JRC SCIENCE FOR POLICY REPORT

RECENT TRENDS IN EU COAL, PEAT AND OIL SHALE REGIONS

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2021

EUR 30618 EN

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JRC Science Hub
https://ec.europa.eu/jrc

JRC123508

EUR 30618 EN

PDF	ISBN 978-92-76-30987-1	ISSN 1831-9424	doi:10.2760/510714
Print	ISBN 978-92-76-31019-8	ISSN 1018-5593	doi:10.2760/975966

Luxembourg: Publications Office of the European Union, 2021

How to cite this report: Kapetaki, Z., Alves Dias, P., Conte, A., Kanellopoulos, K., Mandras, G., Medarac. H., Nijs, W., Ruiz, P., Somers, J., Tarvydas, D., *Recent trends in EU coal, peat and oil shale regions*, EUR 30618 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-30987-1, doi:10.2760/510714, JRC123508.

Recent trends in EU coal, peat and oil shale regions
The European coal sector employs nearly 340 000 people in direct and indirect activities. By 2030, it is estimated that between 54 000 and 112 000 direct jobs may be lost. The peat and oil shale sectors for energy are smaller than the coal sector in Europe. We estimate that there are nearly 12 000 direct and indirect peat-related jobs in the countries of focus, while oil shale-related jobs total nearly 7 000 in Estonia, the only Member State with such activities. With no concrete plans on oil shale use and limited interdependency of direct jobs to peat as a fuel, the impact on jobs in these sectors appears very limited.

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Acknowledgements

This report benefited from data on peat and oil shale provided by Giedrius Giparas, Ingrida Krigere, Katarina Magnusson, Kevin McDonnell, Hannu Salo and Sulev Soosar for their respective countries of expertise.

We would like to thank Brieuc Posnic, Anna Sobczak, Florian Woitek, Nikolaos Koukouzas, Gabriele Morgante, Jose Moya, Andreas Uihlein, Catriona Black and Efstathios Peteves for their invaluable comments and review as well as Maria Ruehringer for the maps production.

We acknowledge the contribution of Eurogeosurveys to the preparation of updated data on coal and lignite mines. In particular, we acknowledge the efforts of Serge van Gessel in mediating interactions with the National Geological Services. This revised report takes account of data provided and data sources identified by these institutions.

We would also like to thank Pauline Lucas, Mirja Tiitinen and Daniel Lundqvist from EuroHeat & Power for their input on District heating related employment.

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Executive summary

Policy context

Aiming to provide dedicated support to EU regions facing a steady decline in the coal sector the European Commission launched in December 2017 the initiative for coal regions in transition as an enabling action under the "Clean Energy for all Europeans" package. Building on work carried out under this package, in December 2019 the European Commission announced the European Green Deal, an integral part of this Commission's strategy to support the EU objective of reaching climate neutrality by 2050. Under the Green Deal, the Just Transition Mechanism (JTM) is a key tool to ensure that the transition towards a climate-neutral economy happens in a fair way, leaving no one behind. The initiative for coal regions in transition, enlarged to oil shale and peat regions in 2020, is a key building block of the European Green Deal and Just Transition Mechanism.

In September 2020, the European Commission presented its plan to reduce EU greenhouse gas emissions by at least 55 % by 2030, compared to 1990 levels. This level of ambition for the next decade will put the EU on a balanced pathway to climate neutrality by 2050. It will require a fundamental rebalancing of our energy system, moving toward accelerated phase-outs of polluting fossil fuels (coal, oil shale, peat) and more sustainable economic frameworks, potentially posing significant challenges for many regions.

This report builds upon the 2018 JRC report[1] on EU coal regions in transition and expands it to include **oil shale** and fuel **peat**, focusing on their energy use.

Current situation

Coal is identified in 19 EU countries and 94 NUTS 2 regions.

In 2018, 90 coal mines were operating in 11 EU countries, i.e. Bulgaria, Czechia, Germany, Greece, Hungary, Italy, Poland, Romania, Slovakia, Slovenia and Spain. Altogether they produced 442 million tonnes of hard coal and lignite.

In 2020 there were 166 coal-fired power plants operating in 18 EU countries, with a total capacity of 112 GW.

Coal activities offer direct employment to around 208 000 people across Europe. 76 % of these jobs are in the mining sector. The regions with the highest number of jobs in the coal sector (mines and power plants) are in Poland, Germany, Czechia, Romania and Bulgaria.

In 25 out of the 29 regions with operating coal mines by 2018-19, coal is used in the carbon-intensive sector. The biggest coal user by far is the iron and steel industry, accounting for 85 % of the total coal used in these sectors.

This report also describes the coal use in carbon-intensive industries (steel, cement, chemicals, paper) in coal regions. These industries use coal as feedstock and fuel and together account for 96 % of coal use in industry. Germany is the largest user of coal in the iron and steel industry as well as in the non-metallic minerals sector. Poland is responsible for nearly half (46 %) of all coal consumption in the chemicals and petrochemicals sector. Use of coal in the pulp and paper industry is mainly restricted to Germany, Poland and Austria.

[1] Alves Dias, P. et al., EU coal regions: opportunities and challenges ahead, EUR 29292 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-89884-6, doi:10.2760/064809, JRC112593

Peat is used in 6 countries (Estonia, Finland, Ireland, Latvia, Lithuania and Sweden), of which Finland and Ireland are the most prominent in terms of energy use.

In 2018, production of peat for energy use reached nearly 9.4 million tonnes, taking place in Estonia, Finland, Ireland, Latvia, Lithuania and Sweden. Finland is the country using the highest share of peat for heating purposes, i.e. 25 % of national gross heat production.

We have identified 208 peat-fired energy plants[2] in the 6 countries of focus, primarily for heat production.

Peat activities relative to energy uses are associated with an estimated direct employment of nearly 6 300 people in the corresponding countries, or 63 % of the people employed in peat extraction activities for all uses.

With regard to carbon-intensive industries, peat is used in the Finnish pulp and paper sectors.

Oil shale is currently used only in Estonia. Estonia produced nearly 16 million tonnes per year of oil shale in 2018 and oil shale activities were associated with the direct employment of slightly fewer than 5 200 people: nearly 0.4 % of the Estonian working population.

As regards carbon-intensive industries, oil shale is used in the Estonian cement and lime sectors.

We estimate that there are nearly 130 000 **indirect jobs** in coal-related activities. The regions with the highest share of total indirect jobs are in Germany (DE40, 28 000), Poland (PL22, 14 000 and PL71, 7 300) and Romania (RO41, 6 400 indirect jobs). For peat-related activities, Finland and Estonia host the regions with the highest share of total indirect jobs, i.e. FI19, 3 700 and EE00, 568 indirect jobs. Oil shale-related activities in Estonia correspond to nearly 3 000 indirect jobs in total.

Future perspectives

Looking ahead, all energy scenarios show rapid changes in the coal sector: from a seven-fold reduction, in the scenarios where coal still plays a role in the 27 EU countries, down to an almost complete phase-out in the scenarios dominated by renewables, electrification and alternative fuels. Long-term energy scenarios do not report peat or oil shale separately.

After 2020, jobs at risk of being lost could rise to around 31 000 due to the application of national coal phase-out policies in electricity generation, or to coal phase-out scenarios considered. Over the same period, additional employment losses resulting from the planned closure of mines may reach 2 400 in Czechia and Germany.

Between 2020 and 2030, the total job losses in coal-fired power plants and mines under various coal phase-out scenarios are likely to range from 54 000 to 112 000.

According to our risk assessment of the public, private and market forces influencing the peat and oil shale sector, the most certain and imminent risks are for peat employment in Ireland. This is due to the clear peat phase-out decision in the country. Finland has also adopted an explicit target to halve the consumption of peat for 2030. Based on the current in-force and announced policies at the date of the study, our analysis does not identify any imminent risk for the peat sector in Estonia, Latvia, Lithuania or Sweden.

[2] In Finland, there are also 139 smaller boiler units.

The jobs identified as at risk indicate that while transition from coal may bring notable challenges for the regions, changes in peat and oil shale are not expected to have such a profound impact.[3]

In Ireland, the regions are already in a de facto advanced state of decarbonisation guided by Bord na Mona, the semi-state owned company responsible for the harvesting of peat. The peat extraction has stop and an alternative strategy was announced to move from peat to renewables. As such, we do not consider Bord na Mona related employment at risk, as they are certainly going to be adapted.

Changes since 2018 report

This report provides detailed information of the changes in the coal sector. The table below summarises the overall changes identified since our previous analysis.

			Coal mines
	No of mines	*EU countries*	*Direct jobs*
2015	*127*	*11*	*174 270*
2018	*90*	*11*	*159 267*
			Coal-fired power plants
	No of plants (capacity GW)	*EU countries*	*Direct jobs*
2016	*196 (132 GW)*	*20*	*51 706*
2018	*179 (130GW)*	*19*	*49 102*
2020	*166 (112 GW)*	*18*	*42 640*

[3] Most data are only available on NUTS 2-level (for peat and oil shale). It is important to note that coal-clusters often bridge several neighbouring statistical regions. Furthermore, the relevance of the coal mining and combustion sectors may be relatively low on the NUTS 2-level, but at the same time effects may be significant on the NUTS 3-/ regional and/or municipality-level.

1 Introduction

Europe is undergoing a transformation of its energy system, embracing wide-scale deployment of renewable and other low-carbon energy technologies. In our previous work (Alves Dias et al., 2018), we reported that traditional energy sectors that rely on the production and use of fossil fuels will shrink, with concomitant negative impacts on employment. In our preceding report, we focused on coal, while with this work we expand our analysis to include peat and oil shale for energy use. Among these fossil fuels, considering their current sector sizes and the corresponding related employment, coal activities are likely to have the biggest impact in the short to medium term.

Coal has historically been one of the main fuels of the European economy. However, there has been a gradual decrease in its use since the 1990s. While coal remains important, many EU Member States (MS) have already announced plans to phase it out. 11 out of 19 countries in the EU-27 using coal and lignite for electricity production[4] have a phase out plan, 8 countries do not. Among those that do have a plan, there are still doubts about whether they are sufficient to meet EU commitments under the Paris agreement.

Coal activities (mining and the operation of power plants) have provided employment in several regions across Europe, but these are also decreasing. In coal mining and related activities, the number of people employed in 2018 was estimated to be around 162 000, a significant decrease from the 2015 estimate of approximately 250 000 to 300 000[5]. We have opted for 2018 as a timestamp for our estimates as this is the latest year for which data on coal mining are available. Whenever data other than coal mining are available for more recent years, we present them as well.

Peat and oil shale are used to a lesser extent for energy than coal. We have identified six EU Member States – Estonia, Finland, Ireland, Latvia, Lithuania and Sweden – with peat-related activities, and only one, Estonia, for oil shale. Almost 10 000 people are employed in peat-extraction activities (for example, in horticulture) and around 6 000 are employed in the oil shale industry. However, in this report we focus on the activities in these sectors related to energy use. Data for these countries have been collected by country experts.

The aim of this report is to update the status of the regions[6] identified in our previous analysis that will be affected by the potential decline of coal mining and coal power plant activities, and to assess the impact on regional jobs. Moreover, the report reviews the status of peat and oil shale for energy use in Europe, as well as the jobs related to these sectors and their potential impact in the field.

The report is structured as follows:

Chapter 2 reports the current status of coal mining, peat, oil shale and power generation in the EU. In Chapter 3, we present changes in coal mining and coal power generation since 2010 and from our previous report (2018). Chapter 4 reviews possible future developments of coal, peat and oil shale activities. Finally, in Chapter 5, we map coal use in carbon-intensive industries.

Relevant country factsheets are provided in Annex L of this report.

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[4] According to Eurostat data [NRG_BAL_PEH_custom_15114] for 2018.

[5] According to Euracoal, in 2015, the coal-mining industry (including direct and indirect activities) provided some 258 000 jobs in the EU-28. This figure is comparable with Eurostat data for the same year (294 400). Many accounts are missing from Eurostat data, so Euracoal is used as a source for 2018.

[6] The analysis has been carried out at NUTS 2 level in line with cohesion policy.

This work was undertaken under an Administrative Arrangement with the European Commission’s Directorate General for Energy. It focuses on the potential impact for the European regions in their transition away from coal, peat and oil shale for energy use.

2 The current status of coal[7], peat and oil shale mining

Historically, coal has played a vital role in the European economy. In 1990, coal provided for almost 41% of gross energy consumption in EU Member States, and 39 % of power generation. Despite the gradual decrease in its use since the 1990s, many of the Member States that joined the EU in the 2000s rely on indigenous coal for power generation. In our previous report, we identified the European regions most likely to be affected by the potential decline of coal mining and coal power plant activities, and assessed the impact on regional jobs. In this report, we extend this analysis to EU regions that rely on peat and oil shale for energy use.

When it comes to resources, estimations for peat on a global scale are difficult and data for many countries are imprecise or only partially ascertained. Most of the world's peatland is in North America and northern parts of Asia, with large areas in northern and central Europe and in Southeast Asia. 85 % of the global peatland area is in only four countries: Russia, Canada, USA and Indonesia. 40 % of the peatland area in Europe has been utilised for centuries for agriculture and forestry (World Energy Council, 2013).

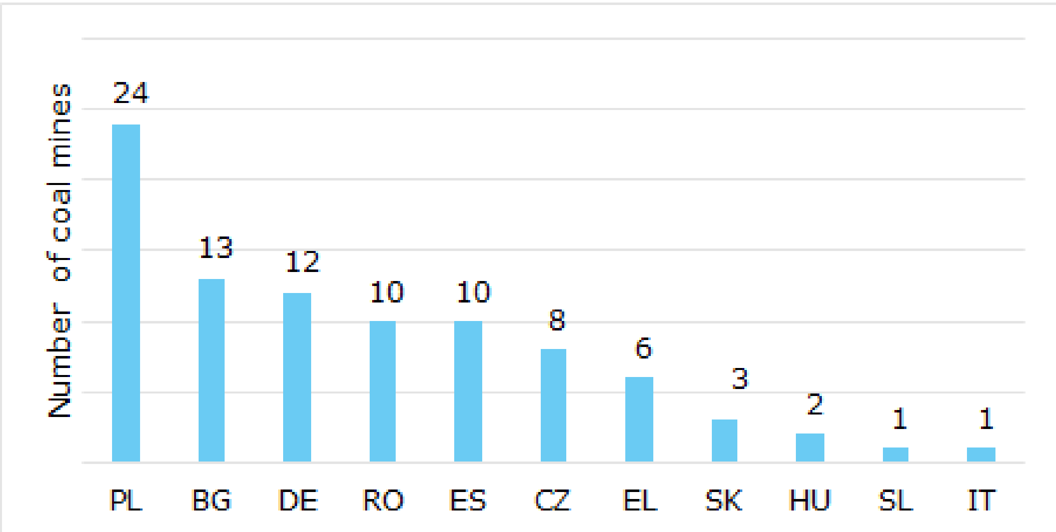
In terms of emissions associated with the end use of coal, peat and oil shale, information can be found at the IEA CO_2 emissions from fuel combustion database (IEA, 2020). A summarised table with information from this database for the countries of scope is presented in Annex L.

2.1 Coal

2.1.1 Operating coal mines in the EU

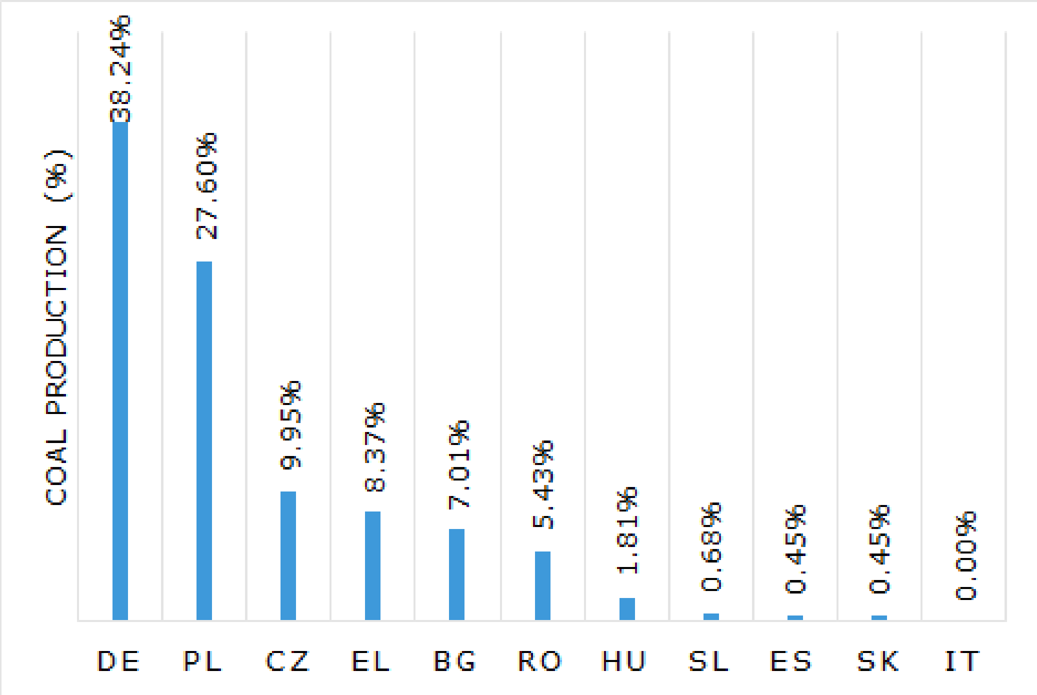
In 2018, 90 coal mines were operating in 11 Member States. Altogether, they produced 442 million tonnes of hard coal and lignite. The majority are in Poland (24), Bulgaria (13) and Germany (12). Germany is the largest coal producer (169 Mt), followed by Poland (122 Mt), Czechia (44 Mt) and Greece (37 Mt). Production in the EU-27 is distributed as shown in Figure 1.

Figure 1. Key figures for European coal mines at national level, a) Number of coal mines, b) Share of EU coal production (%)



a)

[7] The term 'Coal' in this report refers to both hard coal and lignite.



b)

Source: JRC, 2020.

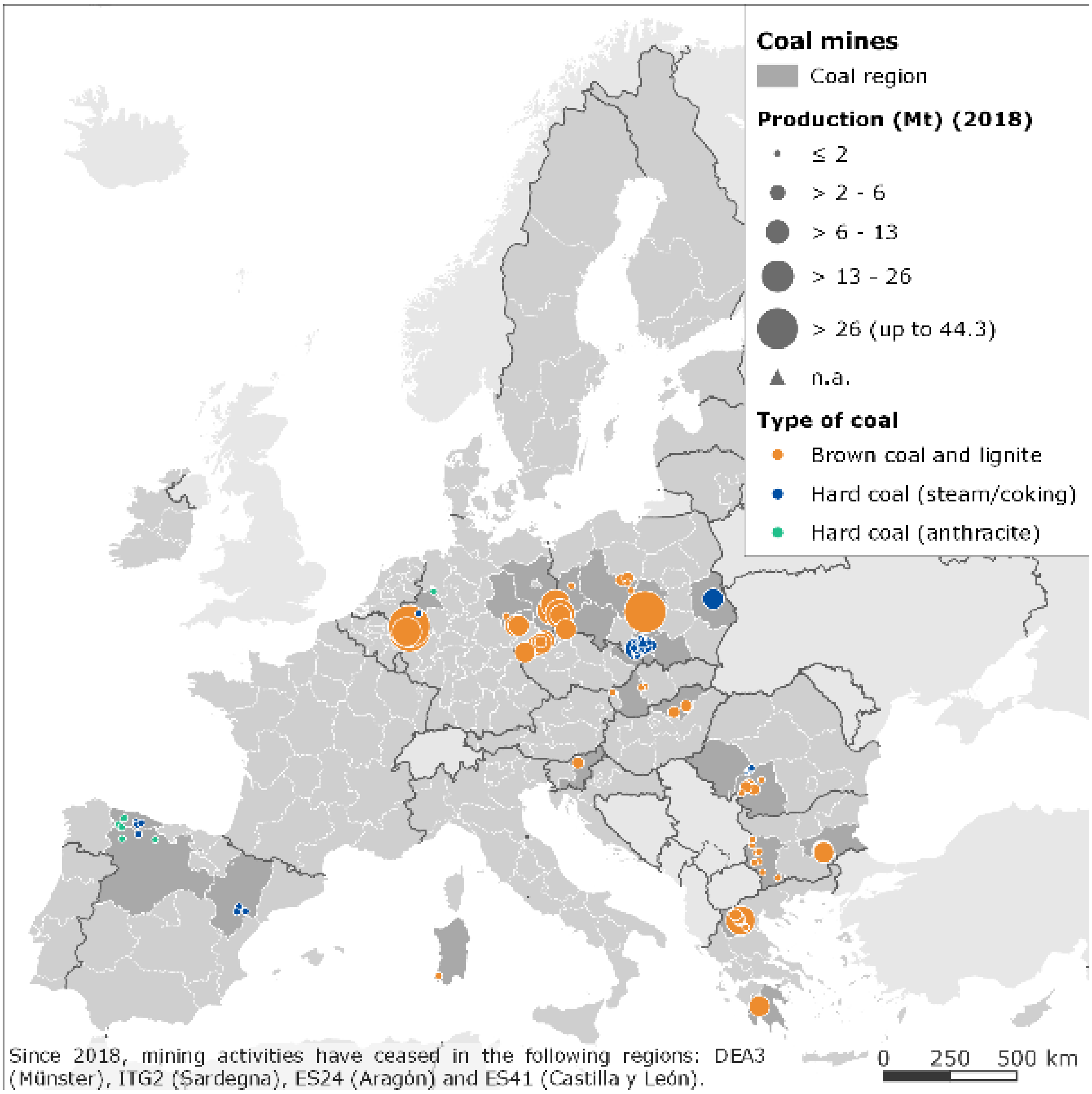
Figure 2 shows the location of mines actively producing coal in 2018, classified according to the type of coal.

Nearly half of coal mines in the EU produce lignite or brown coal; the other half are hard coal mines. The latter produce and market thermal or metallurgical coal. Of these, eight mines provide different hard coal qualities, including steam and coking coal, thus also covering the needs of the steel and iron industry. The remaining production centres supply thermal coal for power and heat generation. Small quantities are supplied elsewhere, mainly to industrial users and households, with chemical by-products from coal gasification also being important in some cases.

At 83 % in 2018, lignite and brown coal accounted for the largest share of coal production. Germany accounted for the majority of lignite production, which totalled 166 million tonnes.

In 2018, hard coal production amounted to 74 Mt. Poland accounted for 63 Mt, Romania for 7 Mt and Czechia for 4.5 Mt. Metallurgical coal represented 17 % of total hard coal production in the EU, an output, which is shared between Poland (83 %) and Czechia (17 %).

Figure 2. Location of operating coal mines in EU and types of coal produced



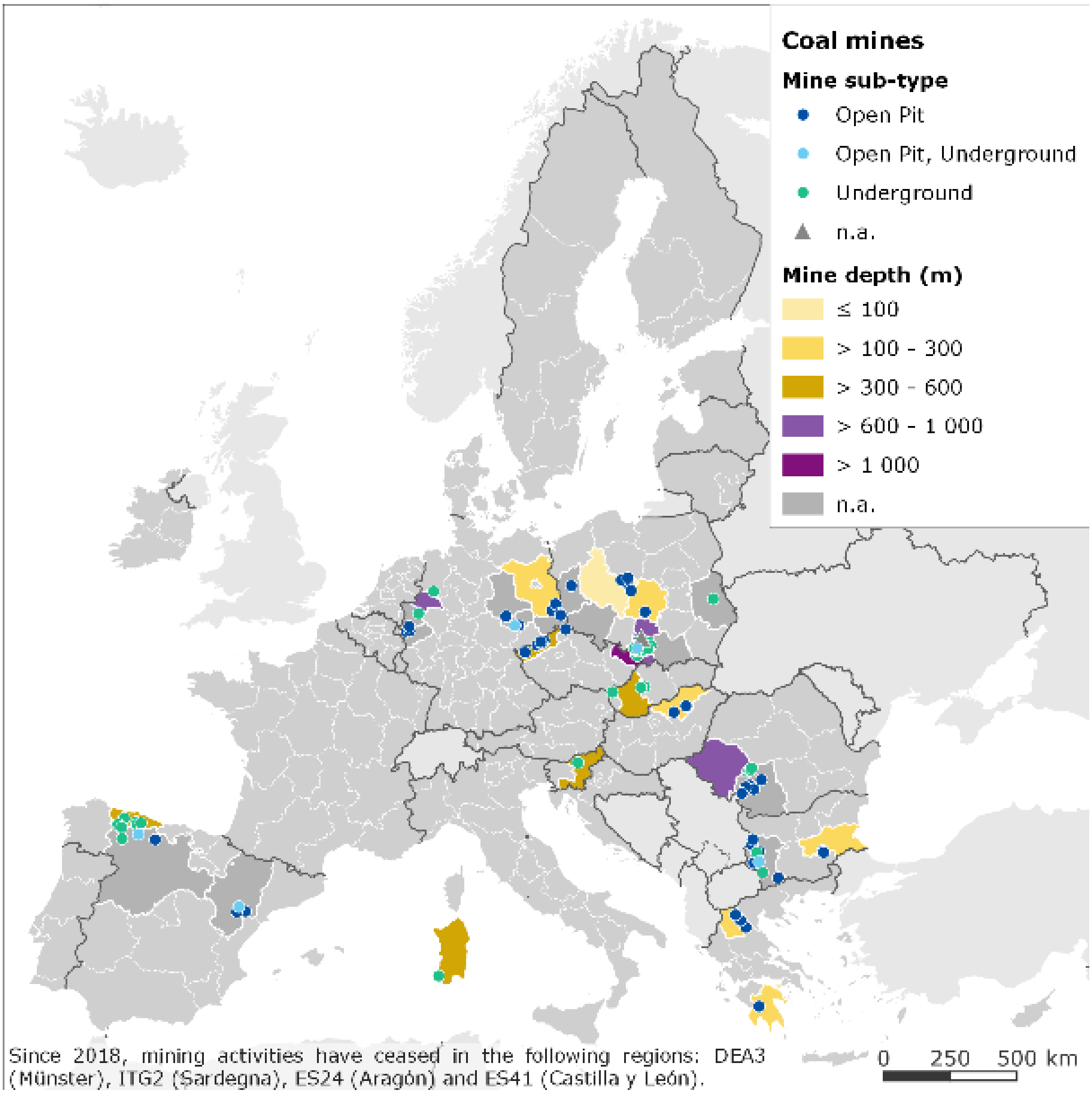
Source: JRC, 2020.

