North Macedonia was granted EU candidate status in 2005 and accession negotiations began in 2022. The country must therefore implement EU legislation, including on energy and the environment. Since independence in 1991, the North Macedonian economy has benefitted from liberalisation efforts, including the creation of fifteen free economic zones.

The country's energy supply depends on lignite and electricity imports from neighbouring countries. Lignite power plants accounted for 39.7% of electricity generation in 2022, with fossil gas (28.1%) and hydro (26.4%) also important. The remainder came from oil (2.5%) and renewables (2.4%).

North Macedonia has 332 million tonnes of lignite reserves and a further 300 million tonnes of resources. Coal resources lie in the Pelagonija and Kicevo basins, including deposits at Suvodol, Brod-Gneotino, Živojno, Oslomej, Popovjani and Stragomiste. The Mariovo basin could also be exploited but plans for a new 300 MW power plant were abandoned.

The country produced 5.1 million tonnes of lignite in 2022 from the Suvodol and Oslomej surface mines of state-owned ELEKTRANI NA SEVERNA MAKEDONIJA (ESM) and several smaller surface mines, some private. The Suvodol mine's surface exploitation potential is almost exhausted and a planned underground expansion has not yet been realised. Together with the smaller Brod-Gneotino mine, it supplies the 675 MW ESM Bitola power plant. The Oslomej mine supplies the 125 MW ESM Oslomej power plant.

The balance of lignite supply – 163 thousand tonnes in 2021 – 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.

To supplement Suvodol mine's declining output, North Macedonia increased its lignite imports to 748 thousand tonnes in 2022, almost half from Greece. In the short term, ESM is ramping up production at its Živojno and Gušterica mines. With the completion in 2022 of the Negotino-Bitola gas pipeline, ESM's planned replacement of the Bitola power plant with 250 MW gas plants and a 280 MW solar park could proceed. Other plans would see the 10 MW solar park completed at Oslomej mine in 2022 expanded to 120 MW and closure of the coal plant.

Montenegro, an EU candidate since 2010, has been in accession negotiations since 2012. The country has a small, open economy that uses the euro as legal tender, facilitating foreign direct investment. Mining and mineral exports play an important role in the economy and, more recently, tourism.

Electricity generation is balanced between lignite-fired (1.4 TWh or 38.2% of total generation in 2021) and hydropower (53.2%) with the balance from a growing share of wind power. Electricity trade with Italy has grown since the completion in 2019 of a 600 MW interconnector with plans to double its capacity to 1 200 MW.

Montenegro mined 1.7 million tonnes of lignite in 2022, mostly for power generation. 217 thousand tonnes were exported. Although not currently exploited, Montenegro has hard coal resources totalling 337 million tonnes.

Montenegro's 225 MW Pljevlja I coal-fired power plant, commissioned in 1982 and owned by the majority state-owned company ELEKTROPRIVREDA CRNE GORE (EPCG), is supplied with brown coal (10 300 kJ/kg) from two surface mines, Potrlica and Sumani I. Both are profitably operated by EPCG-subsidiary RUDNIK UGLJA PLJEVLJA with an overburden ratio of 4.8 cubic metres per tonne (2019 data) and employing 960 workers. Modernisation of the Pljevlja I plant in 2023 by China's DONGFANG ELECTRIC INTERNATIONAL CORPORATION will meet EU pollution standards and supply FGD gypsum as well as district heating to the town of Pljevlja. In September 2019, the government announced that a planned second unit at the site would not proceed.

In 2014, METALFER and PREMOGOVNIK VELENJE acquired the Berane underground coal mine, flooded since 2005. Exploitable reserves are estimated at over 50 million tonnes of brown coal (14 000 - 17 000 kJ/kg). In January 2015, mining restarted at a depth of 200 metres, employing 150 people. Production in 2018 was 56 thousand tonnes, mostly delivered to Pljevlja I. However, the mine was shuttered in 2019. In 2021, Montenegro committed to phase out coal-fired power generation by 2035.

Spain

Among EU member states, Spain has the fourth largest economy with a GDP of €1.3 trillion in 2022. The economic boom of the 2000s was reversed with the 2007-2008 global financial crisis after which the country fell into recession from 2009 to 2013. Spain has since recovered strongly following structural reforms, moving from a trade deficit to surplus. The unemployment rate remains above the EU average, although at 12.5% in 2022 is half the 26.9% recessionary peak of 2013.

Spain is highly dependent on imported oil and fossil gas. The country had an overall import dependence of 73.4% in 2021, well above the EU average of 57.1%. Spain's primary energy production was 51.4 Mtce in 2022, almost entirely from renewable energy sources and nuclear power.

By the end of 2018, all major Spanish coal producers had closed their mining operations: 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.

Spain's remaining coal resources total 4 231 million tonnes, including accessible reserves of 868 million tonnes. In 2022, Spain imported 9.9 million tonnes of coal. Oil, fossil gas and nuclear are now the principal energy sources, with wind and solar providing 8.1% of total primary energy supply.

Hard coal deposits in northwest 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, only one small mine remains: the San Nicolás underground coal mine located in the Lleros de Abajo valley near Mieres which produces up to 200 thousand tonnes each year for heating and the nearby 15 MWe La Pereda experimental power plant. HUNOSA operates this plant which can consume a variety of solid fuels, biomass and wastes, including coal from the San Nicolás mine. After mining coal for decades, HUNOSA is now focused on the energy transition with geothermal, hydrogen and biomass projects, as well as site restoration works. With its consultancy services, HUNOSA employs around 600 people in Asturias.

Spanish electricity production in 2022 came from diverse sources: fossil gas with 86.0 TWh gross (29.4%), followed by wind 62.8 TWh (21.5%), nuclear power 58.6 TWh (20.0%), solar PV / solar thermal 35.7 TWh (12.2%), hydro 17.6 TWh (6.0%), oil 10.6 TWh (3.6%) and coal with 8.7 TWh (3.0%). Solar, wind and other new renewable energy sources accounted for 36.0% of electricity generation in 2022.

Spain plans to be a carbon-neutral country by 2050. In its draft updated *National Energy and Climate Plan 2021-2030*, submitted to the European Commission in July 2023, the government expects coal power plants to cease operation by 2025, driven out of the market by the high cost of CO_2 allowances under the EU emissions trading system. An *Agreement for a Just Energy Transition for Thermal Power Plants in Closure* was signed in 2020 between the government, power plant owners and trade unions with the aim of supporting workers and promoting alternative investments in the affected regions. This followed an earlier agreement of 2018 favourable for mineworkers (*Just Transition from Coal Mining and Sustainable Development of Mining Regions 2019-2027*).

In 2020, five of Spain's remaining coal plants were closed with a total capacity loss of 3 860 GW: ENDESA's 1 300 MW Compostilla II plant in Castilla y León and 1 100 MW Teruel plant in Aragón, GAS NATURAL FENOSA's 580 MW Meirama plant in Galiza, and IBERDROLA's 520 MW Velilla del Río Carrión plant in Castilla y León and 360 MW Lada plant in Asturias. In 2021, ENDESA closed its 1 200 MW Litoral de Almería plant and plans to close the last two 350 MW units at its As Pontes coal plant, perhaps after the summer of 2023. ENERGIAS DE PORTUGAL's 880 MW Aboño plant on Spain's north coast in Asturias, its 570 MW Los Barrios plant next to the Gibraltar-San Roque oil refinery in Andalucía and 350 MW Soto de Ribera plant in Asturias are, for grid security reasons, the only other large coal-fired power plants left in operation.

The FUNDACIÓN CIUDAD DE LA ENERGÍA (CIUDEN) is the leading public developer of CO_2 capture, transport and geological storage in Spain. CIUDEN also has a prominent role in the just transition of the coal mining regions of Castilla y León, acting as co-ordinator for economic development initiatives and viable projects to create employment, in addition to bringing its own technical capacity.

Sweden

There is currently no coal mining in Sweden and imported coal accounted for only 3.4% of the country's primary energy supply in 2022. Coal reserves and resources are estimated at 5 million tonnes in southern Sweden. In 2022, 103 thousand tonnes of peat were harvested.

Since the mid-1990s, coal imports had been stable at close to 3 million tonnes per year but fell to 1.9 million tonnes in 2022. Demand for high-quality coking coal from Australia, the United States and Canada comes mainly from Sweden's speciality steel industry. Limited quantities of steam coal are imported, 635 thousand tonnes in 2022 for use at cement works and at combined heat and power plants which are fuelled mainly with solid biofuels, including the FORTUM /

STOCKHOLM EXERGI Värtahamnen plant in Stockholm. In response to political developments, the owners of the Värtahamnen CHP plant ended coal use in April 2020. Coal was also used by the pulp and paper industry but has been replaced with biofuels.