While Spain produced exclusively hard coal, Bulgaria, Greece, Hungary, Slovakia and Slovenia produced solely lignite and/or brown coal. The largest lignite mines are located in Poland and Germany, where in 2018, three units had an output above 30 Mt each. The most sizeable hard coal facilities are located in Poland, where mines with an annual production capacity of around 10 Mt are located.

Nearly half of all mines are surface operations. Lignite is almost exclusively extracted at opencast mines, with exceptions in Bulgaria, Slovakia and Slovenia, while most hard coal production takes place in underground operations. Deeper mines (more than 800 m) are located in Czechia, Poland and Bulgaria. In Czechia, the deepest coal pits reach depths of up to 1300 m.

The depth of the lignite seams ranges from 150 to 200 m in Greece, 200 to 500 m in Slovenia, 40 to 700 m in Slovakia, 25 to 300 m in Poland, 70 to 270 m in Hungary, up to 400 m in Czechia and up to 830 m in Bulgaria (Figure 3).

Figure 3. Information on the type and depth of active coal mines in the EU



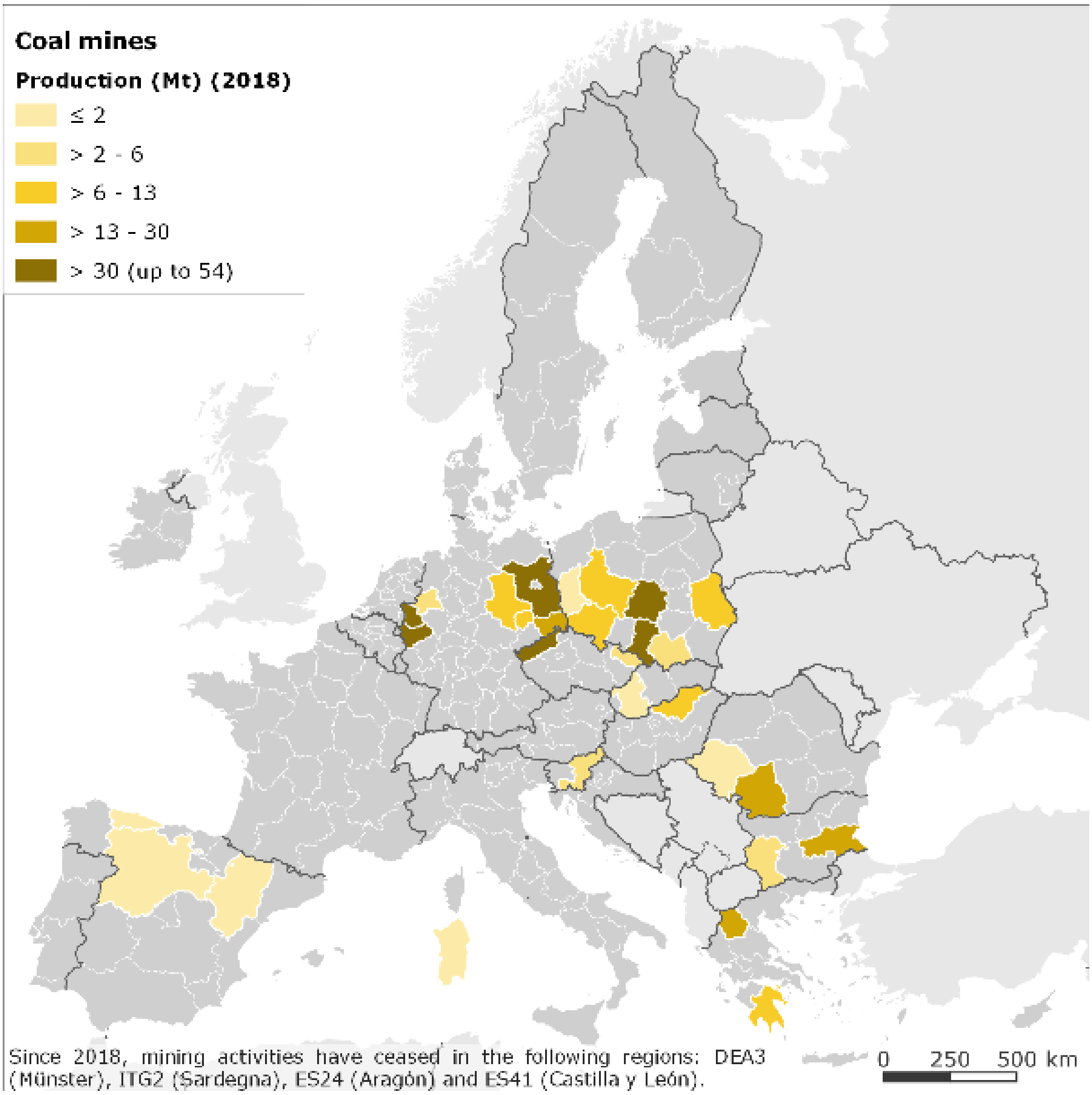
Source: JRC, 2020.

2.1.1.1 Coal mine production at NUTS 2 level

In 2018, coal was mined in 29 NUTS 2 regions across 11 EU Member States, as shown in Figure 4.

Regions with the highest aggregated production of more than 30 million tonnes of coal are located in Germany, Poland and Czechia. Regions with a yearly production of at least 20 million tonnes can also be found in Greece, Bulgaria and Romania. Köln in Germany (DEA2, 53 Mt of lignite) and Śląskie in Poland (PL22, 49 Mt of hard coal) reached the highest production levels in 2018.

Figure 4. Annual production of coal mines, aggregated at NUTS 2 level[8]



Source: JRC, 2020.

Metallurgical coal is only produced in the Upper Silesian Basin within the Śląskie region (PL22) and in Moravskoslezsko (CZ08). In PL22, 78 % of the hard coal produced is classified as thermal coal, while the remaining 22 % is a coking coal product recovered during processing. In CZ08, half of the volume produced is sold as metallurgical coal (Table 1).

Table 1. Distribution of thermal and metallurgical coal shares in coal mining regions in 2018

NUTS 2	Production (Mt)	Thermal coal (%)	Metallurgical coal (%)	Number of mines
PL22	49.4	78	22	5
CZ08	4.5	51	49	3

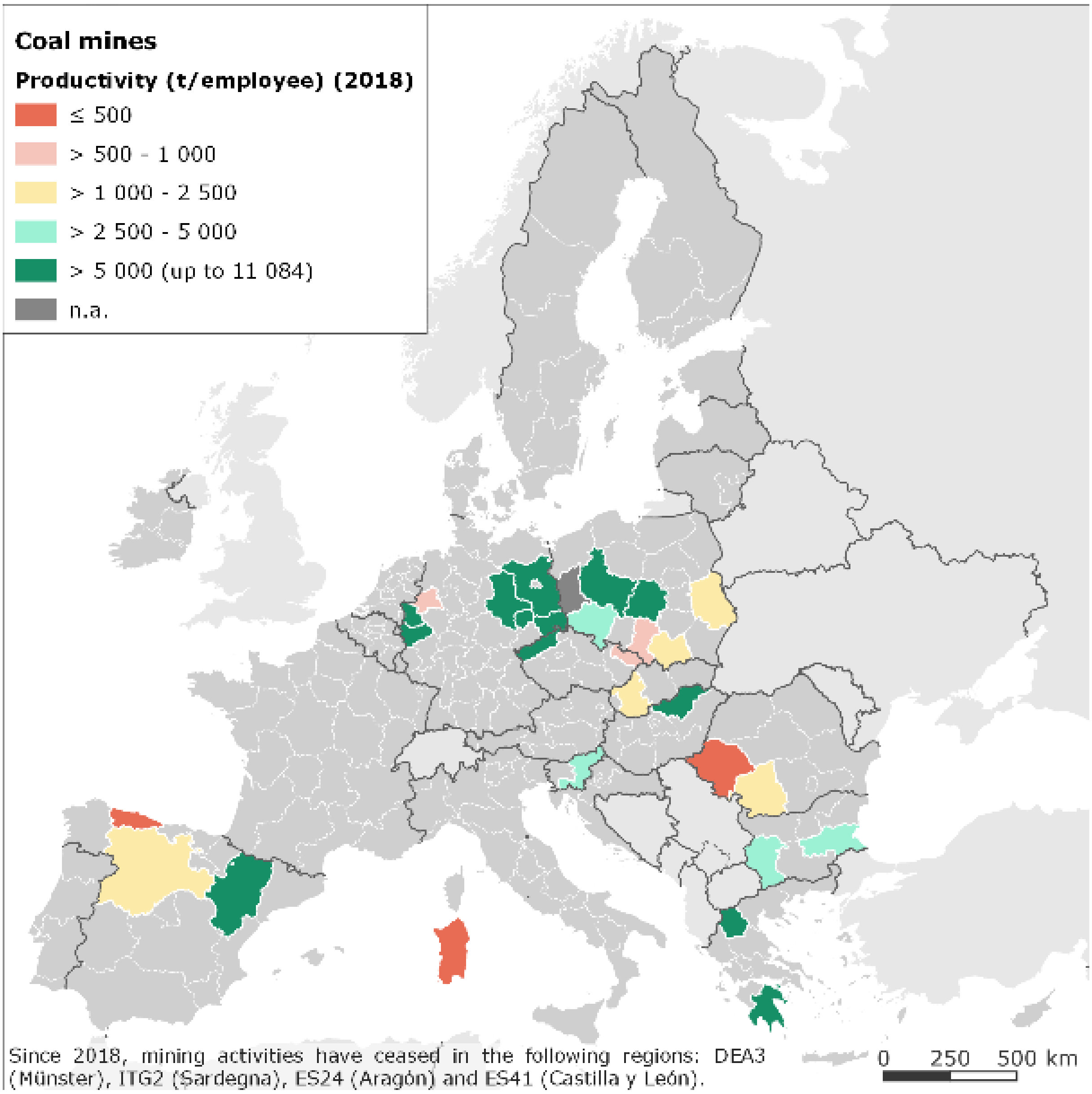
Source: JRC, 2020.

[8] The table used to support the map projection is given in Annex B.

2.1.1.2 Coal mine productivity at NUTS 2 level

As a measure of the competitiveness of a mining region, we estimate productivity as the annual production of coal per person employed. Productivity ranges in 2018 are shown in Figure 5.

Figure 5. Average productivity of coal mines at NUTS 2 level



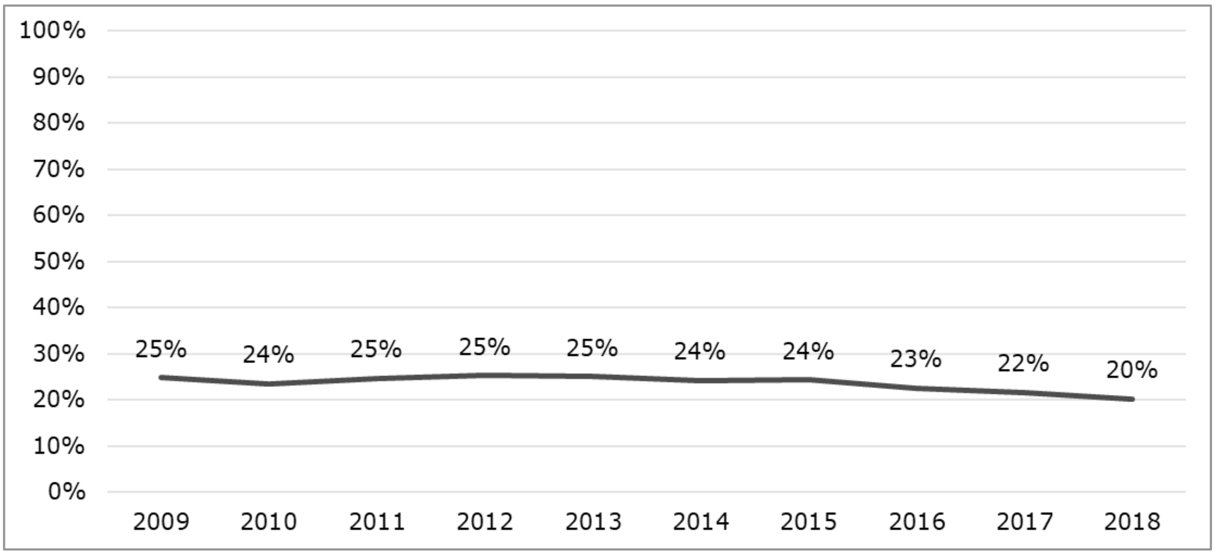
Source: JRC, 2020.

The most productive mines in the EU are located in Germany, Poland and Greece, where surface lignite mines are operated with a production of more than 8 000 tonnes per employee. The least productive regions are located in Spain and Romania where production is below 500 tonnes per employee. The average productivity of Germany's lignite mines was 11 000 tonnes per man-year in 2018.

2.1.2 Operating coal-fired power plants in the EU

The share of electricity from coal-fired power plants in the EU-27 power generation mix changes from year to year. From 2009 to 2015 it remained close to 25 %, but since 2016 it has started to decrease, reaching 20 % in 2018, as shown in Figure 6.[9]

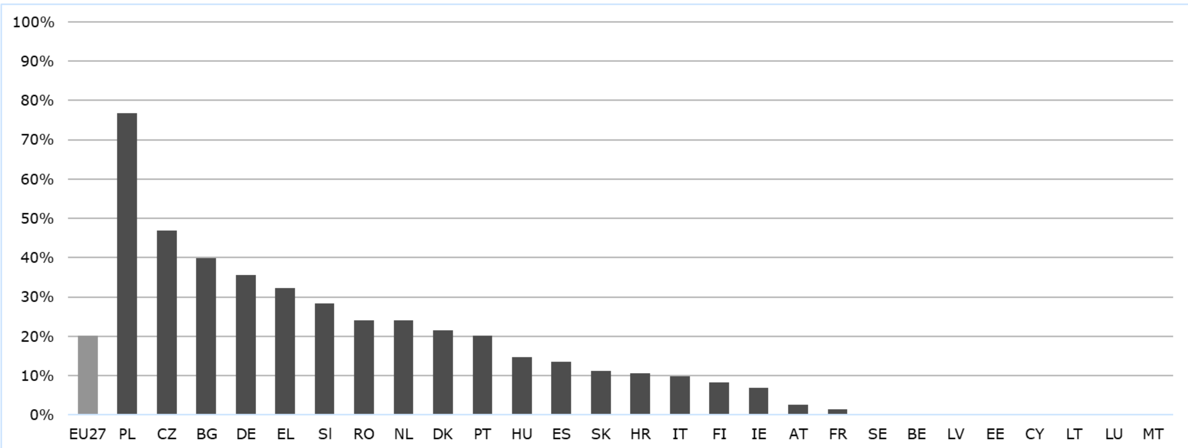
Figure 6. Share of coal in power generation for EU-27



Source: JRC, Eurostat [NRG_BAL_PEH_custom_15114], 2020.

The importance of coal in power generation varies significantly across the EU. While ten countries make marginal or no use of coal in power generation, Poland generates 77 % of electricity from coal and lignite, followed by Czechia with 47 % and Bulgaria with 40 %. Figure 7 and Table 2 show the share of electricity generated from coal in EU Member States. The data from Eurostat relates to 2018.[10]

Figure 7. Share of electricity generation from coal and lignite in total electricity generation in 2018



Source: JRC, Eurostat [NRG_BAL_PEH_custom_15114], 2020.

[9] Eurostat: Production of electricity and derived heat by type of fuel [NRG_BAL_PEH__custom_15114]

[10] The data from Eurostat relates to power generation from all types of coal fuel (anthracite, coking coal, other bituminous coal, sub-bituminous coal, lignite and brown coal briquettes).

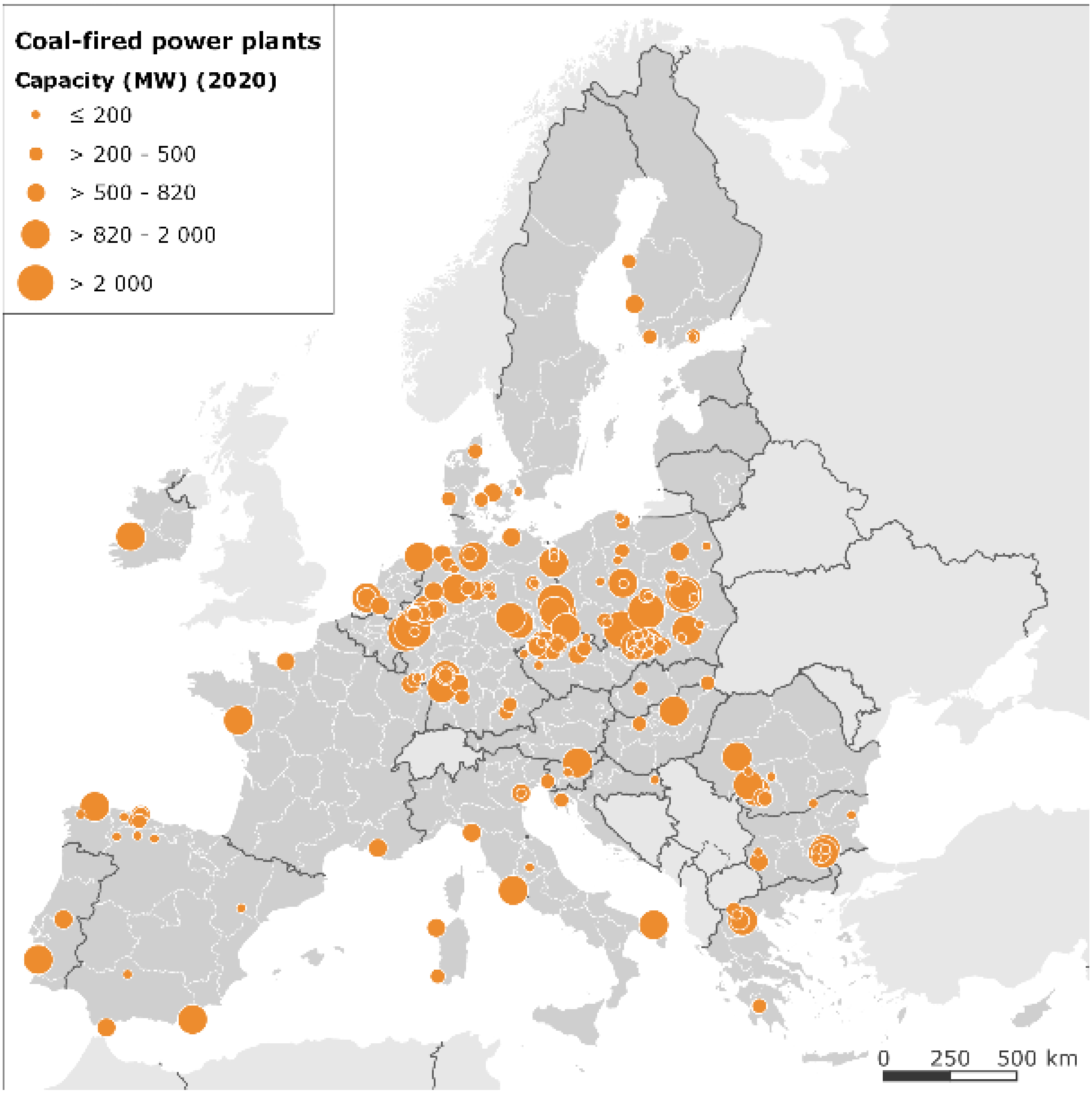
Table 2. Power generation from coal and lignite in 2018

Country	Gross Electricity Production (GWh)	Electricity Production From Coal (GWh)	Share of Coal in Electricity Production (%)
EU-27	2 941 465	595 611	20%
Belgium	74 608	91	0%
Bulgaria	46 815	18 659	40%
Czechia	87 907	41 201	47%
Denmark	30 377	6 570	22%
Germany	641 593	228 156	36%
Estonia	12 360	0	0%
Ireland	31 134	2 152	7%
Greece	53 263	17 185	32%
Spain	274 358	37 341	14%
France	581 276	8 413	1%
Croatia	13 632	1 453	11%
Italy	289 107	28 470	10%
Cyprus	5 061	0	0%
Latvia	6 725	0	0%
Lithuania	3 279	0	0%
Luxemburg	2 201	0	0%
Hungary	31 865	4 669	15%
Malta	1 962	0	0%
Netherlands	114 365	27 470	24%
Austria	68 584	1 805	3%
Poland	169 915	130 563	77%
Portugal	59 636	12 006	20%
Romania	64 876	15 646	24%
Slovenia	16 331	4 622	28%
Slovakia	26 855	3 011	11%
Finland	69 982	5 791	8%
Sweden	163 400	335	0%

Source: JRC with data from Eurostat [NRG_BAL_PEH_custom_15114], 2020.

Our analysis shows that towards the end of 2020, 166 coal-fired power plants were operating in 18 Member States, with a total capacity of 112 GW. Sixty percent of these plants use hard coal (with a total capacity of 67 GW) and the rest use lignite. Their location is shown on the map in Figure 8.

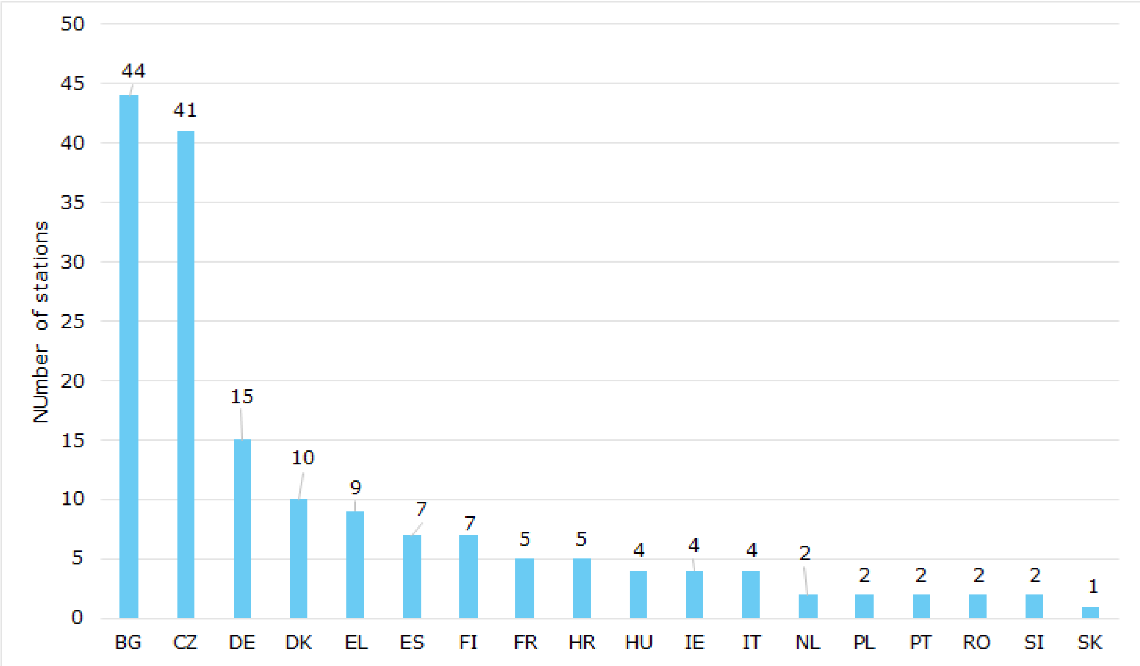
Figure 8. Location of coal-fired power plants with information on capacity at NUTS 2 level



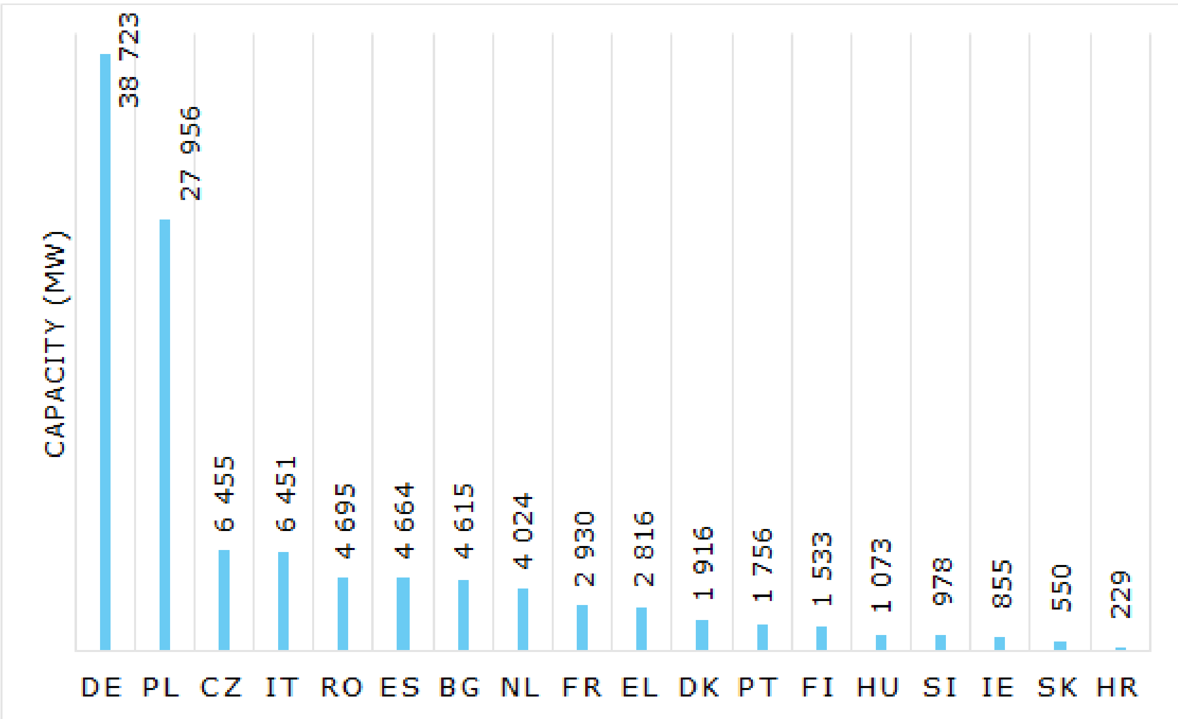
Source: JRC, 2020.