In 2022, nuclear power accounted for 30.0% of Sweden's gross electricity production, while the share of hydro power was 40.4%. The balance was met by wind power (19.2%), CHP plants firing mainly solid biofuels and wastes (8.5%) and fossil fuels (1.7%). Wind and biomass are subsidised while fossil fuels are heavily taxed. A nuclear capacity tax finally ended in 2019.

The role of nuclear power has long been the subject of political debate in Sweden. In June 2010, the parliament agreed that up to ten new nuclear reactors could replace old ones at existing sites. After lengthy negotiations, this policy was restated in a cross-party framework agreement of June 2016 and, in January 2023, the government announced it was preparing legislation to allow more than ten new reactors, some on new sites.

A new Climate Act entered into force on 1 January 2018 with the aim of linking Sweden's annual budget with climate objectives. An independent climate policy council holds the government to account. Support for the minority government relies on the Tidö Agreement of October 2022 which includes a 100% target for fossil-free electricity production by 2040, replacing an earlier 100% renewables target agreed by parliament in 2018.

Sweden works with other Nordic countries on the green transition. For example, the Nordic Co-operation Programme on Energy Policy covers renewable energy including offshore wind, electrification, system integration, closer co-operation on hydrogen strategies, and carbon capture, use and storage (CCUS).

United Kingdom

The United Kingdom has the second largest economy in Europe and was, until 31 January 2020, a member state of the European Union. "Brexit" followed a referendum in June 2016 when citizens narrowly voted to leave the union.

The UK is one of the largest energy consumers in Europe, third after Germany and France. It is the second largest oil and gas producer after Norway. At 37.3% in 2022, the UK's energy import dependence is below the European average.

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 has continued as North Sea oil and gas reserves deplete. In 2014, the UK became a net importer of petroleum products.

The country's identified coal resources are estimated to be 3 814 million tonnes, although total resources could be as large as 186.7 billion tonnes. Economically mineable reserves are 187 million tonnes. The Industrial Revolution was powered by coal in the UK: production peaked at 292 million tonnes in 1917. Coal continued to be the major source of primary energy after World War II when it was used for large-scale power generation. By 2022, coal use had fallen to 6.1 million tonnes when coal accounted for 2.4% of total primary energy supply, used mostly for electricity and steel production.

The UK's remaining coal mines are located in central and northern England, and South Wales. Only one important surface mine remains in production: MERTHYR (SOUTH WALES) Ffos-y-Fran. The last major underground coal mine – Kellingley in North Yorkshire – closed at the end of 2015 and the few remaining underground mines in England and Wales produced just 63 thousand tonnes in 2022. In March 2019, WEST CUMBRIA MINING was granted planning permission for Woodhouse colliery, a new coking coal drift mine with a potential output of 3 million tonnes per annum. The UK government confirmed this permission in December 2022 and, despite ongoing legal challenges, construction is scheduled to start in 2023.

In 2022, hard coal supply totalled 7.0 million tonnes, with 0.7 million tonnes of indigenous production and 6.3 million tonnes of imports. The United States, Russia (banned since August 2022), Australia and South Africa are the main sources. Indigenous production was almost entirely from one surface mine.

Power generation in the UK is very dependent on fossil gas while coal's share has declined from 64.6% in 1990 to 1.7% in 2022, having been in the number one position as recently as 2015 when its share was 33.6%. Gross electricity generation in 2022 was 325.3 TWh, dominated by renewables with a 39.8% share (notably wind at 24.7%), fossil gas (38.4%) and nuclear power (14.7%).

In early 2018, an end date for unabated coal-fired power generation (*i.e.* without CCS) of 1 October 2025 was announced by the UK government. Following many plant closures over recent years, mainly as a result of a carbon tax, the only remaining coal power plant in December 2023 was the 2 000 MW UNIPER Ratcliffe power station in the East Midlands. EPH Kilroot (560 MW) in Northern Ireland closed in September 2023. Two UK generators were granted state support to enable biomass conversions of their coal-fired power plants: EPH Lynemouth, and DRAX GROUP Drax which now plans to install CCS.

The UK power generation sector has little new conventional thermal capacity under construction or planned, with the main emphasis on offshore wind which has grown from nothing in 2006 to 13 900 MW in 2022. The 3 200 MW EDF Hinkley Point C nuclear power plant is under construction with the first of its two units expected to be operational in 2029 followed by the second unit.