The map shows that the highest density of European coal power plants lies in an area stretching from the Netherlands, across Germany and Czechia, to Poland. Lignite is used mainly in Germany, Eastern Europe and the Balkan peninsula, while hard coal is the primary fuel in Germany, Poland and Spain. Germany, Poland and Czechia are the countries that host the largest number of power plants, i.e. 44, 41 and 15, respectively. In terms of capacity, Germany hosts 39 GW, followed by Poland (27 GW), with shares as shown in Figure 9 a) and b).

Figure 9. a) Number of coal power plants by Member State, b) Capacity of coal power plants by Member State



a)



b)

Source: JRC, 2020.

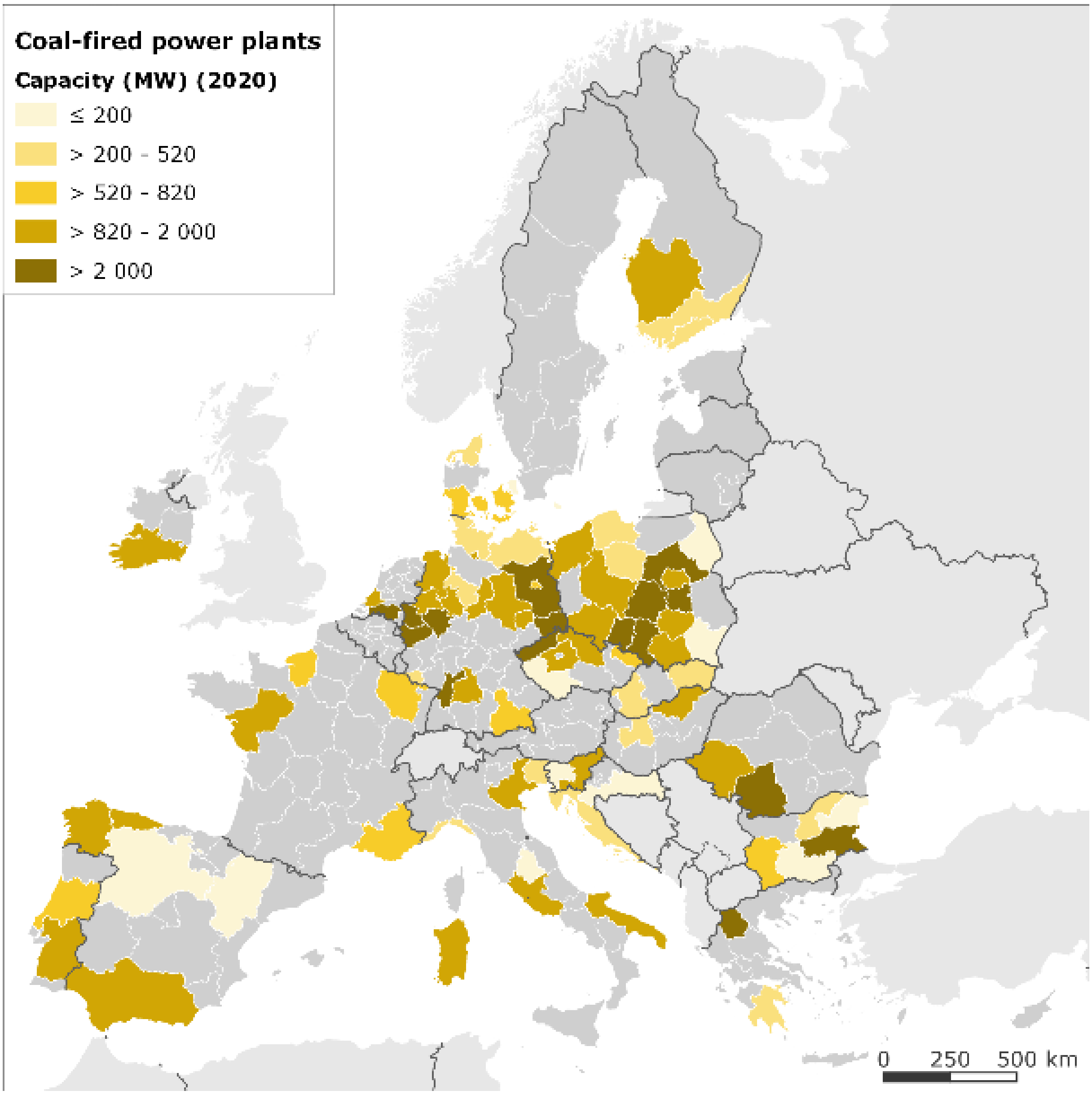
Lignite-fuelled power plants are usually built close to lignite mines, while hard coal power plants are located either close to the mines, where these are the main fuel source, or close to waterways in cases where hard coal is imported.

The average coal power plant efficiency in the EU is 35 %. The efficiency estimate is based on European power plants and refers to average annual efficiency. Thus, we cannot safely compare this number with rest of the world average efficiencies, which according to UNECE is approximately 35% (UNECE, 2015).

Coal power plants with the lowest efficiency (around 30 % or below) are more frequent in eastern European countries. Some of the most efficient coal-fired power plants, with an estimated energy efficiency above 39 %, are located in Germany and the Netherlands[11].

Overall, 85 NUTS 2 regions host coal-fired power plants. The installed capacity of coal-fired power plants, aggregated at NUTS 2 level, is shown in Figure 10.

Figure 10. Installed capacity of coal-fired power plants, aggregated at NUTS 2 level[12]



Source: JRC, 2020.

[11] It is noted that environmental conditions, beyond technology, affect the efficiency of power plants. The high power plant efficiencies in coastal sites in northern Europe are also due to the availability of cold water for power plant cooling.

[12] The map draws information from the JRC-PPDB. The data that underpin this map projection can be found in Annex A.

The map shows that besides the area stretching from the Netherlands and Germany to Czechia and Poland, there are also regions with significant installed capacity exceeding 2 000 MW in Bulgaria, Greece and Romania.

2.1.3 Direct employment in coal power plants and mines

This section presents a first assessment of the number of direct jobs associated with coal mining and coal-fired power generation at NUTS 2 level. The detailed results are presented in Annex C.

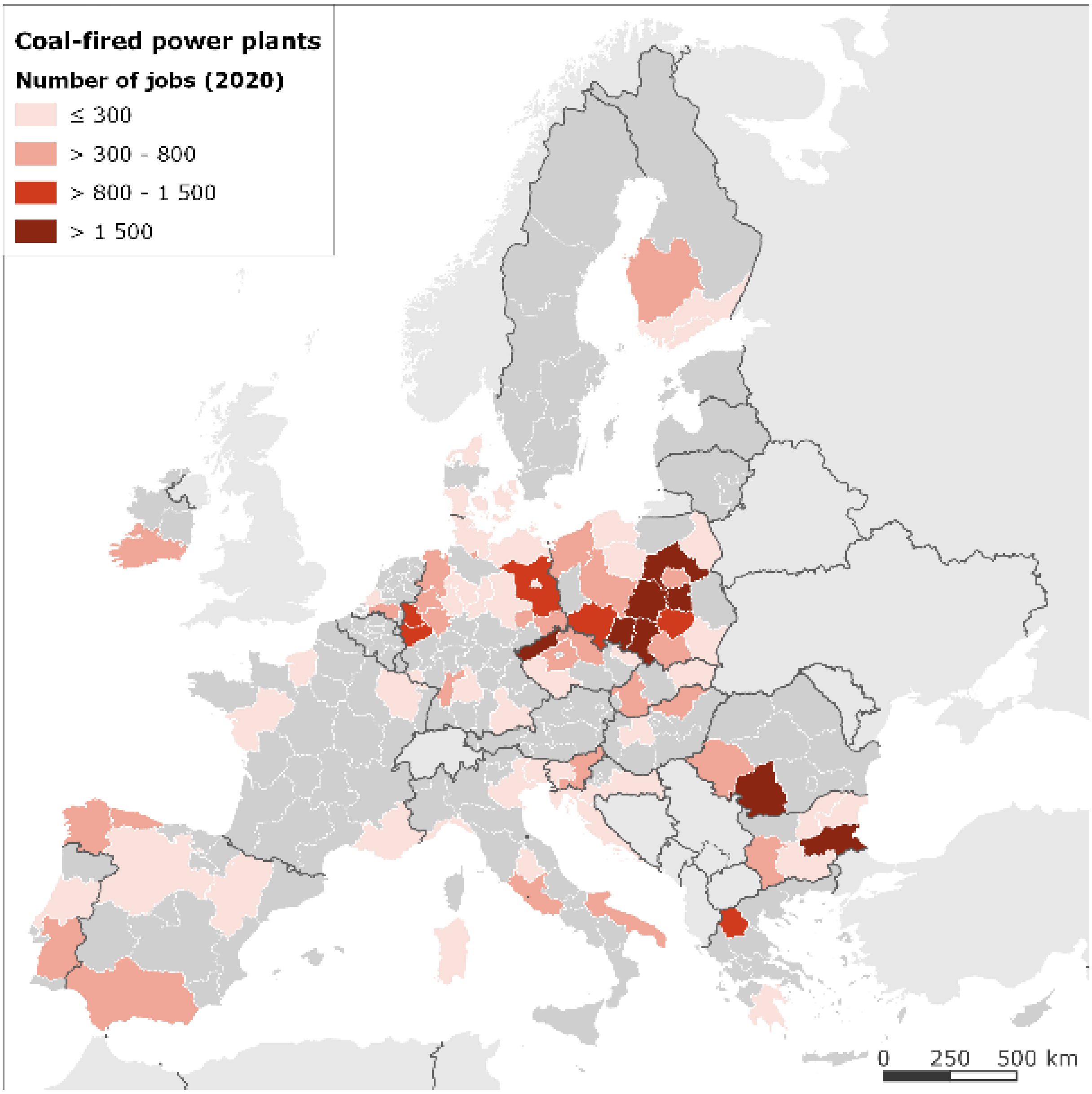
2.1.3.1 Direct jobs in coal-fired power plants

It is estimated that in 2018[13], there were 179 plants and approximately 49 000 people worked in coal-fired power plants in the current EU-27. The number of jobs per Member State ranges from just above 150 in Croatia to around 15 600 in Poland. The map in Figure 11 illustrates the estimated number of direct jobs in active coal-fired power plants at NUTS 2 level. The estimates[14] were calculated based on the installed capacity in each Member State and an indicator provided in Annex D that links jobs with installed capacity (jobs per MW).

[13] We present data for 2018 both for coal-fired power plants and coal mines for a harmonised approach as the latest data available for coal mines refer to 2018.

[14] Specific country indicators (Annex D) were derived based on the actual number of direct jobs in lignite power plant operation in Germany (see (Alves Dias et al., 2018). The basis for deriving the country-specific figures was the size of the average power plant in each Member State compared to the size of the average power plant in Germany. The results of this analysis were within the range of 0.14 to 0.84 jobs per MW provided in relevant publications (GreenPeace, Solar Power Europe, & GWEC, 2015; OECD/IEA, 2008)..

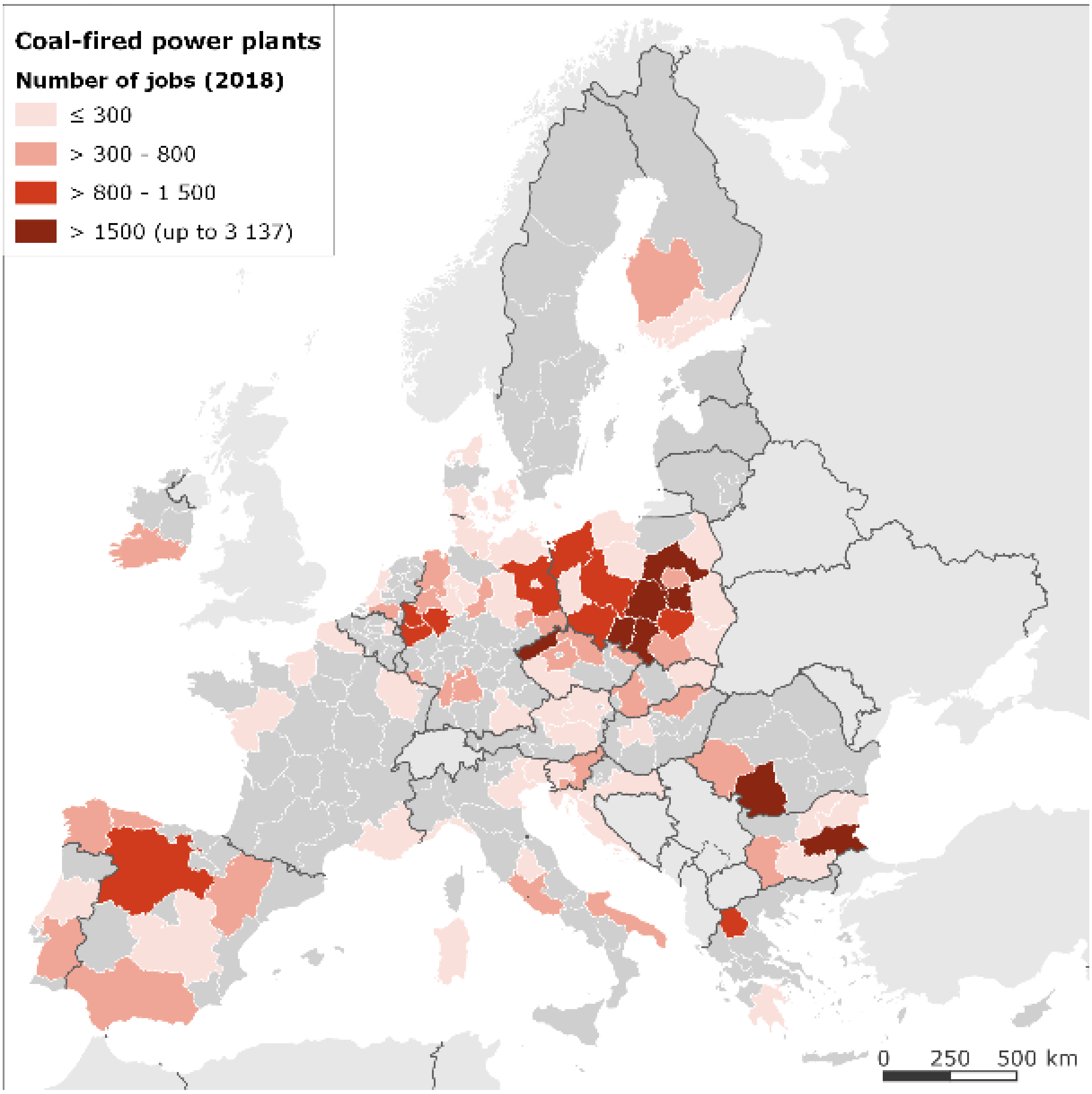
Figure 11. Estimated number of direct jobs for 2018 in active coal-fired power plants[15]



Source: JRC, 2020.

[15] The data supporting the map projection is given in Annex C.

Figure 12. Estimated number of direct jobs for 2020 in active coal-fired power plants[16]



Source: JRC, 2020.

Both for 2018 and 2020, Poland, Germany, Czechia, Romania, Spain and Bulgaria are on the top of the list, each hosting more than 2 500 direct jobs in coal-fired power plants (see Table 3). At regional level, Śląskie (PL22), Łódzkie (PL71), Mazowiecki (PL92), Opolskie (PL52), Sud-Vest Oltenia (RO41), Düsseldorf (DEA1), Yugoiztochen (BG34) and Severozápad (CZ04) are estimated to host more than 1 500 direct jobs each in coal-fired power plants.

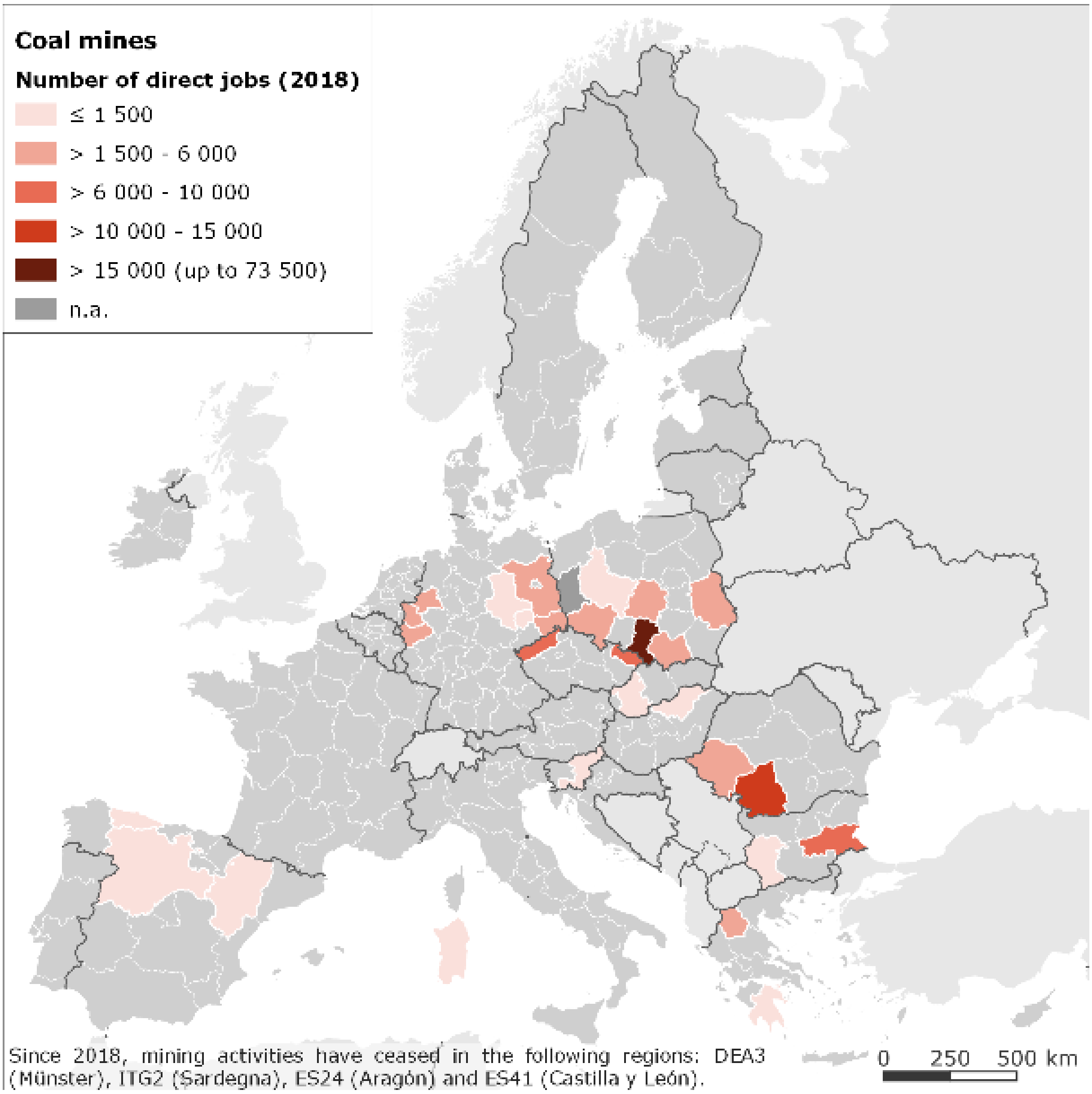
2.1.3.2 Direct jobs in coal mining

In 2018, coal mining provided for 160 000 jobs across the EU-27. Employment at national level ranged from as low as 160 in Italy to just above 90 000 in Poland.

[16] The data supporting the map projection is given in Annex C.

As shown in Figure 13, two regions in Poland and Romania (PL22, RO41) accounted for more than 10 000 employees each in coal mining activities and an additional three in Czechia and Bulgaria (BG34, CZ04 and CZ08) for over 5 000 each. Another 11 regions in Poland, Greece, Germany and Romania employed more than 2 000 workers each in coal mining.

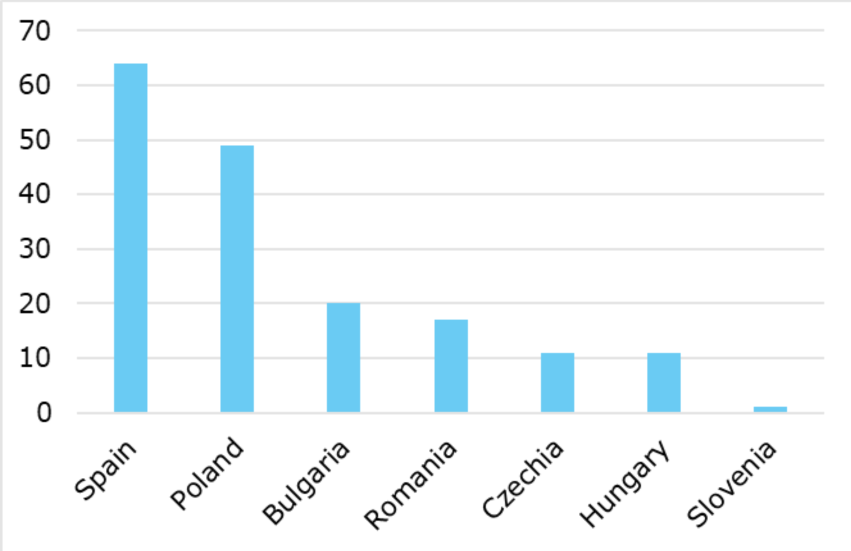
Figure 13. Number of jobs (2018) in coal mines in each NUTS 2 region



Source: JRC, 2020.

In 2018, the region of Silesia in Poland (PL22) provided direct jobs in coal mining for around 73 000 people. This is also one of the two regions with the highest production in Europe, and one of the largest in terms of the number of enterprises active in coal mining (Figure 14).

Figure 14. Number of enterprises in the NACE class "mining of coal and lignite" – data for 2018[17]



Source: JRC, Eurostat [sbs_sc_sca_r2], 2020.

The largest number of coal mining enterprises is located in Spain (64 companies), despite the fact that the country only produces 1.2 % of the total coal produced in the EU-27. Alongside Spain and Poland, there is a notably high number of enterprises active in coal mining in Bulgaria and Romania[18].

It is estimated that management and technical staff account for around 4 % of total employment in a mining operation. Production and auxiliary staff are the largest professional groups, accounting for 80 % of the workforce. The latter include equipment operators, electricians and mechanics. Mine operations staff and supervisors account for the remaining 16 % (Alves Dias et al., 2018).

2.1.3.3 Overall assessment of current direct employment

In the EU-27, coal mining and coal power generation activities provide jobs to about 208 000 people. In 2018, around 159 000 were employed in coal mining and about 49 000 in coal-fired power plants.[19]

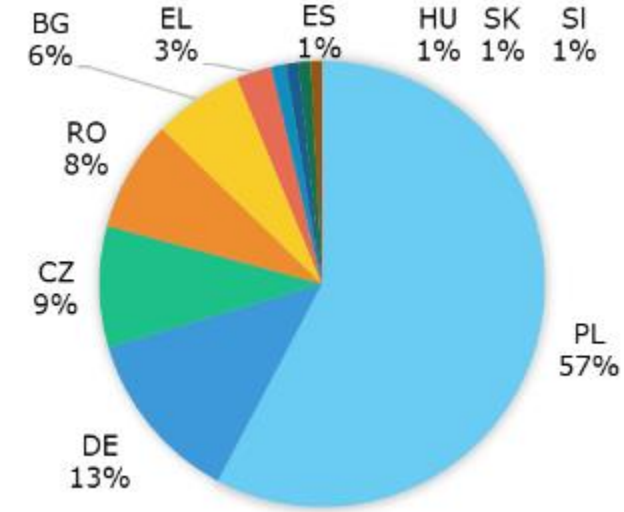
Regarding jobs in coal-fired power plants, Poland has the highest number (15 653), followed by Germany (10 385) and Czechia (3 925). The number of jobs in coal mines is much higher in Poland, Germany, Czechia, Romania, Bulgaria and Greece. Just above 90 000 people are employed in the Polish coal-mining sector, followed by Germany (20 000), Czechia and Romania (almost 14 000 each). Overall, Poland hosts the largest number of jobs in the coal sector (about 107 079), followed by Germany (30 386), Czechia (17 829) and Romania (16 630). Figure 15 demonstrates the corresponding shares by country and Table 3 provides the underlying numbers.

[17] Accounts are not available for Germany, Greece and Slovakia.

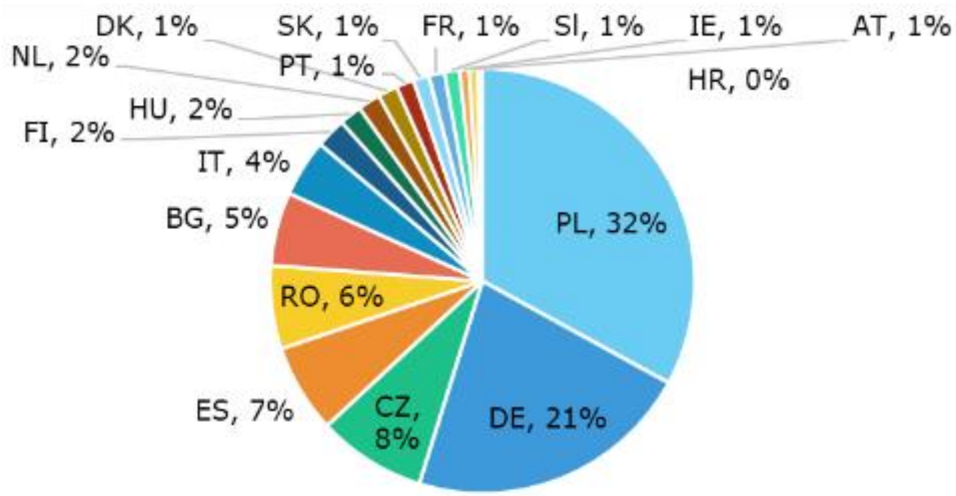
[18] This number includes large enterprises and small dependent companies (e.g. SMEs providing indirect services).

[19] According to Eurostat, the overall number of jobs in the coal mining sector was 113 090 in 2018 (figures for Germany, Greece, Slovakia, Slovenia and Spain were not available). In 2017, including Germany, the number of jobs was estimated at 121 562, but employment statistics are not available for Greece, Slovakia, Slovenia and Spain.

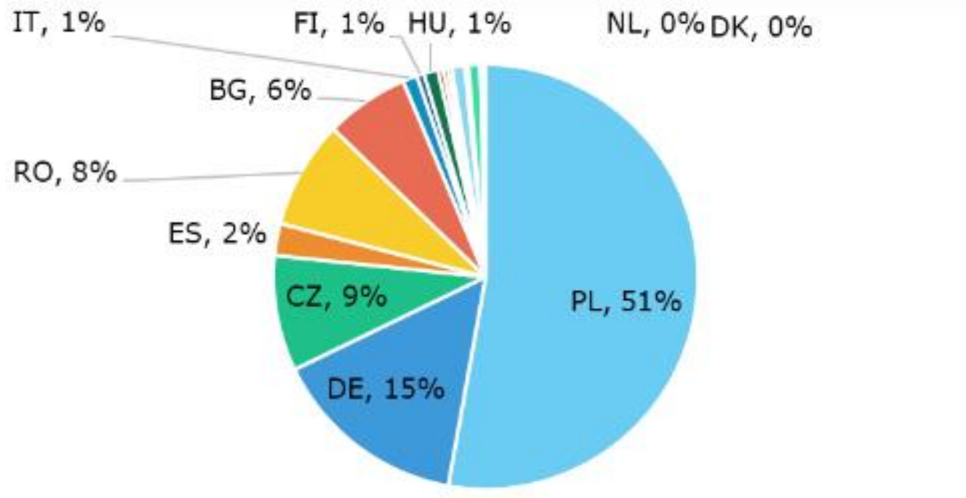
Figure 15. Employment in the European coal sector. a) Share of jobs in coal mines, b) Share of jobs in coal-fired power plants, c) Share of total jobs related to coal activities



a)



b)



c)

Source: JRC, 2020.

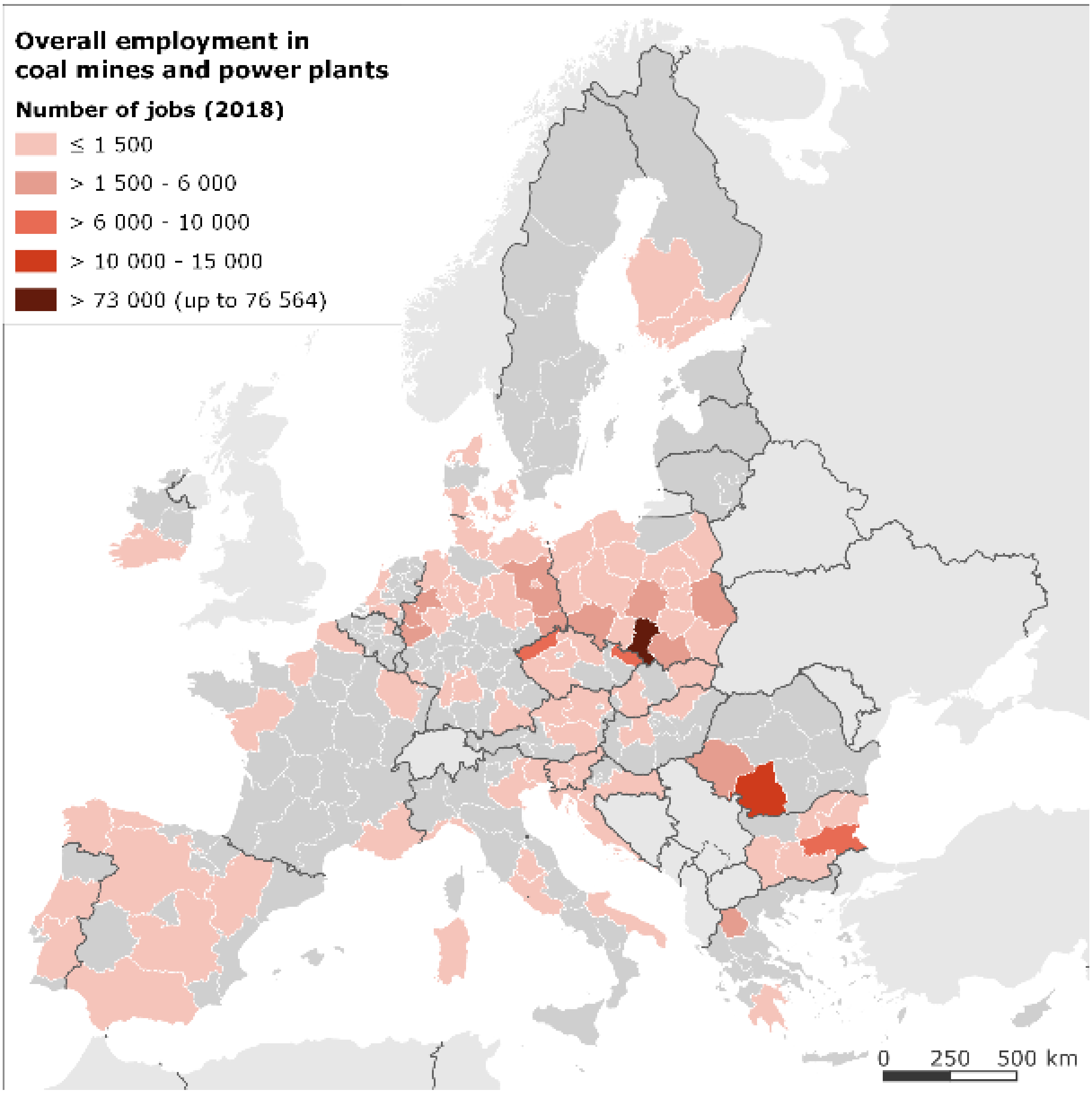
Table 3. Number of jobs in coal power plants and coal mines at country level (values refer to 2018)

Country	Power plant employment	Coal mine employment	Overall employment
Poland	15 653	91 400	107 079
Germany	10 385	20 000	30 386
Czechia	3 925	13 900	17 829
Romania	3 008	13 600	16 630
Bulgaria	2 660	10 300	12 944
Greece	1 605	4 000	5 687
Spain	3 210	1 700	4 943
Hungary	811	1 400	2 211
Italy	2 079	160	2 239
Slovakia	573	1 400	1 976
Slovenia	545	1 300	1 797
Finland	1 095	0	1 095
Netherlands	810	0	810
Denmark	711	0	711
Portugal	643	0	643
France	568	0	568
Ireland	342	0	342
Austria	322	0	322
Croatia	157	0	157

Source: JRC, 2020.

The distribution of the overall number of jobs in the two coal-related sectors – power plants and mining – is given at each NUTS 2 region in Figure 16. As shown on the map, the regions with the highest overall employment are located in Poland, Germany, Czechia and Romania.

Figure 16. Overall number of jobs in coal power plants and coal mines in NUTS 2 regions[20]



Source: JRC, 2020.

2.2 Peat

According to the International Peatland Society, peat is "the surface organic layer of a soil that consists of partially decomposed organic matter. This is derived mostly from plant material, which has accumulated under conditions of waterlogging, oxygen deficiency, high acidity and nutrient deficiency".[21] Peat consists of partially decomposed organic material, derived mostly from plants, that has accumulated under conditions of waterlogging, oxygen deficiency, acidity and nutrient deficiency. The energy content of in-situ peat depends on its moisture and ash content. Peatlands are landscape areas, with or without vegetation, that have a naturally accumulated peat layer on the surface. For land to be designated as peatland, the thickness of the peat layer must be at least 20 cm if drained, and 30 cm if undrained. Peatland reserves are most frequently quoted on

[20] The table used to support the map projection is given in Annex C.
[21] https://peatlands.org/peat/.

an area basis because initial inventory normally arises through soil survey or remote sensing (World Energy Council, 2013).

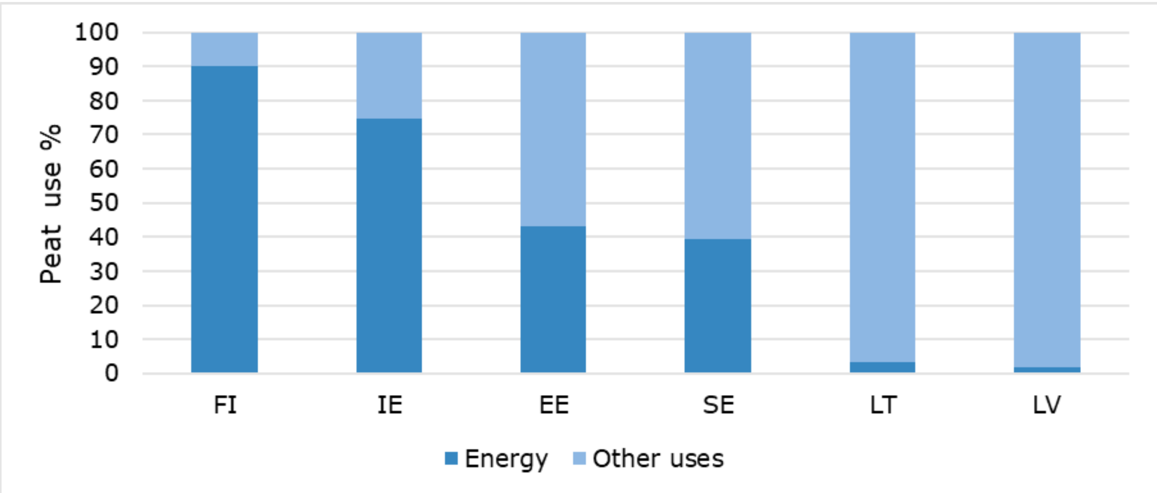
In terms of climate change mitigation, ”peatlands cover less than three percent of the Earth’s surface but are the largest terrestrial organic carbon stock – storing twice as much carbon as in the world’s forests. In fact, greenhouse gas emissions from drained or burned peatlands account for five percent of the global carbon budget” (Crump, 2017).

Peat has a large number of uses, which may be classified under the following categories (World Energy Council, 2013):

- Energy (as fuel for electricity/heat generation, and directly as a source of heat for industrial, residential and other purposes)
- Horticultural and agricultural (e.g. as growing medium, soil improver, cowshed/stable litter, compost ingredient);
- Other (e.g. as a source of organic and chemical products such as activated carbon, resins and waxes, medicinal products such as steroids and antibiotics, and therapeutic applications such as peat baths and preparations).

The analysis (European Commission, 2018) in support of the Commission communication COM(2018) 773 shows that limiting the use of organic soil and peatlands is “an effective way to reduce soil carbon losses and associated CO_2 emissions”. While such efforts in reducing the CO_2 emissions can affect peat production, this study aims to assess the potential impact of decarbonising the energy system on the peat sector. Therefore, the analysis focuses on peat for energy use and, as such, on the most important producers and users of peat-derived energy within the EU-27: Finland, Ireland, Sweden, Latvia, Lithuania and Estonia. The relevant peat production of countries like Germany and Poland is out of the scope of this analysis due to its mostly agricultural use. Figure 17 shows the share of peat production for energy purposes in the scope countries.

Figure 17. Share of peat production for energy uses[22]



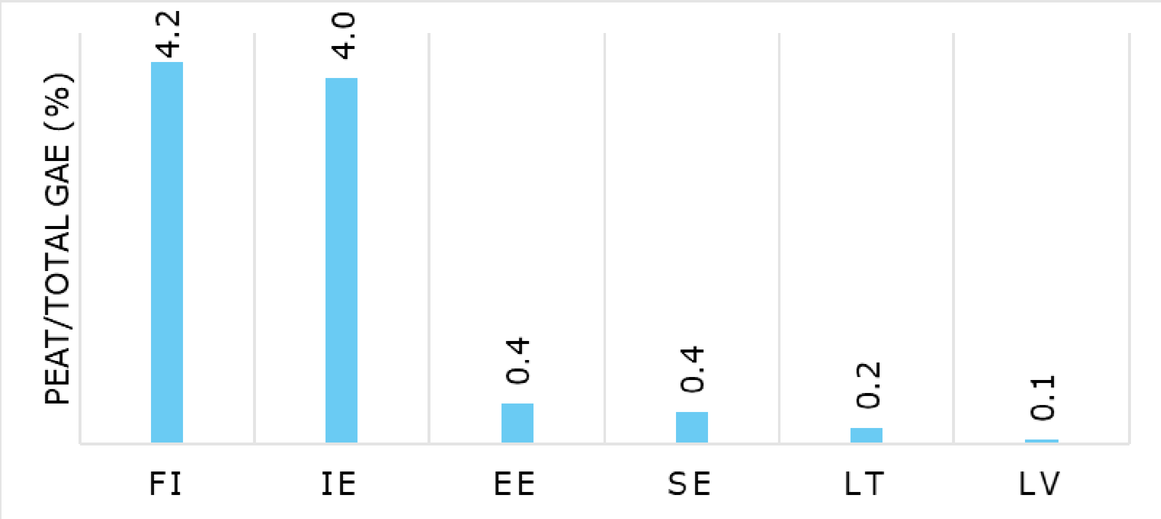
Source: JRC, 2020.

The majority of the countries within scope show a share of energy use for peat of over 40 %.[23] Only Latvia and Lithuania currently have a peat sector practically reconverted to

[22] Percentage for IE is based on exports and not including unregistered internal agricultural use.

agricultural uses. Figure 18 shows how peat reaches the highest (close to 4 %) contribution to Gross Available Energy (GAE) in Finland and Ireland, while in the rest of the scope countries it does not go over 0.5 %.

Figure 18. Share of peat production over total national Gross Available Energy (GAE)



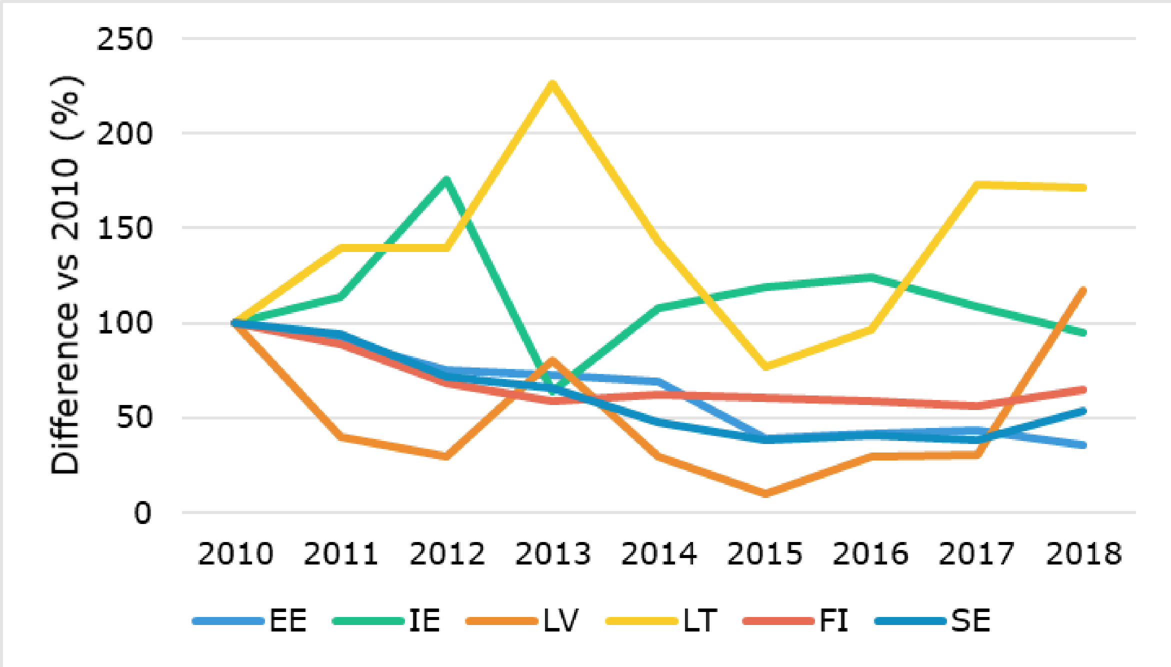
Source: JRC, 2020.

A National Experts Pool (NEP) provided the main input data for this section (named in the acknowledgements section of this report), complemented by additional sets where referred The whole analysis is framed within Eurostat energy balances.

In terms of the historical evolution of peat energy end uses, Figure 19 shows a common trend cannot be identified for the scope countries. Estonia, Finland and Sweden show a clear trend of reduction, approximately halving peat use in 2018 with respect to 2010.

[23] Note that the absolute amount of peat consumption for energy uses in LT and LV is so small that presenting the share in those countries is not meaningful.

Figure 19. 2010 Indexed evolution of the peat contribution to national Gross Available Energy



Source: JRC, 2020.

Structurally speaking, there are some differences between the coal and peat value chains. The strong link between mines and power plants that can be distinguished in the coal sector is more diluted in the value chain for fuel peat, mainly due to:

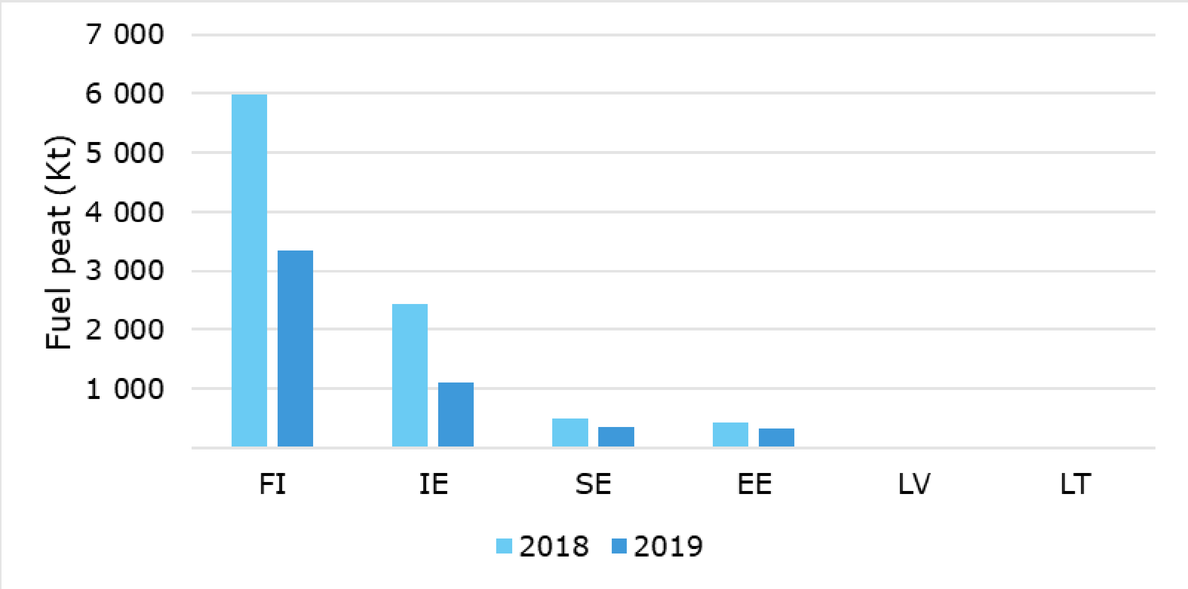
- Several possible end use sectors for peat: there is a remarkable range of shares of production allocated to fuel or to agricultural uses.
- Size of end use transformation facilities: unlike the majority of coal currently being fed to medium and large (1 000MW scale) thermal power plants, fuel peat is used in medium/small power plants (in the range of 100MW), in cogeneration for industrial or district heating, and even in local heat-distributing isolated networks.
- Co-firing with biomass: peat-firing power plants often do not use peat as a main fuel as clearly as coal power plants do. Co-firing with other biomass – typically forest-based – fuels is quite common. The same applies for district heating networks.

This more ramified value chain implies that the variations in one activity are not totally translated up/down-stream.

2.2.1 Operating fuel peat extraction sites in the EU-27

The most recent fuel peat mining production in the scope countries is outlined in Figure 18. The main producers show a significant reduction in production over the last two years (-44 % and -55 % for Finland and Ireland, respectively), while the other countries maintain a more stable trend. The total 2019 registered production of fuel peat in the scope countries was 4 928 kt. The two largest peat-producing countries are Finland and Ireland, with an annual production in 2019 of 3 268 kt and 1 092 kt, respectively. Sweden comes next with almost 344 kt, followed closely by Estonia with nearly 335 kt. Peat production in Latvia (~10 kt) and Lithuania (24 kt) is marginal compared to the other countries.

Figure 20. Peat production for energy use by country in 2018 and 2019 (kt)



Source: JRC, 2020.

2.2.1.1 Peat production at NUTS 2 level

During the period 2013-2019, 28 companies extracted fuel peat in Estonia. In 2018, production reached 415 kt. Most of these companies have mining permits for several deposit areas and therefore operate extraction units in different locations. The companies with a majority in peat production are located in Parnu (158 kt) and Tartu (70 kt) counties.