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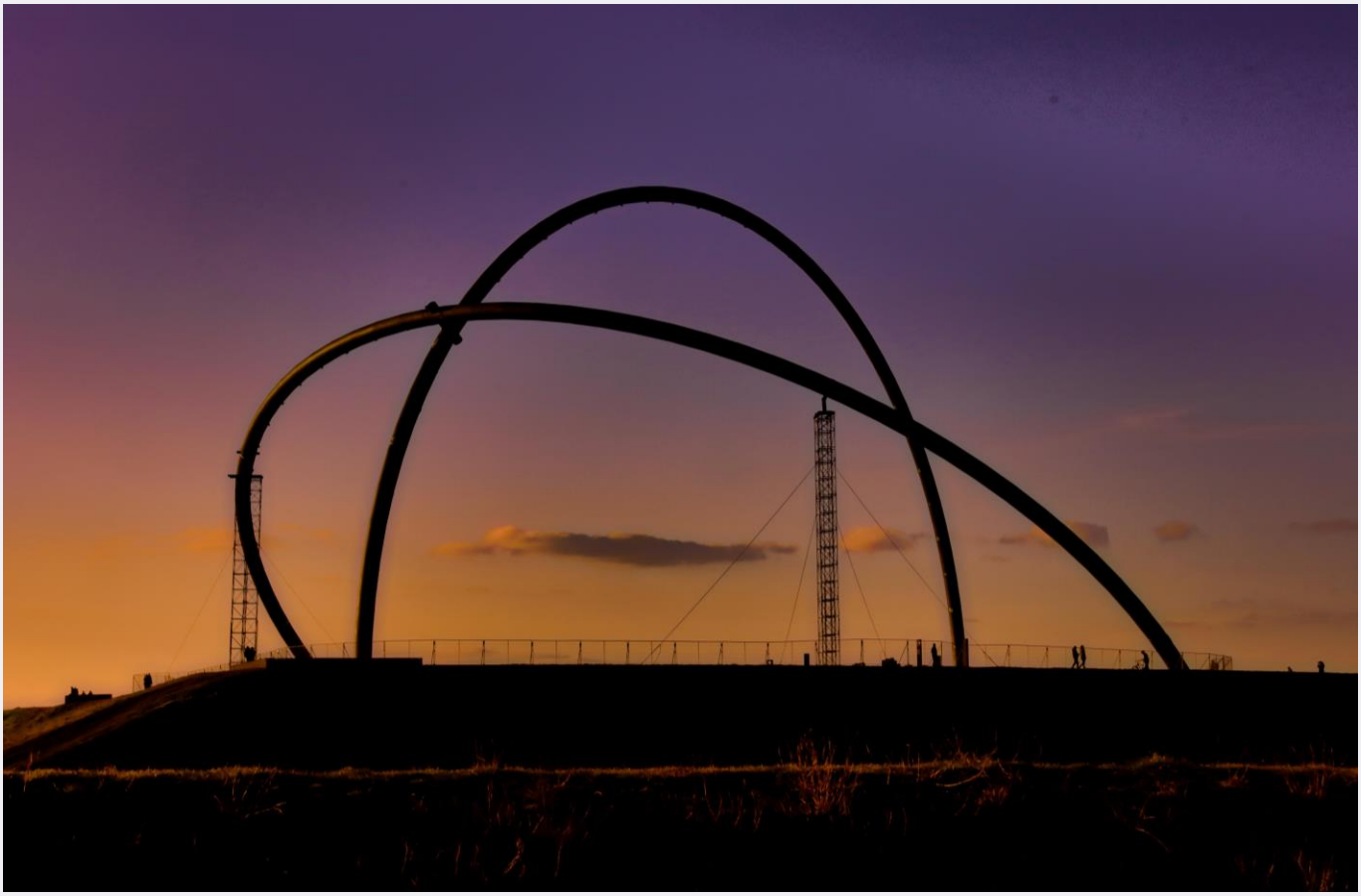