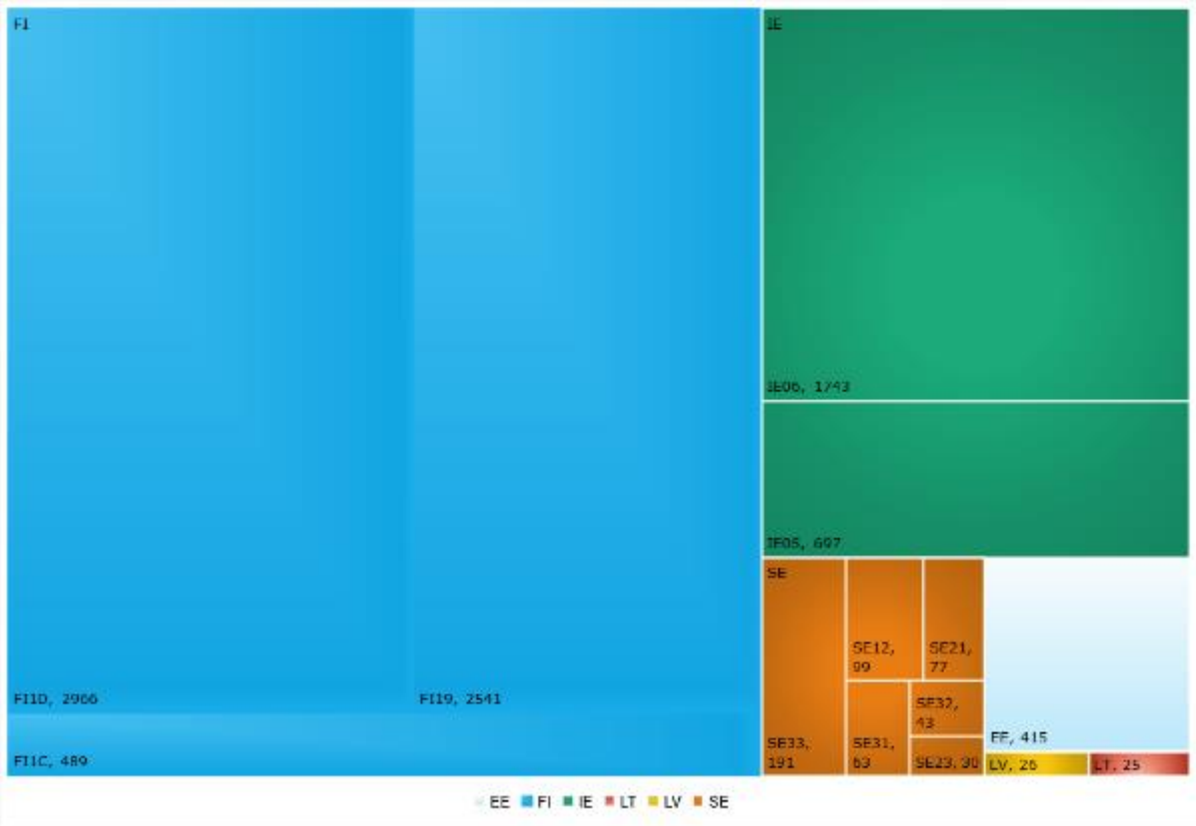
In Finland, the three NUTS 2 regions most prominently producing fuel peat are Pohjois-ja Itä-Suomi (FI1D, 2 754 kt), Länsi-Suomi (FI19, 2 779 kt) and Etelä-Suomi (FI1C, 464 kt). However, most of these sites are expected to close down by 2033.

In Ireland, peatlands cover 16.2 % of the landmass. Bord na Móna currently owns or controls approximately 7 %, or about 80 000 hectares, of the country's peatlands, spread throughout twelve counties in approximately 130 bogs. These lands are located mainly in Eastern and Midlands (IE06).

In Lithuania, the majority of peat production (~14 kt) takes place in the Vidurio ir vakarų Lietuvos regionas (LT02) and in Latvia, in the county of Livanu (7.67 kt).

Sweden is one of the most peat-rich countries in the world, with peatlands making up 15 % of its land area. Peat accounts for a very small part of Sweden's total energy production and is used as a fuel at district heating plants, usually together with various types of biofuels (Swedish Geological Survey, 2020). Peat production in Sweden was nearly 228 kt in 2019. The region with the highest production is Övre Norrland (SE33, 86 kt), followed by Östra Mellansverige (SE12, 45 kt), Småland med öarna (SE21, 35 kt) and Norra Mellansverige (SE31, 29 kt), with lesser production in other regions. Figure 21 shows the relative weight of the peat production areas in regions with peat production for energy use.

Figure 21. Peat production (kt) by NUTS 2 region (2018)



Source: JRC, 2020.

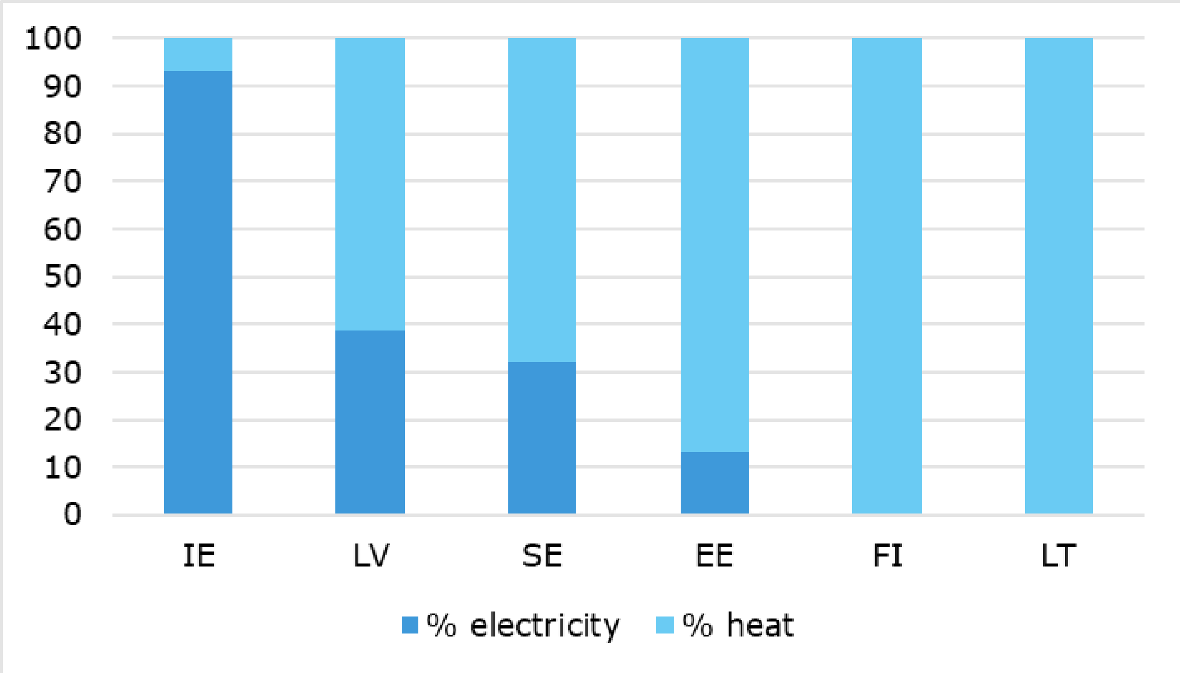
2.2.2 Transformation and peat energy end use

The fuel peat transformation and end-use sectors are less defined and structured when compared with the coal mines and their corresponding power plants.

Figure 20 shows the relevance of peat in national gross available energy. While the contribution of fuel peat is not depicted as critical at national level, nationwide figures do not convey local restrictions that should be considered. At local level, energy transport infrastructure and alternative supply options and available resources define the relevance of the peat supply.

Figure 20 shows the diverse national profiles for fuel peat end use. Ireland is clearly the biggest electricity producer, while electricity production is a minor path for the other scope countries. Across all scope countries, transformation and end use technologies are more distributed, in small (100 MW scale) cogeneration plants, industrial cogeneration facilities, district heating networks and more localised small-scale heat supply facilities. The smallest scale facilities are sparse and corresponding data is only partially available and not extensive.

Figure 22. Share of electrical and thermal end uses for fuel peat 2018



Source: JRC, 2020.

We have identified 208 peat-fired power plants[24] in the six countries of focus, totalling 102 000 TJ of electricity and heat generation. This is slightly more than 4 % of the total heat and electricity produced in these countries. Data are not available for Sweden and Finland but for Estonia, Ireland, Latvia and Lithuania, the majority of the plants are fairly new built with an average age of 12, 17, 5 and 11 years, respectively.

Finland is the country with the highest share of heat production from peat: nearly 25 % of the heat produced at a national level. According to the latest studies and surveys, some 800 000 people – 15 % of the population – live within district heating networks heated with peat & wood fuels.[25] This number has been reported to be even higher in the literature, nearing 1 000 000 (Child & Breyeer, 2016). The regions with the highest volume of energy plants using fuel peat are Länsi-Suomi (FI19) and Pohjois- ja Itä-Suomi (FI1D).

When it comes to electricity production, Ireland is the country with the highest share so far, as nearly 6 % of the electricity produced in Ireland has been from peat co-firing plants in the Eastern and Midland region (IE06). Peat use in electricity generation in Ireland fell by 3.3 % (from 712 TJ to 19 762 TJ) in 2018 and accounted for 10.3 % of the fuel mix.

2.2.3 Direct fuel peat employment

Assessing the employment related to fuel peat use can be challenging due to the diffuse nature of its value chain. For the production/mining sector, we have assigned which employment fraction corresponds to energy use, and which to agricultural uses following their corresponding registered demands. Furthermore, employment related to the mining of fuel peat may disappear or become related to agriculture if the type of demand for peat changes. In the transformation/end use sector, criteria based on fuel type and

[24] In Finland, there are also 139 smaller boiler units.
[25] Based on expert data.

sectorial employment intensity have to be applied to establish how much employment may be related to the use of fuel peat. Similarly, employment associated with operating a district heating network fuelled with peat may become biomass-related if the fuel use changes.

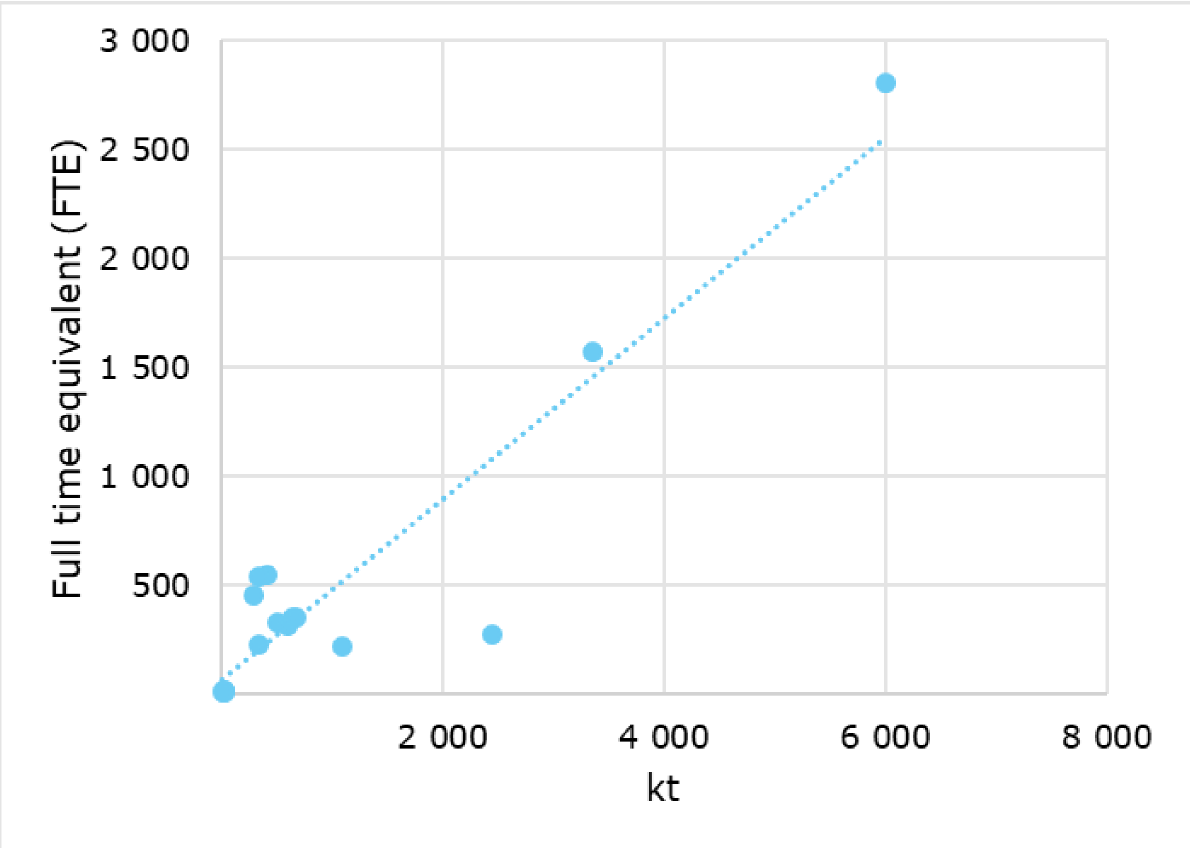
Furthermore, employment related to the mining of fuel peat may disappear or become related to agriculture if the type of demand for peat changes. In the same way, employment associated with operating a district heating network fuelled with peat may become biomass-related if the fuel use changes.

2.2.3.1 Direct jobs in peat extraction

As peat is harvested in a rather superficial, open surface configuration of mining, there are no depth of mining considerations affecting the profile of activities and the corresponding employment intensity.

As with coal mines, we have evaluated the productivity of peat extraction sites, i.e. the ratio of production by the number of employees. The simplicity of exploitation activities results in a very strong correlation between employment and the corresponding production, as shown in Figure 23. Figure 23 shows the national registered employment at national level for the different countries. The marks highlight the available national data points within the 2017-2019 period.

Figure 23. Correlation between national fuel peat production and related employment[26]



Source: JRC, 2020.

[26] For Finland and Sweden, the direct jobs associated with peat production were estimated in-house. All the direct jobs (either provided by experts or estimated in-house) analysed correspond to fuel peat activities.

The employment estimations presented in this section are derived from the sectorial characterisation of each country, as provided by the NEP, and corrected for fuel peat use and updated following registered production where needed.

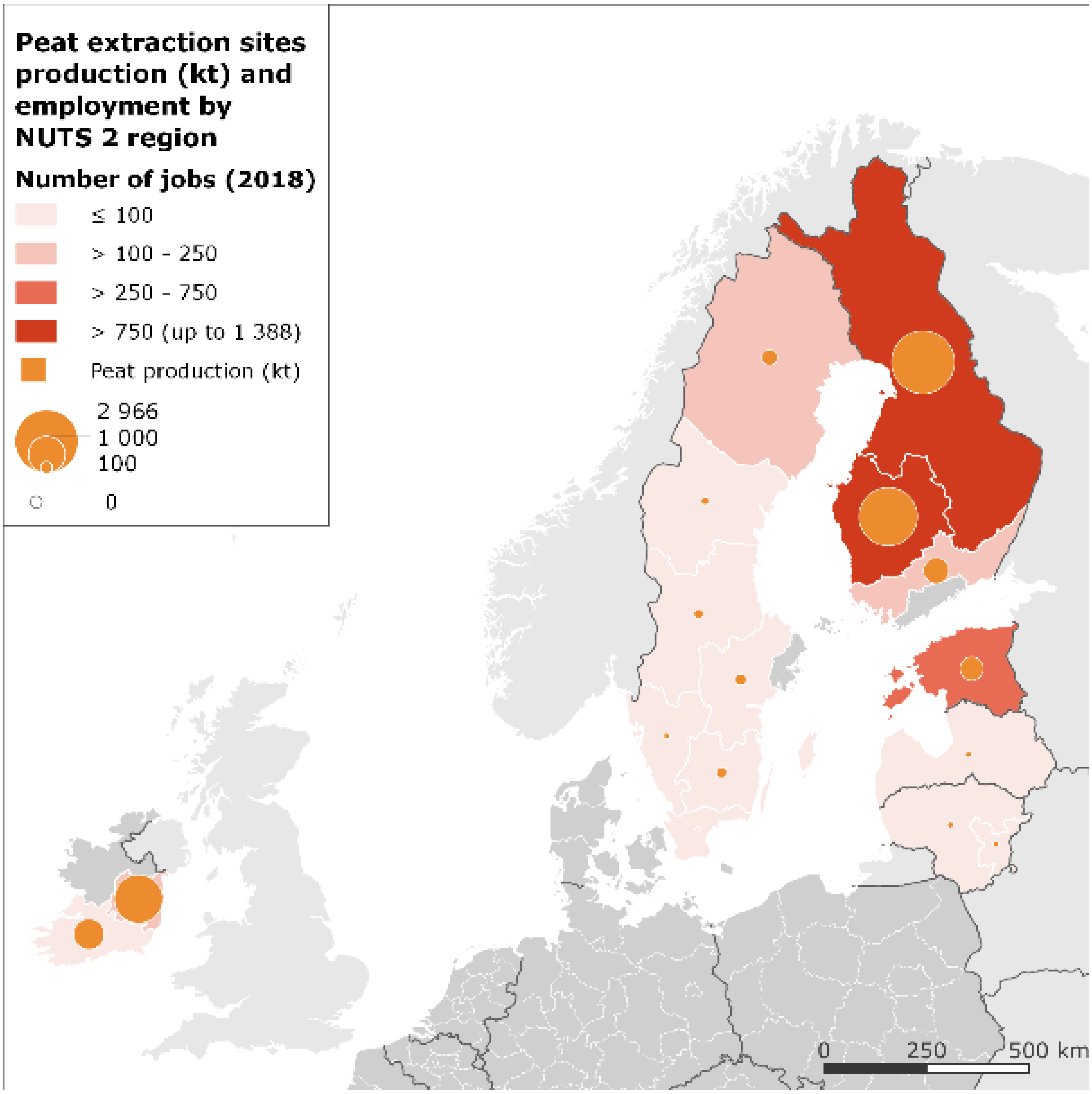
As shown in Figure 23, and reflecting the national relevance of fuel peat use, Finland, which currently has more than 600 registered sites for peat extraction, enjoys the biggest concentration of fuel peat-related employment. Pohjois-ja Itä-Suomi (FI1D) registers almost 1 400 full-time equivalents (FTE), Länsi-Suomi (FI19) almost 1 200 FTE and Etelä-Suomi (FI1C) close to 230 FTE. Estonian extraction activity is performed by 26 registered companies, which hosts almost 550 FTE. In Ireland, we estimate 220 FTE in Eastern and Midland and 80 FTE in Southern Ireland. Bord na Móna is the only moss peat company in Ireland, which holds a licence to mine fuel peat. The rest of the NUTS 2 areas show figures close to or below 50 FTE. **Error! Reference source not found.** s hows the total national figures for all the scope countries. Annex K provides the relevant information at NUTS 2 level. Lithuania and Latvia, as depicted in Figure 17, have relevant peat sectors, mostly devoted to agricultural supplies. Lithuania has 8 active peat extraction sites, partially devoted to energy uses. This requires an annual workforce of around 19 FTE. Latvia conducted a significant restructuring of the peat sector in the early 1990s, reducing their production to 30 %. There are 4 remaining sites with partial peat fuel production which require around 13 FTE.

Table 4. 2018 Fuel peat mining national direct employment

Country (NUTS 0)	Fuel peat extraction FTE
EE	552
FI	2 806
IE	280
LT	19
LV	13
SE	329

Source: JRC, 2020.

Figure 24. NUTS 2 distribution of fuel peat production and corresponding employment



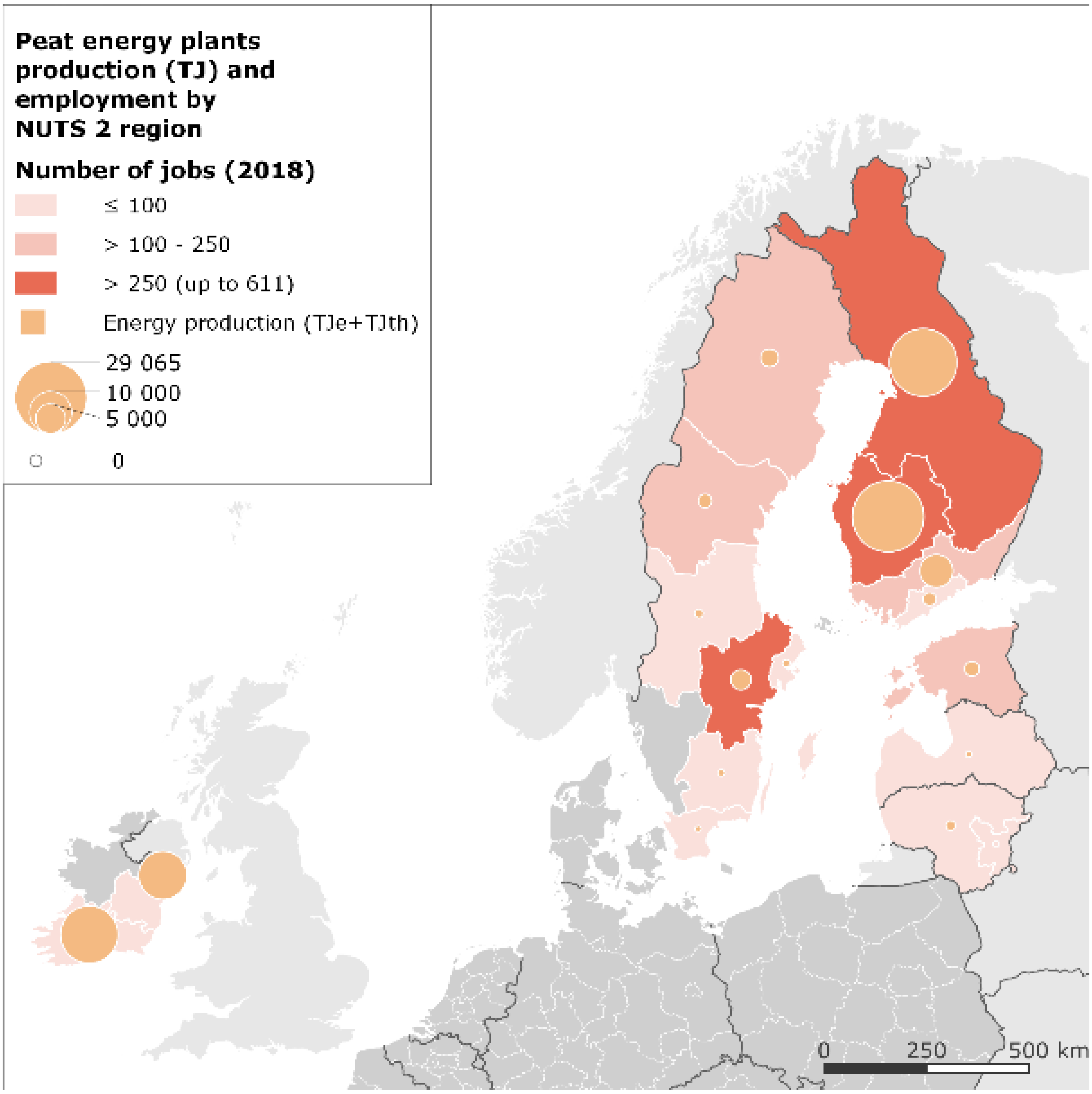
Source: JRC, 2020.

2.2.3.2 *Direct jobs in peat end use sector*

The transformation and end use sector fuelled with peat is far from homogenous regarding end use commodity (heat or power), technologies (from industrial cogeneration to district boilers) and concentration (from big power plants to local community district heating networks and briquette burners). It is therefore very difficult to observe any pattern across the countries within scope.

Figure 25 shows the distribution of peat-derived energy end use and associated employment. As peat is a low heating value fuel, it is typically consumed close to production sites. The end use and employment map is therefore quite analogous to the production depicted in Figure 25.

Figure 25. NUTS 2 distribution of fuel peat end use and related employment



Source: JRC, 2020.

In correspondence with its recorded production, Finland tops the table in peat-related energy consumption and employment. According to information from the NEP and as shown in Figure 22, peat in Finland is mostly used as a thermal fuel in district heating networks. The NEP does not provide employment data regarding these sectors. Assuming an employment intensity analogous to the Danish district heating network, it can be estimated that there are nearly 1 300 jobs in Finnish district heating networks currently partially fuelled with peat. Swedish regions show a more diverse electric/thermal fuel peat consumption pattern. Peat use and employment levels from quality-audited networks have been used to assess related employment. For electricity-related jobs, we assumed that power production in Finland requires the same employment intensity as plants of a similar scale in Ireland. That results in a total of 709 jobs a year, distributed across the regions following the registered consumption. In Estonia, 230 FTE are employed in the power sector. Registered employment in the 13 peat co-firing power plants has been weighted with the corresponding peat use. Ireland's end use sector is more accurately documented, as there are 3 mid-scale (more than 100 MW) power plants co-firing peat, with employment levels clearly registered by the NEP. Peat-derived production requires 46 FTE in these plants. Latvia and Lithuania show very similar figures (18 and 13 FTE, respectively) related to their registered peat use for energy supply. Latvia has 12 registered thermal supply plants and Lithuania has 8 companies co-firing peat in different shares.

Table 5. 2018 Fuel peat end use national direct employment

Country (NUTS 0)	Fuel peat end use FTE
EE	230
FI	1 300[27]
IE	46
LT	18
LV	13
SE	709

Source: JRC, 2020.