EU statistics

Data for EU member states that use only imported coal, 2022

	Population (million)	GDP (€ billion)	Primary energy production (Mtce)	Total primary energy supply (Mtce)	Primary coal and peat consumption (Mtce)	Gross power generation (TWh)	Coal and peat power generation (TWh)	Capacity of coal-fired generation (MW net)
Austria	9.1	447.2	17.3	45.4	3.5	69.2	2.0	*n.a.*
Belgium	11.8	554.0	22.7	72.2	3.9	95.9	2.3	*n.a.*
Croatia	3.9	68.0	5.3	11.9	0.6	14.2	1.6	217
Denmark	5.9	380.6	14.2	22.8	1.5	35.1	4.4	3 165
Finland*	5.6	268.6	28.0	45.7	3.1	72.2	6.2	1 682
France	68.1	2 639.1	154.0	306.7	10.7	474.8	6.0	1 816
Ireland*	5.2	506.3	4.5	19.5	1.0	33.9	2.6	855
Italy	58.9	1 946.5	48.9	206.5	10.6	284.0	24.2	8 417
Netherlands	17.8	958.5	34.7	91.4	7.9	121.8	17.4	4 006
Spain	48.1	1 346.4	51.4	165.5	5.1	292.5	8.7	4 642
Sweden*	10.5	562.5	51.0	64.5	2.2	173.2	0.7	*n.a.*

* *coal figure includes peat*

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

Coal production and imports in 2022 for the EU-27

	Hard coal production (million tonnes)	Lignite production (million tonnes)	Hard coal imports (million tonnes)
Austria			2.5
Belgium			3.2
Bulgaria		35.5	1.3
Croatia			0.6
Czech Republic	1.8	33.4	4.4
Denmark			1.9
Finland			4.0
France			7.8
Germany		130.8	42.3
Greece		14.3	0.1
Hungary		4.9	0.8
Ireland			1.5
Italy			11.8
Netherlands			9.0
Poland	52.8	54.6	20.2
Romania		18.2	0.6
Slovakia		0.9	2.9
Slovenia		2.4	0.4
Spain			9.9
Sweden			1.9
others			0.4
EU-27	**54.6**	**294.9**	**127.5**

Sources: EURACOAL members and Eurostat nrg_cb_sff database, last update 21.12.2023

Power generation structure in the EU-27 in 2022

	Total gross power generation (TWh)	EU share (%)	Coal & coal products (%)	Oil (%)	Fossil gas (%)	Nuclear energy (%)	Hydro (%)	New renewables (%)	Waste & other (%)
Austria	69.2	2.5	2.8	1.0	15.7	0.0	50.1	22.7	7.6
Belgium	95.9	3.4	2.4	0.3	22.9	45.7	0.3	25.2	3.2
Bulgaria	50.5	1.8	43.1	1.0	4.1	32.6	7.5	11.6	0.1
Croatia	14.2	0.5	11.0	0.6	24.7	0.0	38.4	24.6	0.8
Cyprus	5.3	0.2	0.0	83.2	0.0	0.0	0.0	16.8	0.0
Czechia	84.8	3.0	44.1	0.1	5.1	36.6	2.5	10.2	1.4
Denmark	35.1	1.2	12.6	0.9	2.9	0.0	0.0	81.1	2.4
Estonia**	8.9	0.3	66.0	0.4	0.6	0.0	0.3	31.7	1.1
Finland*	72.2	2.6	8.6	0.3	1.3	35.1	18.7	34.9	1.1
France	474.8	16.8	1.3	1.3	9.6	62.1	9.6	14.3	1.8
Germany	580.3	20.5	32.7	0.9	14.8	6.0	3.0	40.2	2.3
Greece	52.7	1.9	10.9	9.7	36.3	0.0	7.3	35.3	0.4
Hungary	35.8	1.3	8.6	0.2	24.7	44.2	0.5	20.9	0.9
Ireland*	33.9	1.2	7.7	3.2	48.8	0.0	2.1	36.5	1.7
Italy	284.0	10.1	8.5	4.5	49.8	0.0	10.0	25.4	1.8
Latvia	5.0	0.2	0.0	0.1	24.2	0.0	55.0	20.7	0.0
Lithuania	4.8	0.2	0.0	7.9	10.8	0.0	9.7	53.6	18.1
Luxembourg	2.2	0.1	0.0	0.0	4.4	0.0	2.9	42.3	50.4
Malta	2.3	0.1	0.0	2.5	84.5	0.0	0.0	12.9	0.0
Netherlands	121.8	4.3	14.3	1.3	39.2	3.4	0.0	39.6	2.1
Poland	179.7	6.4	70.5	1.3	6.3	0.0	1.1	19.9	0.9
Portugal	48.8	1.7	0.0	2.6	35.6	0.0	13.4	43.2	5.2
Romania	56.0	2.0	18.7	2.0	16.7	19.8	25.0	17.2	0.7
Slovakia	26.8	1.0	7.7	1.9	7.8	59.3	13.3	8.0	1.9
Slovenia	13.6	0.5	23.0	0.4	3.6	41.2	23.1	6.8	1.9
Spain	292.5	10.4	3.0	3.6	29.4	20.0	6.0	36.0	1.9
Sweden*	173.2	6.1	0.4	0.3	0.1	30.0	40.4	27.9	1.0
EU-27	**2 824.3**	**100.0**	**17.1**	**2.0**	**19.2**	**21.6**	**9.8**	**28.5**	**2.0**

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

Source: Eurostat nrg_bal_peh database, last update 19.12.2023

EURACOAL

The European Association for Coal and Lignite is the umbrella organisation of the European coal industry. Associations and companies from fourteen countries work together in EURACOAL to ensure that the interests of coal producers, importers, traders and consumers are properly served. Its twenty-four members and observers come from across the EU-27 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 and climate protection. EURACOAL seeks to be an active communicator, with the aim of creating an appropriate legal framework within which the coal industry and coal consumers can operate.

Country	Member Association / Company
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)
Germany	BSN – Branchenverband Steinkohle und Nachbergbau e.V. (Association for Hard Coal and Post-mining)
	DEBRIV – Deutscher Braunkohlen-Industrie-Verein e.V. (German Association of Lignite Producers)
	DMT GmbH & Co KG
Greece	CERTH/CPERI – Chemical Process and Energy Resources Institute
	PPC – Public Power Corporation S.A.
Hungary	Borsod-Abaúj-Zemplén County Government
Poland	GIG – Główny Instytut Górnictwa (Central Mining Institute)
	GIPH – Górnicza Izba Przemysłowo-Handlowa (Mining Chamber of Industry and Commerce)
	IMG-PAN – Strata Mechanics Research Institute, Polish Academy of Sciences
	Lubelski Węgiel „Bogdanka" S.A.
	PGG – Polska Grupa Górnicza S.A. (Polish Mining Group)
	PPWB – Porozumienie Producetów Węgla Brunatnego (Confederation of Polish Lignite Producers)
Romania	PATROMIN – Asociaţia Patronală Minieră din Romania (Mining Employers Association of Romania)
Serbia	EPS – Elektroprivreda Srbije JSC (Electric Power Industry of Serbia)
Slovak Republic	HBP – Hornonitrianske bane Prievidza a.s.
Slovenia	Premogovnik Velenje d.o.o.
Spain	Geocontrol S.A.
	SYSTRA SUBTERRA Ingeniería S.L.
Türkiye	TKİ – Turkish Coal Enterprises
Ukraine	DTEK
	PRJSC Donetsksteel

As at 31 December 2023

Coal classification

Coal Types and Peat					Total water content (%)	Energy content a.f.* (kJ/kg)	Volatiles d.a.f.** (%)	Vitrinite reflection in oil (%)
UNECE	USA (ASTM)	Germany (DIN)						
Peat	Peat	Torf			75	6 700		
Ortho-lignite	Lignite	Weichbraunkohle			35	16 500		0.3
Meta-lignite	Sub-bituminous coal	Mattbraunkohle		Hartkohle	25	19 000		0.45
Sub-bituminous coal		Glanzbraunkohle			10	25 000	45	0.65
Bituminous coal	High volatile bituminous coal	Flammkohle	Steinkohle				40	0.75
		Gasflammkohle					35	1.0
	Medium volatile bituminous coal	Gaskohle				36 000	28	1.2
		Fettkohle			Hard Coking Coal		19	1.6
	Low volatile bituminous coal	Eßkohle					14	1.9
Anthracite	Semi-anthracite	Magerkohle			3	36 000	10	2.2
	Anthracite	Anthrazit						

* *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 (2009), Energierohstoffe 2009: Reserven, Ressourcen, Verfügbarkeit, Bundesanstalt für Geowissenschaften und Rohstoffe (BGR), Hannover, Abbildung 2.4, p. 21, ISBN 978-3-9813373-1-0, 10 November 2009

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. Where the word "coal" is used, it can refer to all types of coal, including hard 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 the Eurostat Statistics Explained website.