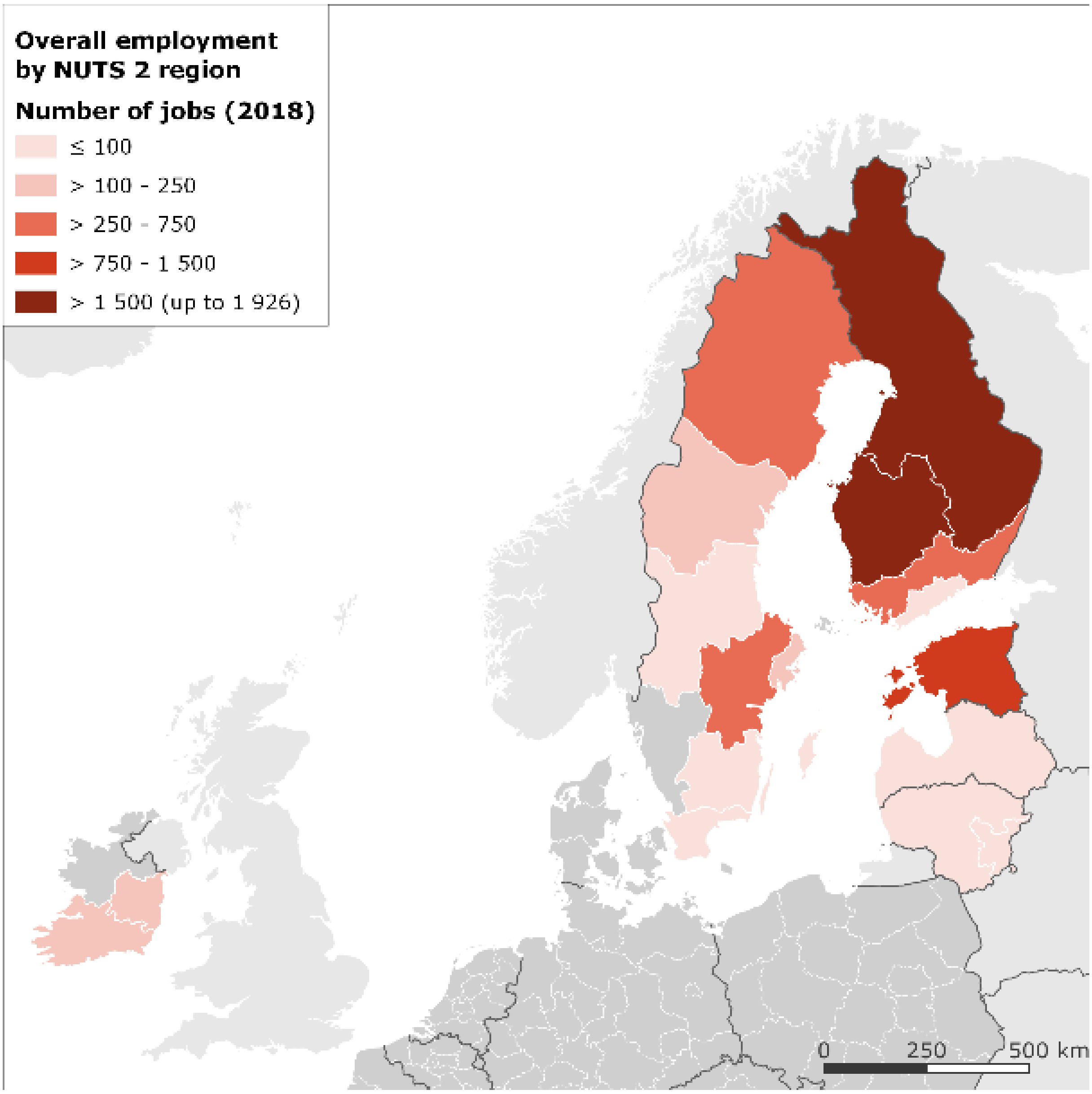
2.2.4 Overall assessment of current direct employment

Compared with coal or other fossil fuels, peat has a lower heating value. As a result, its use tends to be quite local to its mining location. Therefore, employment related to mining and end use is concentrated in the same or nearby regions. Figure 24 shows the regional overlap of both mining and end use-related employment.

Finnish regions show the highest peat-related total employment with 1 926 and 1 800 jobs for Pohjois-ja Itä-Suomi and Länsi-Suomi, with 358 jobs and 21 jobs for Etelä-Suomi and Helsinki-Uusimaa. In line with the degree of fuel flexibility of the power plants, the employment currently associated with peat use could become associated with biomass instead, if the fuel mix were altered. Estonia is the next highest employer, with around 781 FTE, while Sweden ranges more widely, from 325 FTE in Övre Norrland, down to 92 in Norra Mellansverige. Ireland ranges from 209 in Eastern and Midland to 107 in Southern Ireland. For Lithuania and Latvia, we estimate 32 and 26 jobs respectively, as the highest regional peat-related employment.

[27] Extrapolated from Danish employment estimated by EuroHeat.

Figure 26. NUTS 2 Estimated employment related to the energy use of peat



Source: JRC, 2020.

While employment related to peat energy use is far from comparable to that of coal, some regional and local communities might need support to ensure a fair and organised transition to a carbon-free energy supply.

2.3 Oil shale

Oil shale is a rock that contains significant amounts of organic material in the form of kerogen. Up to one third of the rock can be solid organic material. Liquid and gaseous hydrocarbons can be extracted from the oil shale, but the rock must be heated and/or treated with solvents. This is usually much less efficient than drilling rocks that will yield oil or gas directly into a well. The processes used for hydrocarbon extraction also produce emissions and waste products that cause significant environmental concerns.

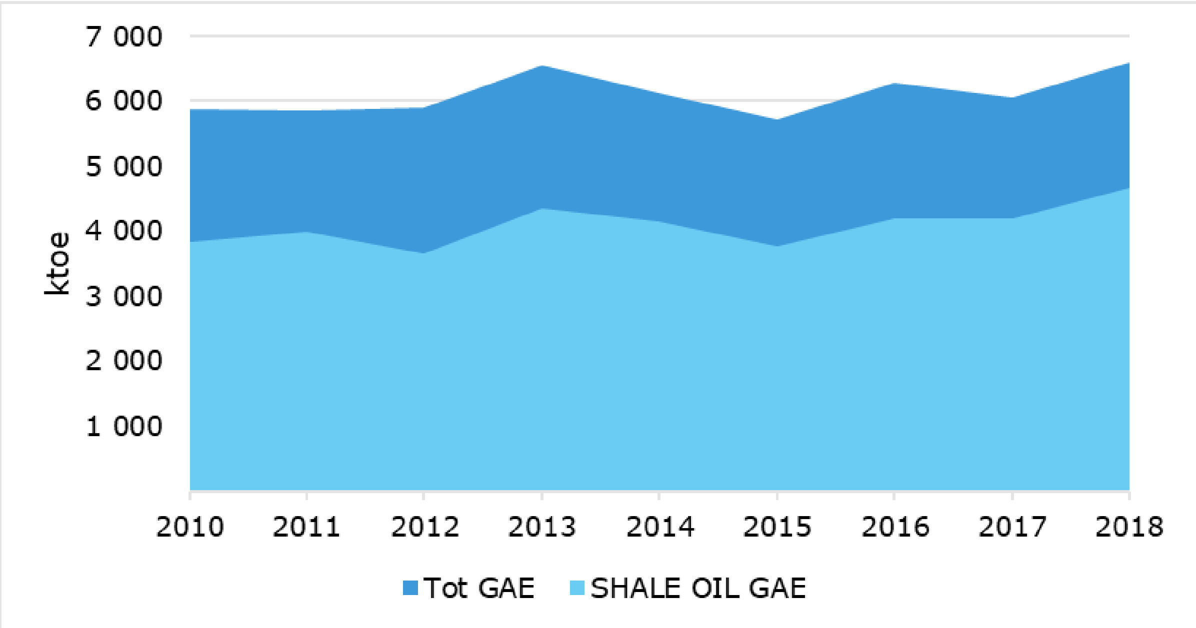
Oil shale usually meets the definition of "shale" in that it is "a laminated rock consisting of at least 67 % clay minerals," however it sometimes contains enough organic material and carbonate minerals that clay minerals account for less than 67 % of the rock (Dyni, 2005).

According to the European Academy's Science Advisory Council (EASAC, 2007), about two-thirds of European oil shale resources are located in Russia. Within the EU, oil shales are found in 14 Member States. While some areas of the EU (for example France) have had long experience of exploiting oil shales in earlier periods of their history, today only Estonia is actively engaged in exploitation on a significant scale.

Both oil shale and peat are among the most important mineral resources in Estonia. Oil shale reserves are located in the north-east part of country (mainly in Ida-Viru county).

Figure 27 shows the registered evolution of total shale gross available energy for Estonia. Shale oil consistently provides more than 60 % of the country's gross available energy, peaking at 71 % by 2018.[28] This weight in the energy mix makes Estonia the third highest EU contributor to CO_2 emissions per capita.

Figure 27. Total shale oil-supplied gross available energy (GAE) for Estonia



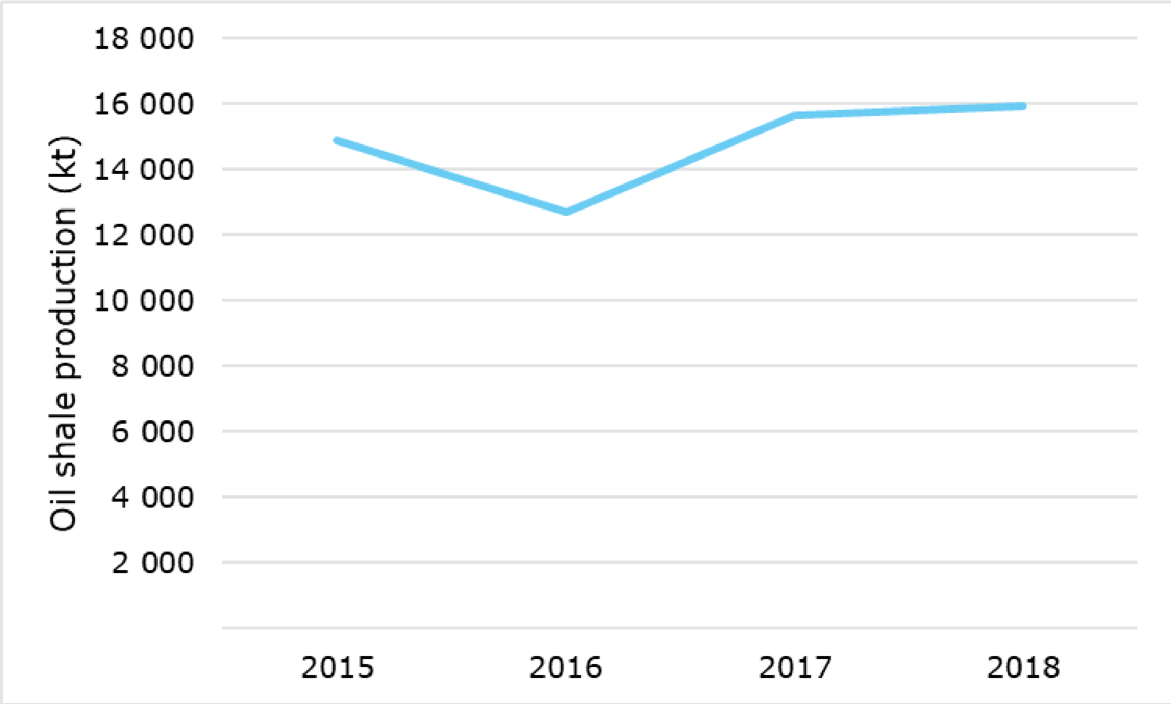
Source: JRC, 2020.

2.3.1 Operating oil shale extraction sites and power plants in the EU

In Estonia, oil shale is mined primarily in Ida-Viru county. In 2018, 15 945 kt of oil shale was extracted (Figure 28). On the basis of its proportion of Gross Available Energy, shale production has remained stable across the last decade.

[28] 2019 and 2020 data may vary greatly from 2018, but at the time of conducting the analysis no official data were available for these years.

Figure 28. Oil shale production by year in Estonia

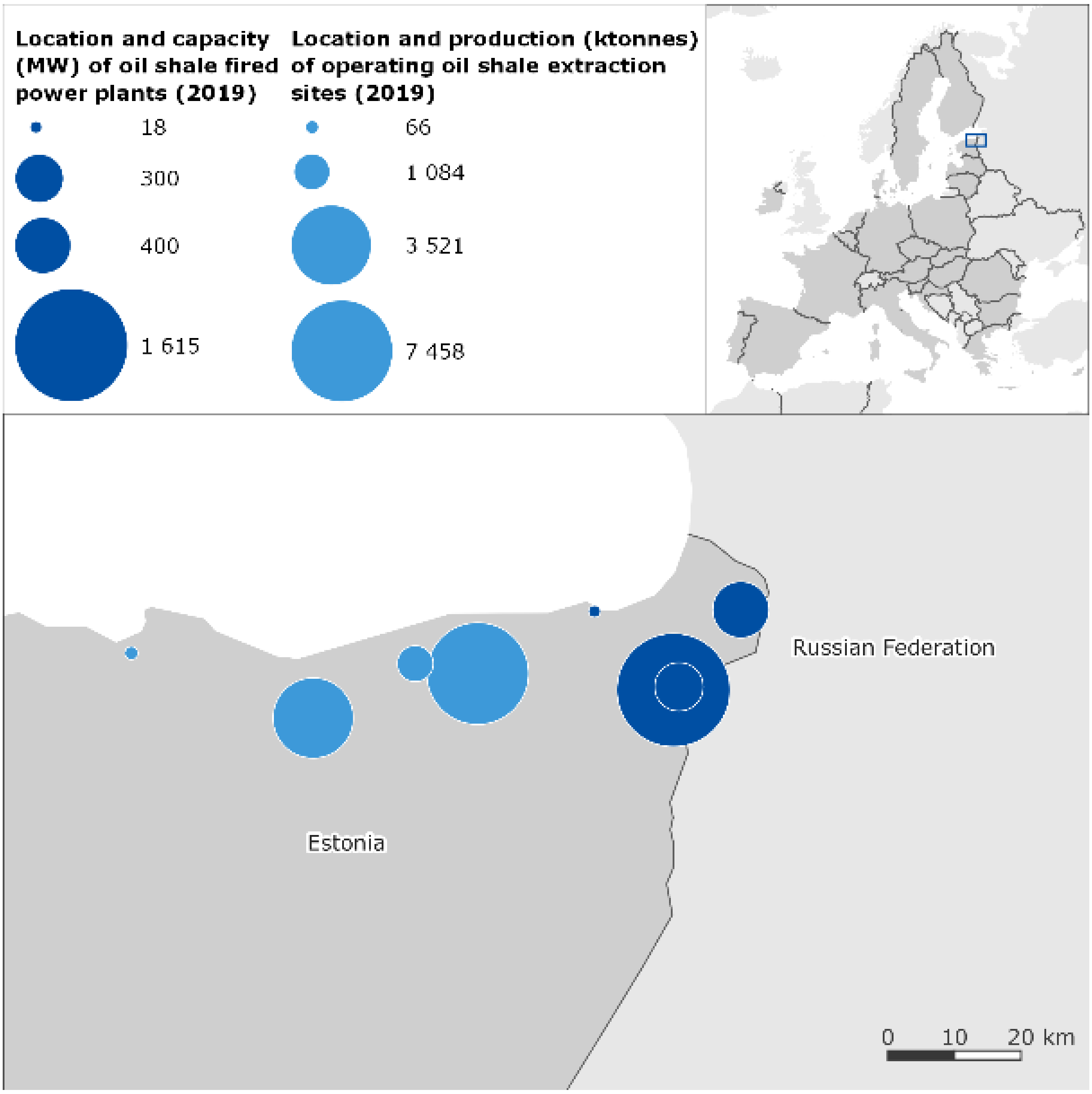


Source: JRC, 2020.

Oil shale mining areas and operating oil shale extraction sites are concentrated in the north east part of the country (Figure 29).

In 2019, six plants using oil shale were identified in Estonia, with four of them in Ida-Viru county. Their capacities range from 18 to 1 615 MWe and their efficiency starts at 35 %. Two industrial plants, Kiviõli Keemiatööstuse OÜ (chemicals) and Kunda Nordic Tsement AS (cement) were also identified.

Figure 29. Location[29] of oil shale extraction sites and oil shale-fired power plants with information on capacity



Source: JRC, 2020.

2.3.2 Direct employment in oil shale-fired power plants and sites

Most oil shale companies are quite large enterprise groups, owning and operating many power/boiler plants, including many that do not use peat or oil shale. In 2018, the total number of direct jobs in oil shale extraction was 3 375. 1 868 jobs were registered in oil shale plants. In 2019, the number of jobs in extraction decreased to 2 918, with the majority of the jobs (2 743) in the county of Ida-Viru and some 175 jobs in the county of Lääne-Viru. For the same year, employment in shale oil-related plants was more stable, at an unchanged 1 821 jobs.

[29] Locations are approximate and may refer to companies.

Estonia's labour force consists of 984 000 people (EURES, 2020), which means that one in every 250 employees is employed within the oil shale sector.

Jobs in the oil shale sector[30] in Estonia are presented in Table 6.

Table 6. Direct jobs and evolution per Estonian county in the oil shale sector

Year / County	2018		2019	
	Extraction	**Energy plants**	**Extraction**	**Energy plants**
Ida-Viru	2 840	1 679	2 743	1 646
Lääne-Viru	535	189	175	175
TOTAL	3 375	1 868	2 918	1 821

Source: JRC, 2020.

2.4 Indirect jobs in coal, peat and oil shale-related activities

Information on indirect jobs related to coal, peat and shale oil activities across all the EU-27 regions (NUTS 2 level) is not readily available. However, the input-output (IO) modelling approach allows us to assess cross-sectorial employment multipliers to estimate indirect jobs (Hewings, 1985). This is done by assuming that the levels of employment in an economic sector are closely related to its output in such a way that the employment/output ratio can be defined for all output levels.

The IO modelling system is very useful whenever the objective is to evaluate both the direct impacts of a change in the final demand of one sector and the indirect effects generated by the inter-industry linkages along the supply chains[31].

In this analysis, the IO multipliers are derived in relation to changes in employment instead of final demand, meaning that indirect jobs can be calculated using direct jobs (see Annex F for a brief description of the methodology).

Moreover, we use a system of multi-regional IO tables for the EU-27 interlinked with trade in goods and services within the same country as well as with regions in other Member States.[32] Trade links between regions, besides extending the supply-chain coverage to all sectors that might be impacted by changes in mining and power plant activities, allow us to assess indirect jobs at intra-regional level and to consider spill-over effects at inter-regional level.

Indirect jobs in coal-related activities

The number of indirect employees and a comparison between direct jobs in coal-related activities and indirect jobs is provided in the Table 7 for the EU countries involved in the analysis. The complete results at NUTS 2 level are reported in Annex F.

Looking at the ratio between indirect and direct jobs, the coefficients range noticeably between different Member States. Our results suggest that for every direct job, the associated indirect jobs could be in the range of less than 1 up to 2.45. Direct jobs are related to the specific industry and indirect jobs are those that support that sector. As such, this ratio provides a preliminary view of the integration of the region, both in the intra- and the inter-region supply chain. A ratio higher than one means that a region's industry sustains more indirect jobs than direct. The top three countries where the

[30] Includes oil shale extraction activities and oil shale energy plants including industrial facilities.

[31] Some examples of policy analysis based on the IO methodology are provided in (Thissen et al., 2019).

[32] This database has been developed jointly by the JRC and the PBL institution in the Netherlands. For a detailed description of the methodology used, see (Thissen et al., 2019).

proportion of direct jobs is higher are Poland, Bulgaria, and Slovenia, while indirect jobs account for a higher proportion in Austria, Netherlands, Italy and Germany. Overall, the activities along the supply chain provide around 131 000 indirect jobs in the EU, with an indirect jobs/direct jobs ratio of 0.64 (direct jobs total around 208 000).

Table 7. 2018 number of indirect jobs in coal-related activities at intra- and inter-regional level and indirect jobs/direct jobs ratio

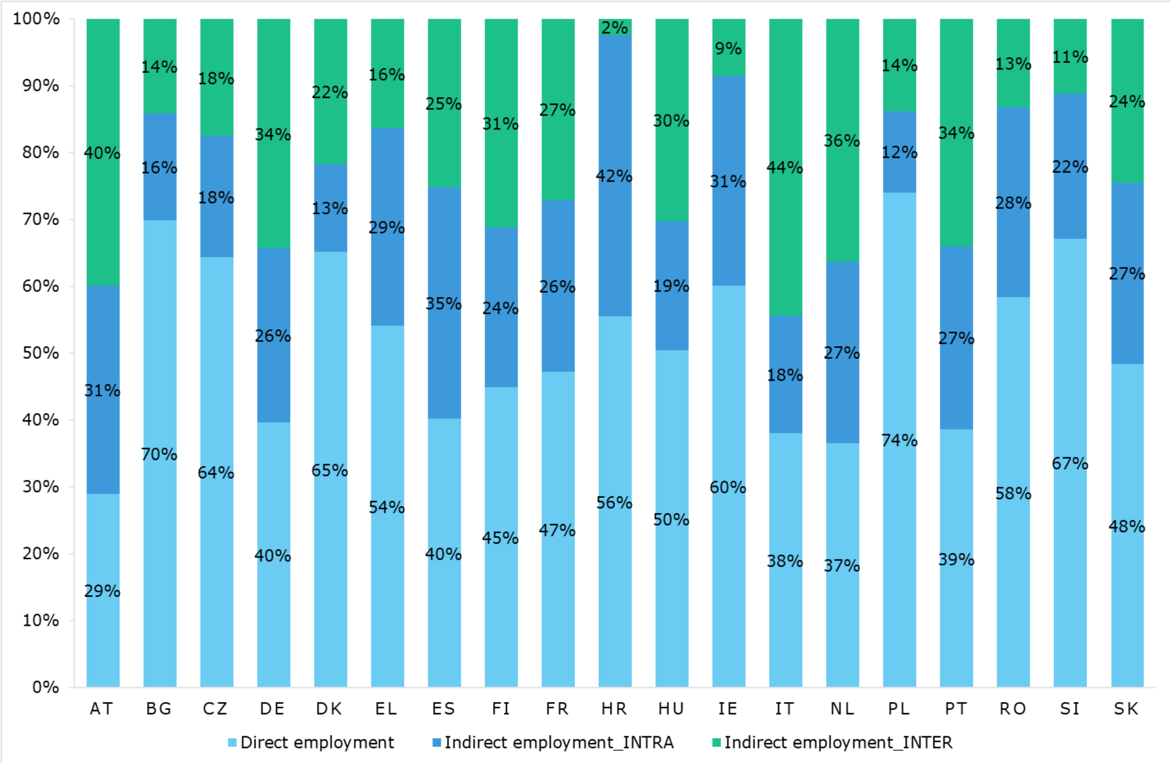
Country	**Intra-regional**	**Inter-regional**	**Total**	**Indirect jobs/Direct jobs (Ratio)**
Austria	346	443	789	*2.45*
Bulgaria	2 964	2 620	5 584	*0.43*
Czechia	5 025	4 852	9 878	*0.55*
Germany	17 224	22 703	39 927	*1.52*
Denmark	143	237	380	*0.53*
Greece	3 094	1 716	4 810	*0.85*
Spain	3 876	2 825	6 700	*1.49*
Finland	582	760	1 342	*1.23*
France	310	326	635	*1.12*
Croatia	119	7	126	*0.80*
Hungary	844	1 325	2 169	*0.98*
Ireland	179	49	227	*0.66*
Italy	963	2 421	3 384	*1.63*
Netherlands	599	804	1 403	*1.73*
Poland	17 620	19 942	37 561	*0.35*
Portugal	458	567	1 024	*1.59*
Romania	8 085	3 779	11 864	*0.71*
Slovenia	582	298	880	*0.49*
Slovakia	1 113	998	2 111	*1.07*
TOTAL	**64 123**	**66 670**	**130 793**	**0.64**

Source: JRC, 2020.

Figure 30, where the contribution of direct and indirect (intra and inter) jobs in coal-related activities is shown, highlights the importance of considering trade spill-over effects.

Given the picture of the economy implemented in the IO, our estimates indicate that the largest number of persons employed in activities indirectly related to coal is in Germany (almost 40 000). However, only 26 % of them work in the supply chain of national coal mines and power plants, while the remaining jobs (34 %) are generated from coal-related activities in the rest of the EU. Conversely, in Romania, the country with the third largest workforce indirectly related to coal (almost 12 000), 28 % of these jobs are generated from activities within the country while the 13 % come from trade links, reflecting a productive structure less open to trade than the German one.

Figure 30. Contribution (%) of direct and indirect (intra and inter) jobs in coal-related activities



Source: JRC, 2020.