Data sources and references

Unless otherwise stated, statistical data is from EURACOAL members, national government agencies, Eurostat, the International Energy Agency, and the World Bank.

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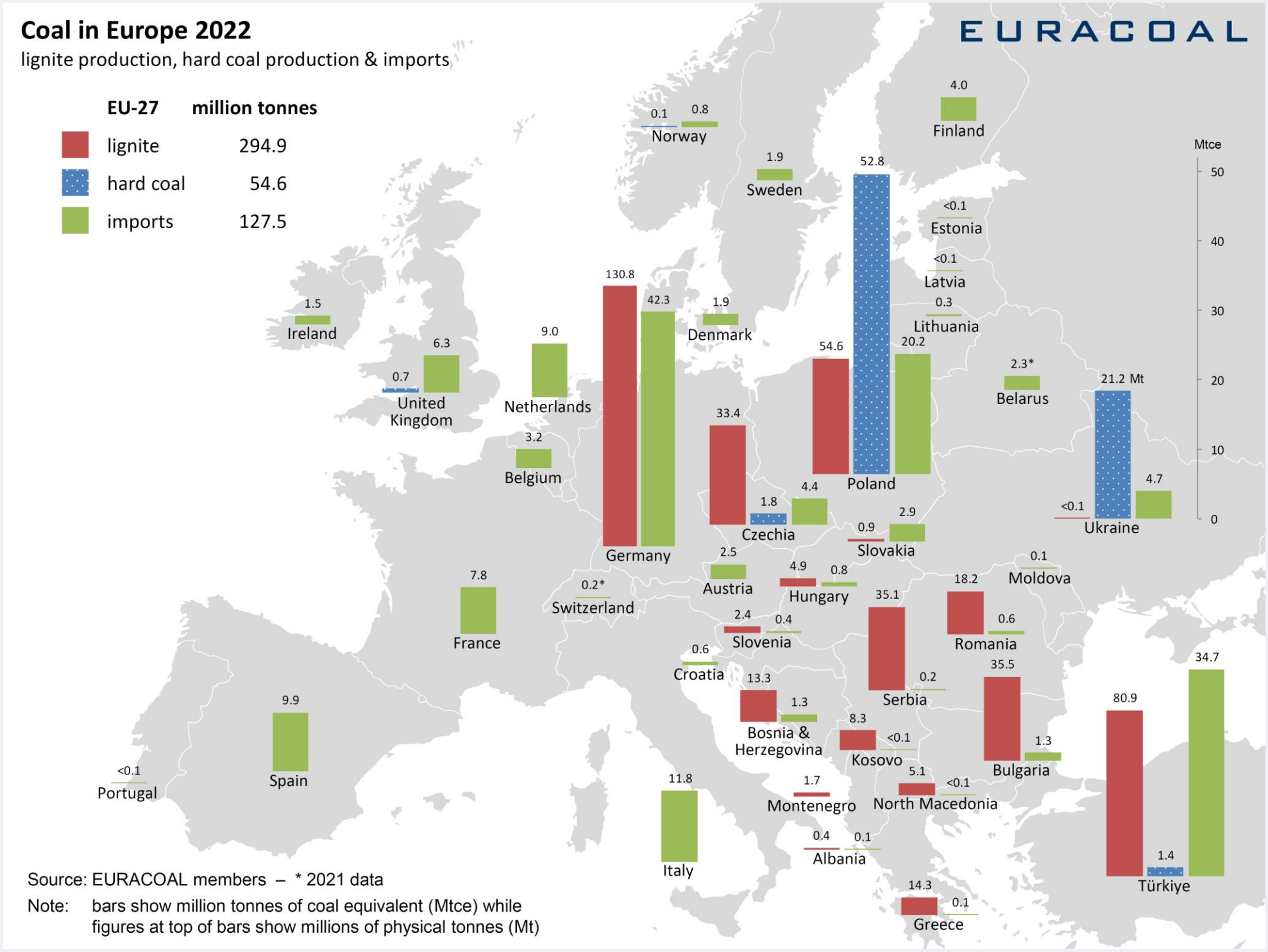
Coal in Europe 2022

lignite production, hard coal production & imports

EURACOAL

EU-27	million tonnes
lignite	294.9
hard coal	54.6
imports	127.5



Source: EURACOAL members – * 2021 data

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

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