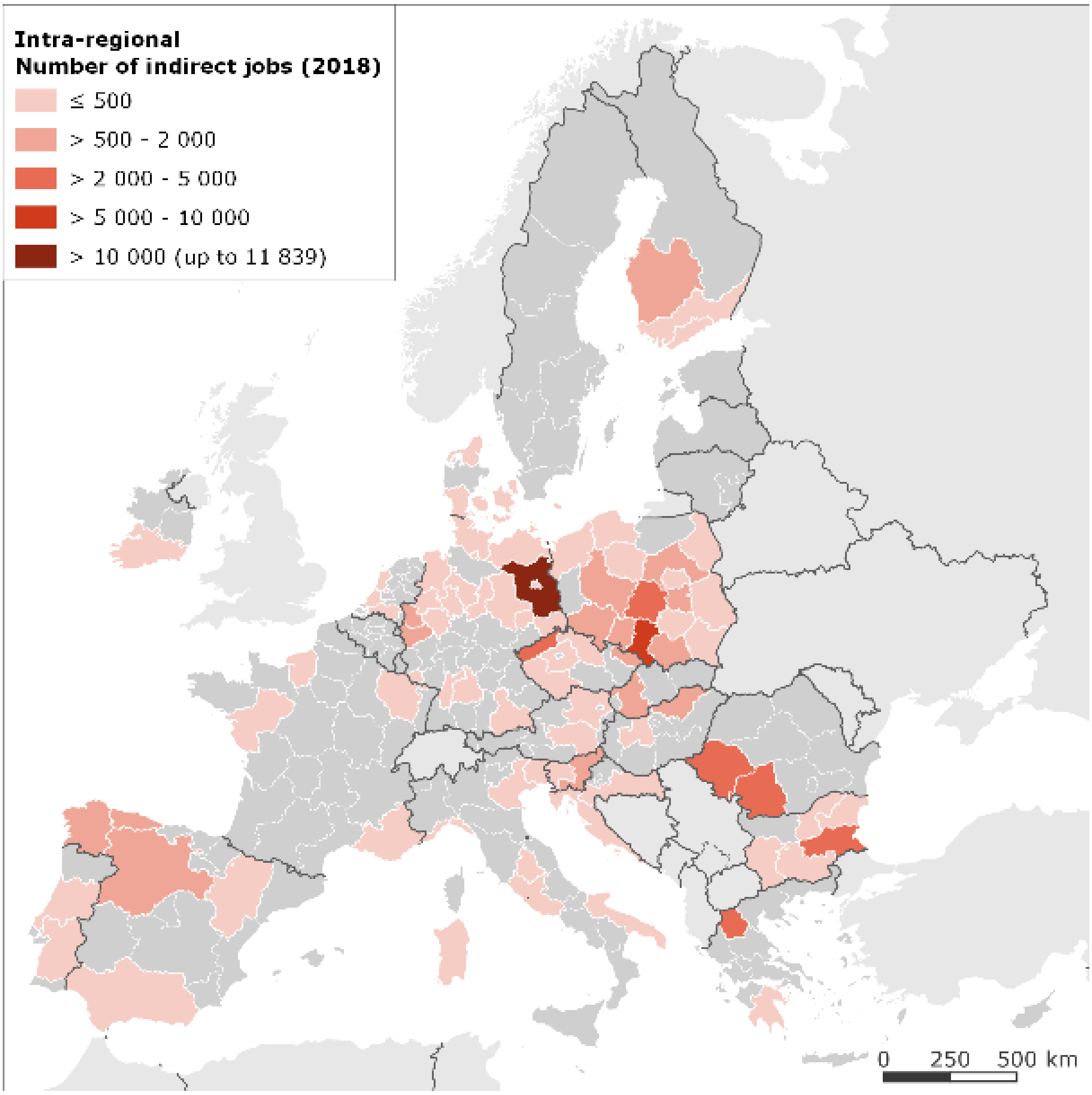
However, country-level results mask a noteworthy within-country regional heterogeneity, where the size and the distribution of indirect jobs in intra-regional supply chains in the NUTS 2 regions of the EU are reported.

The five regions with the largest intra-regional indirect jobs (Figure 31) belong to Germany, Poland and Romania, with almost 31 000 indirect jobs accounting for 50 % of all domestic indirect jobs in the EU. More precisely, Brandenburg (DE40) hosts around 12 000 indirect jobs, followed by Śląskie (PL22) with more than 7 500 jobs. The regions of Sud-Vest Oltenia (RO41), Vest (RO42) and Łódzkie (PL71) range between 5 000 and 3 000 indirect jobs.

The distribution of indirect jobs in the inter-regional supply chains (Figure 32) shows that the five regions with the highest inter-regional indirect jobs (Annex F) account for 48 %

(around 32 000 indirect jobs) of all EU inter-regional indirect jobs. The same regions in Germany and Poland, Brandenburg (DE40)[33] and Śląskie region (PL22),) have inter-regional supply chains with the higher number of employees (above 6 000 people) followed by the Łódzkie (PL71) region with almost 4 000 jobs and two regions of Czechia and Bulgaria, the Severozápad (CZ04) region and Yugoiztochen (BG34) with more than 2 000 indirect jobs each.

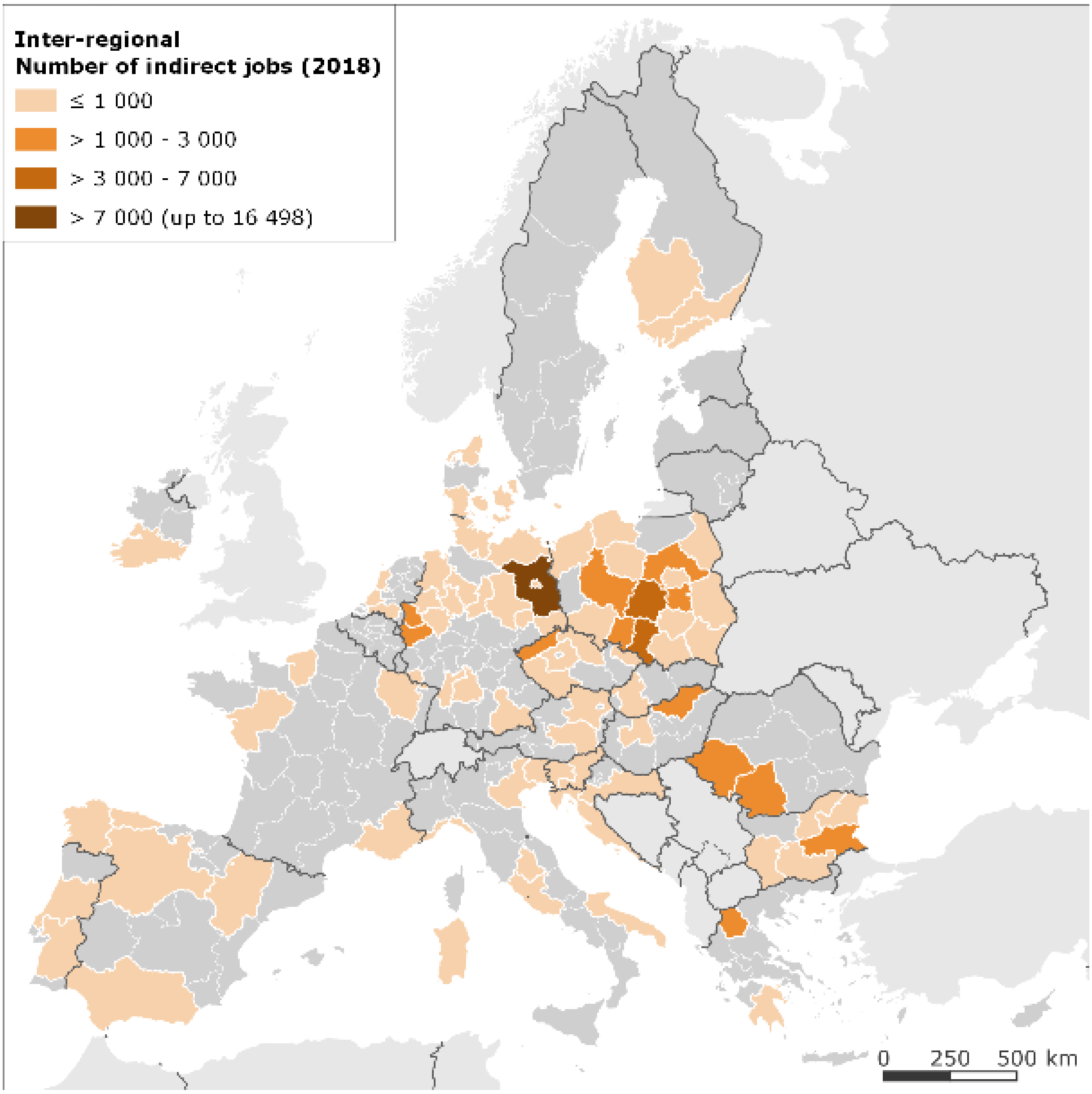
Figure 31. Distribution of indirect jobs in intra-regional supply chains (2018)



Source: JRC, 2020.

[33] Note that the DE40 region provides around 70 % of both intra- and inter-regional indirect jobs in Germany (See Annex F). Despite proximity to the capital region (Berlin), potentially reflecting a very strong supply chain integration between these two regions, our results are higher than the most recent calculations (2018) of Rhineland-Westphalia Institute for Economic Research (RWI). Available at: http://www.rwi-essen.de/media/content/pages/publikationen/rwi-materialien/rwi-materialien_126.pdf

Figure 32. Distribution of indirect jobs in inter-regional supply chains (2018)



Source: JRC, 2020.

Changes in coal-related indirect jobs estimation

When comparing the results between our analysis in the 2018 report (Alves Dias, P., et al, 2018) and the current one, we observe a 37 % decrease in the 2020 indirect jobs estimates.[34] This difference can be explained by looking at the geographical coverage, the new 2020 direct jobs estimates and at the system of IO tables used.

In the previous report we included the United Kingdom (EU-28) which led to higher estimates because of the inter-regional links (trade effect) along the supply chain between the UK and the EU-27. Moreover, the 2020 direct jobs estimates for the EU-27 are 12.5 % lower than those provided for the 2018 report (~231 000, UK excluded) as

[34] Refers to EU 27. In the previous report we included the United Kingdom (EU-28) which, with more than 6 000 direct jobs, accounted for almost 6 300 indirect jobs (3 % of total reported indirect jobs for 2018).

the number of direct jobs is currently estimated to be lower (see Chapter 3). Turning to the IO data used, since the previous report we have been working to improve our regional IO tables and trade links (more info in Annex E). The revision of the data led to different employment multipliers and different results.

Indirect jobs in peat and oil shale-related activities

As a result of the IO-based assessment introduced at the beginning of this section, the indirect jobs and the ratio between indirect and direct jobs in peat-related activities are shown in Table 8[35].

Looking at the ratio between indirect and direct jobs, our estimates indicate that for every direct job in peat-related activities, the associated indirect jobs could be between 0.21 (Etelä-Suomi, FI1C) and 2.06 (Länsi-Suomi, FI19). As with coal, a ratio higher than one means that a region's industry sustains more indirect jobs than direct. Overall, the activities along the supply chain provide around 6 000 indirect jobs in the EU, with an indirect jobs/direct jobs ratio of 0.94 (direct jobs are around 6 300).

Table 8 shows that the five regions with the highest intra-regional indirect jobs are Länsi-Suomi (FI19), Eesti (EE00), Pohjois- ja Itä-Suomi (FI1D), Östra Mellansverige (SE12) and Övre Norrland (SE33), with a total of 2 650 indirect jobs. These account for 87 % of all domestic peat-related indirect jobs. West Finland (FL19) alone accounts for more than 1 500 indirect jobs, while the other four are all below 500 jobs. The same regions, in the inter-regional supply chains, have a share of 91 % of all inter-regional jobs. Even in this case, the region with the highest number of inter-regional indirect jobs is Länsi-Suomi (FL19).

Table 8. 2018 number of indirect jobs[36] in peat-related activities at intra- and inter-regional level and indirect jobs/direct jobs ratio

Country	**Intra-regional**	**Inter-regional**	**Total**	**Indirect jobs/Direct jobs (Ratio)**
Peat				
Estonia	471	97	568	*0.73*
Finland	1 874	2 248	4 123	*0.67*
Ireland	114	56	170	0.53
Lithuania	29	4	34	0.66
Latvia	29	3	32	*1.25*
Sweden	536	446	982	*0.95*
Total	3 053	2 854	5 909	*0.80*

[35] Results are reported directly at regional level given the limited number of countries/regions included in the analysis.

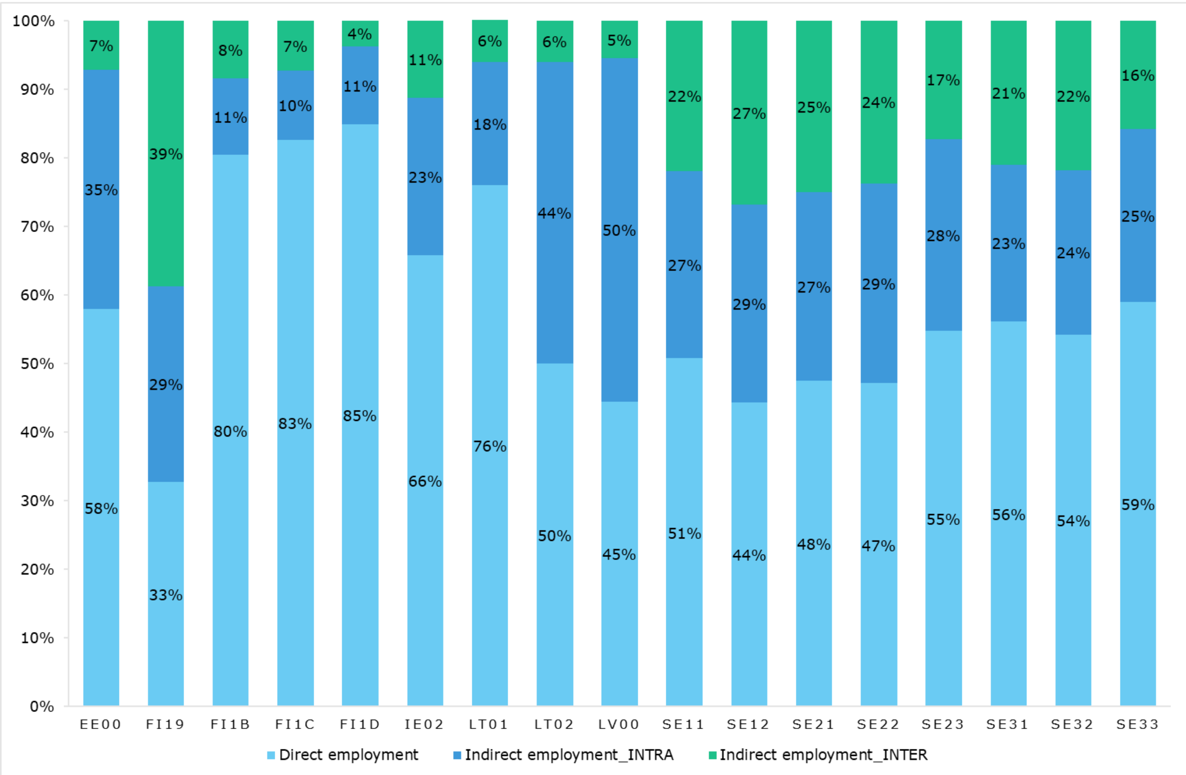
[36] As the IO method accounts for economic/labour interactions at sectorial level, very local and low figures (below 50 jobs) have to be taken into account as analytical figures.

Oil shale				
Estonia	2 400	510	2 910	*0.66*

Source: JRC, 2020.

The contribution of direct and indirect (intra and inter) jobs in peat-related activities is depicted in Figure 33. Interestingly, three out of four Finnish regions (Etelä-Suomi, FI1C, Pohjois- ja Itä-Suomi, FI1D and Helsinki-Uusimaa, FL1B), with a share above 80 %, show the highest direct job contribution to the total (direct plus indirect) peat-related employment (see also section 2.2.3). Länsi-Suomi (FL19) seems to have a productive structure very open to trade, given the 39 % of indirect jobs generated from peat-related activities along the EU supply chain.

Figure 33. Contribution (%) of direct and indirect (intra and inter) jobs in peat-related activities



Source: JRC, 2020.

Turning to shale oil, Estonia (EE00) is the only Member State with oil shale use. The indirect/direct jobs ratio is 0.66 while indirect jobs total 2 910. Intra-regional jobs make up 83 % of the total (2 400) while inter-regional jobs account for 510.

2.5 Key points

- Coal activities are currently present in 19 Member States and 94 NUTS 2 regions.
- The highest density of European coal-fired power plants lies in an area stretching from the Netherlands, across Germany and Czechia, to Poland; and from Romania, across Bulgaria, to Greece.
- Regions with the highest aggregated coal production, of more than 30 million

tonnes of coal per year, are located in Germany, Poland and Czechia.

- The most productive mines in the EU, exceeding a production of 8 000 tonnes per employee, are located in Germany, Poland and Greece, where surface lignite mines are operated. The least productive regions, with production below 500 tonnes per employee, are located in Spain and Romania.
- Coal activities offer direct employment to around 208 000 people across Europe. 76 % of these jobs are in the mining sector.
- The regions with the highest number of jobs in the coal sector (mines and power plants) are located in Poland, Germany, Czechia, Romania and Bulgaria.
- Peat-fired energy plants are located in Estonia, Finland, Ireland, Latvia, Lithuania and Sweden, primarily for heat production (~76 179 TJ in total). Finland has the highest heat generation from peat (~61 877 TJ).
- In 2019, peat production of nearly 5 million tonnes took place in Estonia, Finland, Ireland, Latvia, Lithuania and Sweden. Finland was the biggest producer with nearly 3.3 million tonnes.
- Peat activities are associated with an estimated direct employment of nearly 6 313 people in the corresponding countries.
- The regions with the highest number of jobs in the peat sector (sites and power plants) are located in Pohjois- ja Itä-Suomi, FI1D (1 240), Länsi-Suomi, FI19 (1 191), Estonia, EE00 (944), and Vidurio ir vakarų Lietuvos regionas, LT02 (503).
- Oil shale activities are identified solely in Estonia.
- Oil shale power plants are located primarily in Ida-Viru county, in the north-east of the country.
- Oil shale production of nearly 12 million tonnes per year takes place in Ida-Viru and Lääne-Viru counties.
- Oil shale activities are associated with the direct employment of slightly fewer than 4 000 people in Estonia, nearly 0.4 % of the working population.
- Ida-Viru is the county where jobs in the oil shale sector (sites and power plants) are primarily located.
- Oil shale-related indirect jobs are estimated at about 2 910 in Estonia.
- The highest share of coal-related indirect jobs is to be found in Germany (~40 000 jobs), while for peat, Finland tops the chart (~4 000 jobs).
- Key figures for the EU (2018):

	Coal	Peat	Oil shale
Mines/extraction sites (production, mil tonnes)	442	9	12
Gross heat and electricity production (GWh)[37]	331 082	15 108	10 010

[37] Data from Eurostat [nrg_bal_c]. "Coal" contains categories "anthracite" and "lignite".

	Overall direct jobs	208 369	6 313	3 988
	Overall indirect jobs	130 000	12 000	7 000

3 Changes in coal mining and coal power generation up to 2020

3.1 Mine closures since 2010

As a result of changes in the EU power sector combined with inefficient and costly production, comparably cheap imported hard coal, and the increasing volatility of coking coal prices in international markets, many EU mines have closed over the years. Others have remained active only through State Aid[38] subsidies, allowed under the expired EC Regulation No 1407/2002[39].

In particular, hard coal producers saw a significant reduction of mining capacity over the last decade (Figure 34a), reflecting the continuation of a trend initiated much earlier as the industry went through a process of transformation. Since 2010, hard coal production has fallen by 43 % with the closure of 63 mines (Figure 35).

With a view to facilitating the closure of uncompetitive hard coal mines until the end of 2018, state support to the coal sector was gradually phased out following the Council Decision 2010/787/EU[40]. Pursuant to this Regulation, subsidies were permitted only to cover production losses and exceptional costs related to the inevitable closure of the mines, including social welfare benefits and rehabilitation of sites.

In line with this framework, between 2012 and 2015 the European Commission approved public funding for the closure of various uncompetitive hard coal mines in Czechia, Germany, Romania, Poland and Spain. In accordance with EU State Aid law, mines receiving aid were wound up by the end of 2018.

There were exceptions in Romania, where mining activities at Lonea and Lupeni that should have terminated in 2018 were still ongoing in 2019 due to the potential risks associated with their closure (European Commission, 2020b). Following the bankruptcy of the state-owned mining operator in October 2019, and in the absence of any viable restructuring plan, coal extraction is expected to completely cease in Vest.

More recently, the Commission authorised the extension for an additional period of 5 years, until the end of 2023, of a State Aid regime for the further restructuring of the hard coal mining sector. Such continuation was found necessary to support the sector's restructuring efforts, for example in Poland and Spain (Box 1). In accordance with the requirements of European regulations, State support will fund severance payments, compensatory pensions and social security benefits. Furthermore, it will be used to secure mine shafts and decommissioning of mine infrastructure, mitigation of environmental impacts and land restoration, investments and projects aimed at the industrial redevelopment of the sites for the period 2019-2027 (European Commission, 2020c).

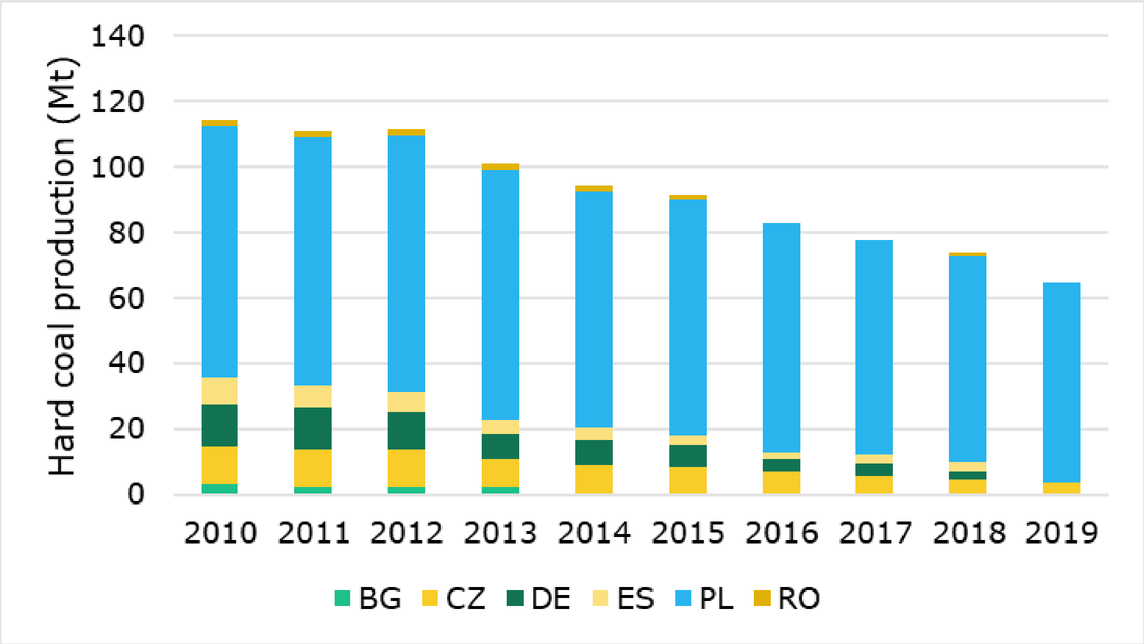
As the share of coal in total primary energy supply decreases, lignite production, less costly and generally competitive without State Aid, is also challenged. Between 2010 and 2019, lignite production dropped by 22 % with the closure of 19 mines (Figure 34b).

[38] Information on State Aid primarily from EC, DG COMP, State Aid Register https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=3_SA_46891

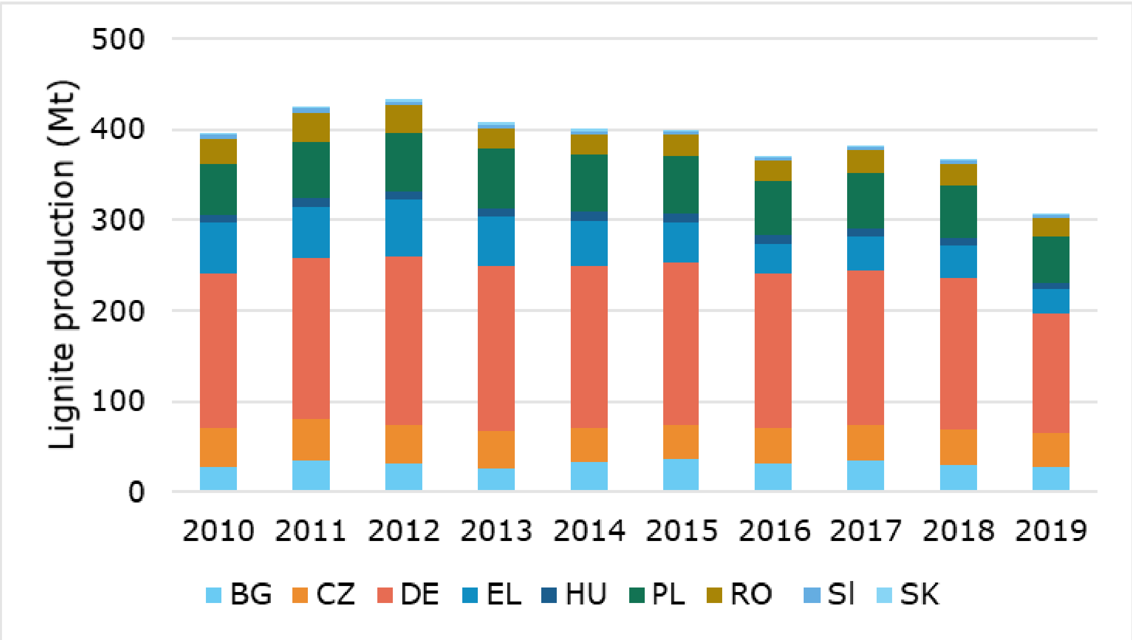
[39] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32002R1407

[40] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010D0787

Figure 34. Production of hard coal and lignite in 2010-2019



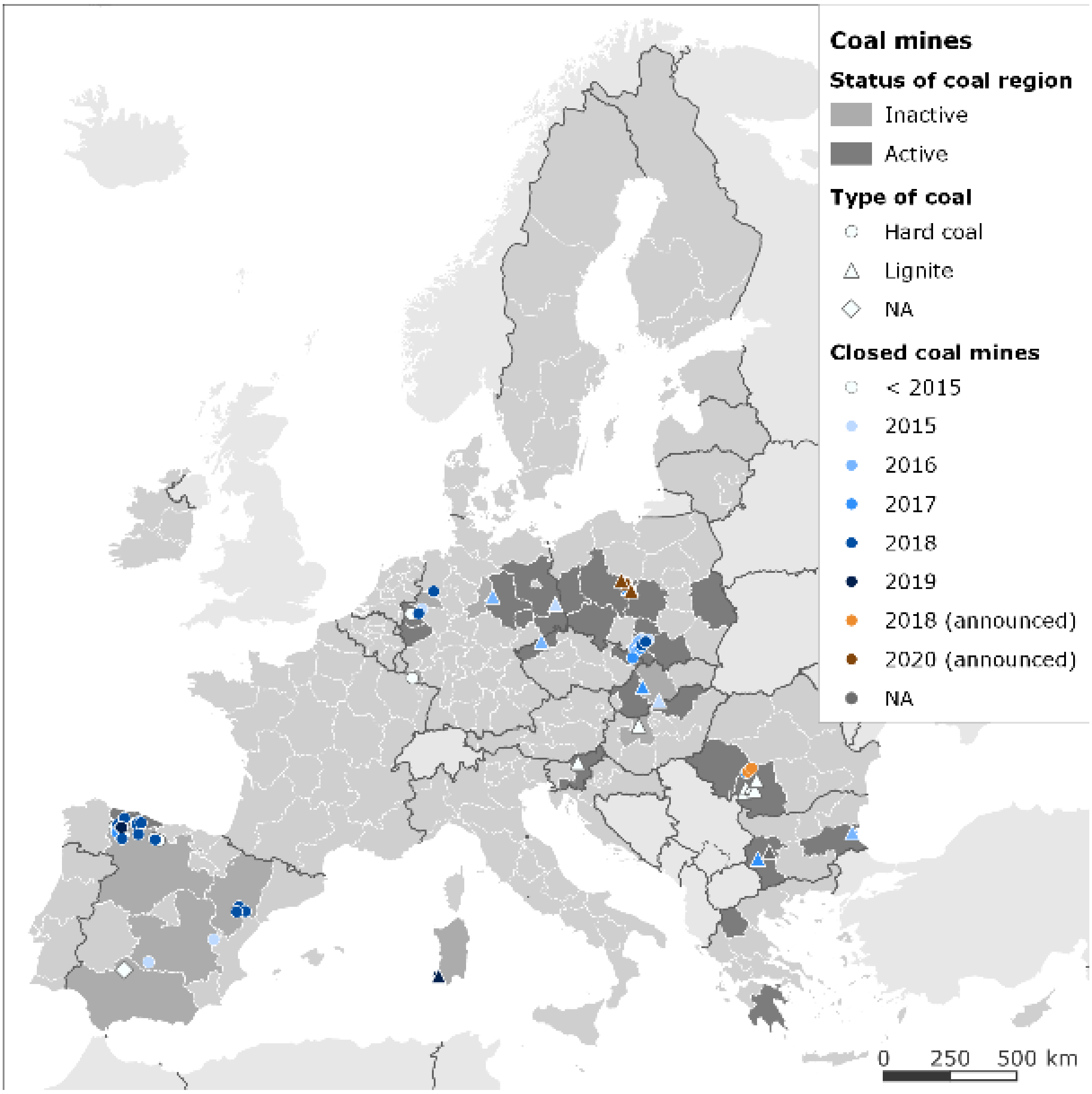
a)



b)

Source: Euracoal 2010-2020 (Euracoal, 2020b), 2020.

Figure 35. Location of mines that have closed or will close in the timeframe 2010-2020



Source: JRC, 2020.

Box 1. Spain: Measures supporting the structural change and transition process

On 24 October 2018, a framework agreement was signed for a "Fair Transition of Coal Mining and Sustainable Development of the Mining Communities for the period 2019-2027".

The Just Transition Agreement replaces subsidies to the coal industry with a sustainable development plan, in accordance with the requirements of European regulations, for the period 2019-2027 (IndustriALL Union, 2018). The Agreement establishes compensation payments and access to early retirement aid for miners. It also prioritises environmental restoration, infrastructure development, and the development of new and expanding businesses in the mining communities.

The government will grant support for a total amount of EUR 250 million during the period 2019-2023, to be executed until 2027.

Box 2. Germany and Poland: Measures supporting the structural change and transition process

To ensure the implementation of the agreed closure commitments and to support the decommissioning process, Germany (for hard coal only) and Poland opted for the creation of single run-off companies that would combine the closure activities of multiple companies.

In Germany, closure activities and mine management tasks were combined in the private RAG Foundation. The company was created in 2007 to fund the industry's perpetual responsibilities from 2019 onwards and to avoid a transfer of financial risk to the public sector. RAG's core activities are now mine water management, repairing subsidence damage due to past coal mining, securing old shafts and tunnels and the restructuring of former coal mining areas (Euracoal, 2020a). Post-closure liabilities, and environmental rehabilitation and repurposing, are financed by the proceeds of the Foundation which also promotes education, science and culture in the mining regions. The Foundation's assets/obligations consist not only of the old mines. While it was still profitable, RAG invested in other industrial sectors, namely in real estate (including housing for their workers) and the chemical industry, thereby guaranteeing availability of financial means to implement perpetual obligations (Coal regions in transition platform, 2020).

In Poland, unprofitable mines or units of integrated mines have been transferred to SPÓŁKA RESTRUKTURYZACII KOPALŃ (SRK – Mines Restructuring Company) for their eventual closure. From May 1, 2015 to December 31, 2018, there were sixteen mines managed by this restructuring company. The company carries out closure planning activities, safety, environmental rehabilitation and land restoration works, organises repurposing processes and supports job creation in coal mining regions (SRK, 2020).

3.2 Changes in coal production between 2015 and 2018 (comparison to the previous report)

Between 2015 and 2018, coal output in the EU-27 gradually declined as 37 mines closed in several Member States, i.e. Bulgaria, Czechia, Germany, Poland, Romania, Slovakia and Spain. Lignite production diminished by 8 % over the period considered and hard coal sales declined by 20 %.

In 10 regions, coal production decreased more than 20 % (Figure 36). Production fell steadily in Münster (DEA3), by 58 %, as Germany's last hard coal mines (Prosper-Haniel and Ibbenbüren) prepared for closure at the end of 2018.

In Vest (RO42), production decreased from 1.3 Mt in 2015 to 0.7 Mt in 2018, a decline of 46 %. Petrila mine closed in 2015, followed in 2017 by Paroseni and Uricani mines.

Coal production fell by 45 % in Moravskoslezsko (CZ08) with the closure of Paskov mine in 2017, coupled with a reduction in output in the three remaining hard coal mines from 7.5 to 4.5 Mt.

The mining area in Wielkopolskie (PL41) yielded a total lignite output of 7.6 Mt in 2018, a decrease of 45 % when compared to 2015, following the closure of Kozmin and Wladyslawow, belonging to the Adamów mining site. Its output has since fallen further as this site also nears completion, scheduled for 2020.

Between 2015 and 2018, 14 mines were decommissioned in Śląskie (PL22). The region yielded a total hard coal output of 49 Mt in 2018, a decrease of 16 % when compared to 2015.

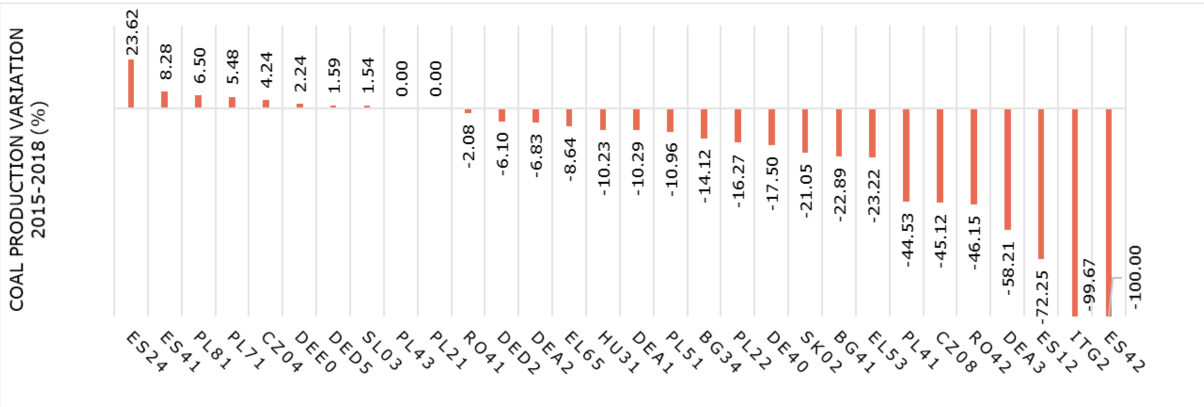
Since the closure of the Puertollano opencast mine in 2015, coal production in Castilla-La Mancha (ES42) has definitely ended. In Braunschweig (DE91), lignite mining ended with the closure of Schoningen mine in 2016.

Mining activities were also stopped at Monte Sinni mine in south-west Sardegna (ITG2) at the end of 2018. Saleable production in 2018 was estimated at 243 tonnes.

By the end of 2018, nearly all Spanish coal producers had closed their mining operations in accordance with EU State Aid rules. In Asturias (ES12), a total of 0.3 Mt was produced in 2018 at three mining sites, decreasing by 72 % since 2015. Today only one underground mine remains, producing just 200 000 tonnes each year. The mine is scheduled to close in 2021 (European Commission, 2020a). In 2018, 0.5 and 1.6 million tonnes were extracted in Castilla y León (ES41) and Aragón (ES24), respectively, outstripping production in 2015. In 2018 there were seven active mining sites in both regions that closed down by the end of 2018.

Despite an overall decrease in production across EU Member States, operators in six regions in Slovenia, Germany, Czechia and Poland have slightly increased their outputs over the same period. Coal sales increased by 6.5 % in Lubelskie (PL81), where hard coal production totalled 9 Mt.

Figure 36. Percentage change in coal production by region between 2015 and 2018



Source: JRC, 2020.

3.3 The evolution of coal mining employment since 2010

Employment trends in hard coal and lignite production are presented in Figure 37.

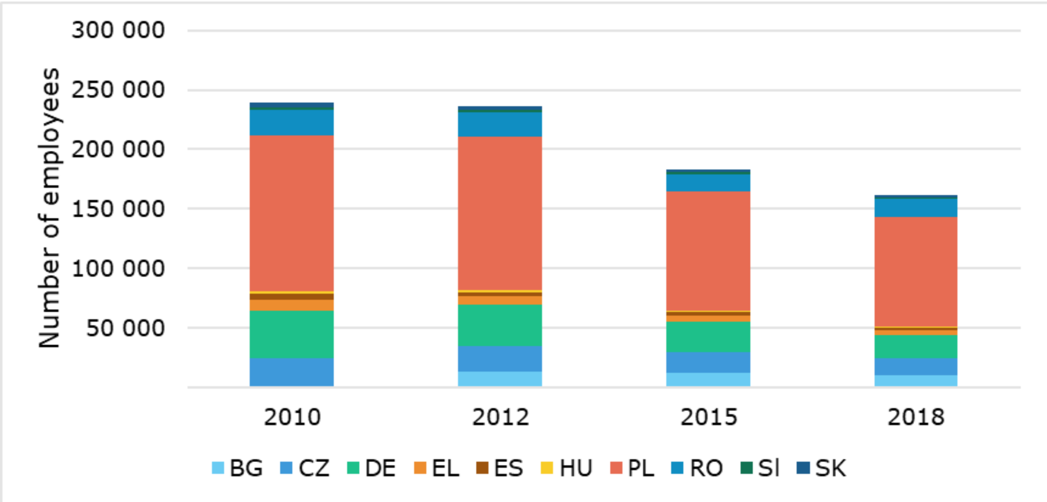
According to Euracoal (Euracoal, 2020b), between 2010 and 2018, coal jobs decreased from 239 400 to 161 930, a decline of 32 %.

Spain accounts for the largest decrease of mining employees over that period (-71 %), followed by Germany, Greece and Slovakia (about -50 % each).

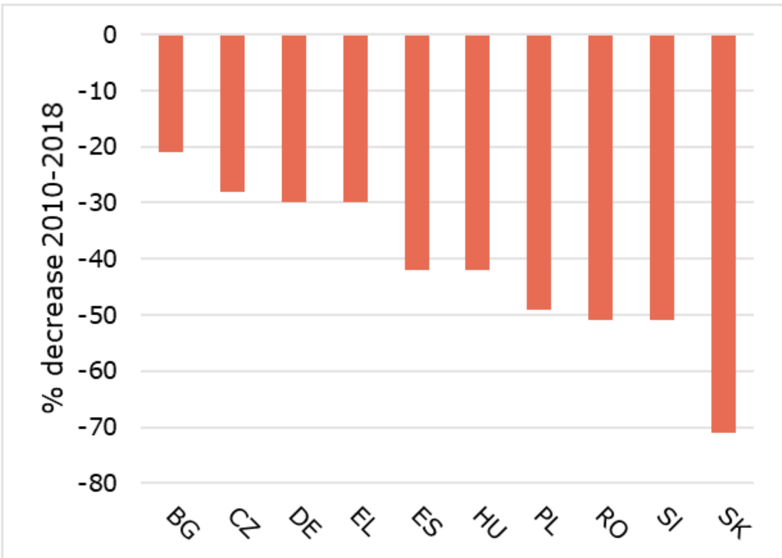
On the other hand, the reduction in the workforce in the same period was lowest in Bulgaria (-21 %), Poland, Romania and Slovenia (about -30 % each).

Despite the significant reduction of mining capacity over the last decade, more coal mining employees are in Poland than in any other member state.

Figure 37. a) Evolution of the number of employees within the coal mining sector from 2010 to 2018 and b) percentage decrease in the same period



a)



b)

Source: Euracoal (Euracoal, 2020b), 2020.

3.3.1 Variation of direct employment in coal mining regions between 2015 and 2018 (comparison to the previous report)

As coal production declines following the completion of mining and mine decommissioning, so too does the number of jobs in the same regions.

Broadly in line with production trends, the number of employees in hard coal mining decreased from 110 269 in 2015 to 98 480 at the end of 2018, a decline of 11 %. Over the same period, the number of jobs in lignite mining decreased by 5 %, from 64 001 in 2015 to 60 787 in 2018.

Figure 38 shows which Member States experienced the highest direct job losses in coal mining between 2015 and 2018. The total number of losses in that period is 15 000 for the EU-27. Shares were highest in Germany and Czechia, at 32 % and 27 %, respectively.

At the end of 2018, the three mining areas in Spain employed a total workforce of about 1 733. Since 2015, the closure of nearly all coal mines in Spain led to 1 623 job losses.

In Münster (DEA3), the decline in local production led to a 57 % job reduction, from 9 640 in 2015 to 4 125 in 2018 (Figure 39).

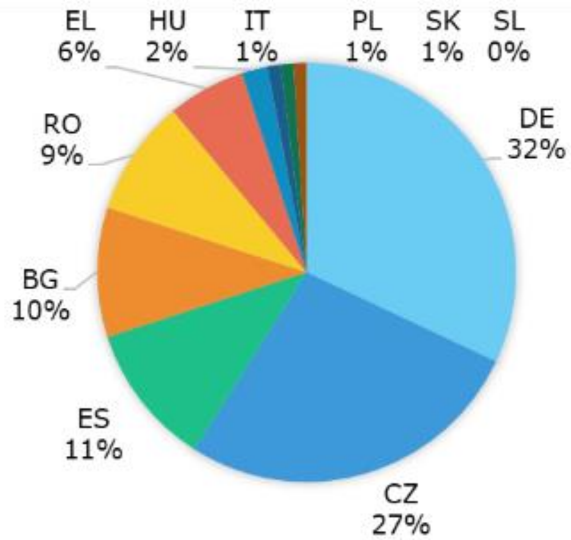
Italy ceased coal production in 2019 and employed a total workforce of 160 in 2018, 54 % less than in 2015.

Employment figures also fell by 33 % in the northern Moravia mining area (CZ08), where the number of employees in hard coal mining was 6 757 at the end of 2018. Over the same period, employment in Vest (RO42) decreased by 32 %. Following many mine closures, in 2018 a total workforce of 3 022 was employed in the region.

Between 2015 and 2018, 2 932 jobs were discontinued in Yugoiztochen (BG34), Západné Slovensko (SK02), Észak-Magyarország (HU31) and Dytiki Makedonia (EL53). The regions' employment losses varied between 13 % and 24 % (Figure 40).

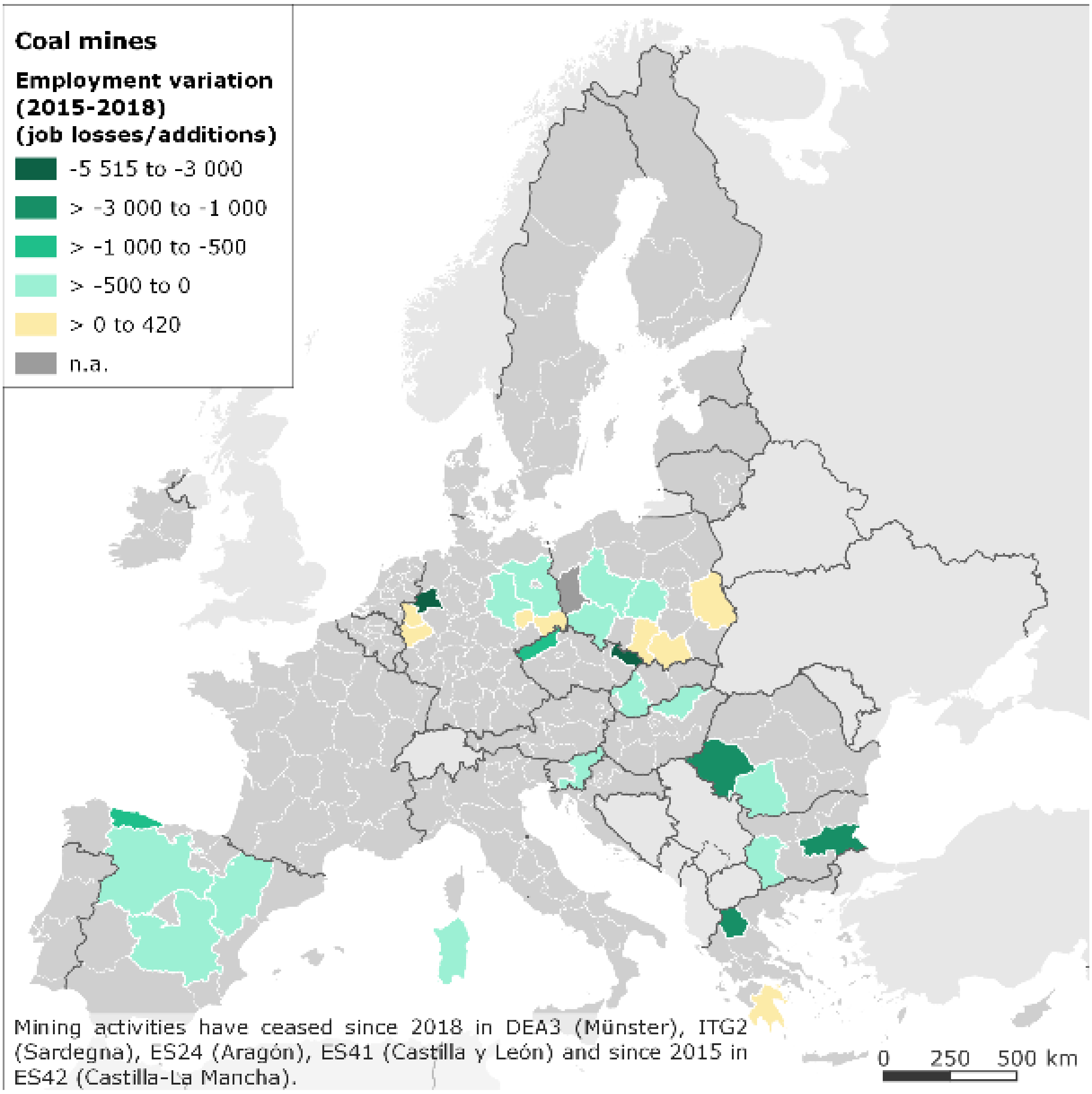
In the opposite direction, 1 184 jobs were created in Greece and Germany, despite lower lignite sales from the four mining areas concerned.

Figure 38. Distribution of mining employment losses between 2015 and 2018, by Member State



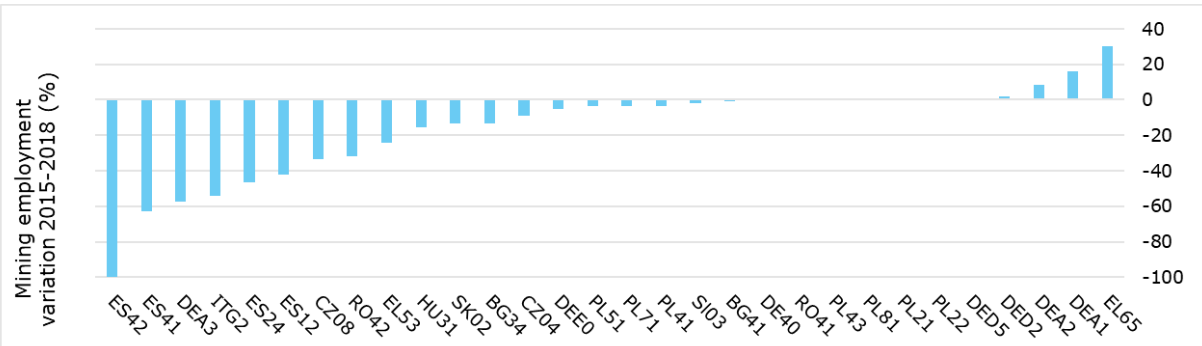
Source: JRC, 2020.

Figure 39. Regional distribution of mining employment losses between 2015 and 2018



Source: JRC, 2020.

Figure 40. Percentage change in coal mining employment by region between 2015 and 2018



Source: JRC, 2020.

3.4 Retired coal-fired generation capacity between 2016 and 2020

During the last four years (2020 included), more than 26 GW of coal-fired capacity was retired. The following table provides the aggregate retirements (MW) per country.

Table 9. Recently retired coal-fired capacity (MW) in the EU

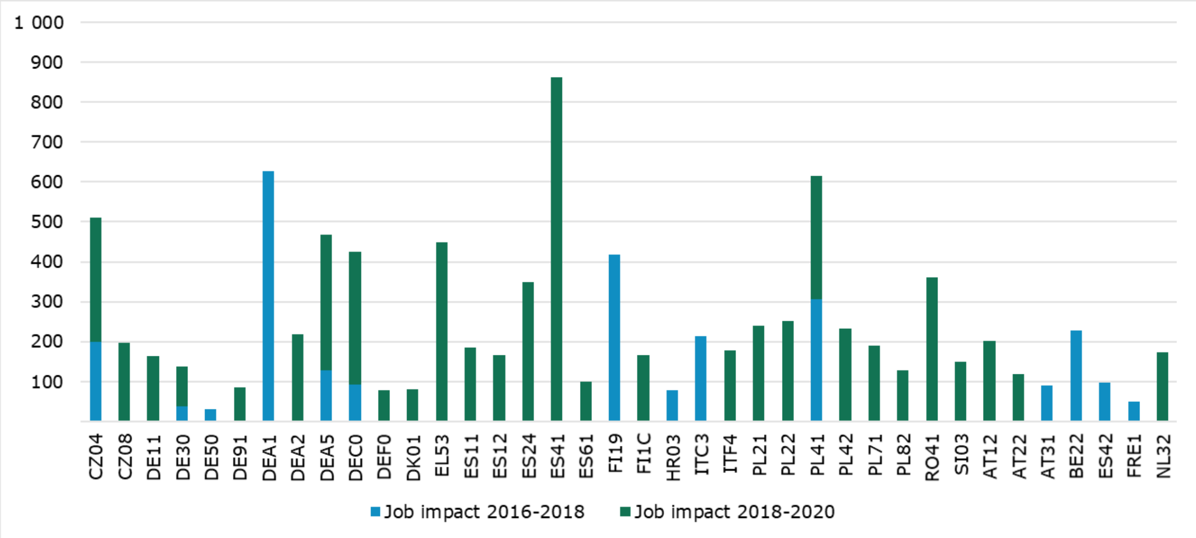
Country	**Retired 2016-2018 (MW)**	**Retired 2018-2020 (MW)**
Austria	150	535
Belgium	470	0
Croatia	115	0
Czechia	378	960
Denmark	0	250
Finland	690	275
France	250	0
Germany	3 820	5 468
Greece	0	1 089
Italy	729	605
Netherlands	0	1 090
Poland	600	2 635
Romania	0	643
Slovenia	0	373
Spain	296	5 009
Total	**7 498**	**18 932**

Source: JRC, 2020.

3.5 Direct employment lost in coal power plants

The actual impact on employment of the fleet retirements presented in the previous section is not known. Personnel employed in the retired plants may have been retired, transferred to another position, or even maintained on site to supervise the eventual decommissioning. However, by applying the same methodology (see paragraph 2.1.3.1) we used for assessing the impact on employment by 2030 due to power plant decommissioning, we can provide a rough estimate of the job positions that may have been lost or transferred to other activities. This estimate is provided at NUTS 2 level in the figure below.

Figure 41. Estimated jobs possibly already affected by power plant decommissioning



Source: JRC, 2020.

The most extensive retirements of coal-fired power plants between 2016 and 2018 occurred in Germany (DEA1) and Finland (FI19), with 2 610 MW and 690 MW retired, while between 2018 and 2020, the regions with the highest numbers of potentially affected jobs are found in Spain (ES41) and Greece (EL53) with 2 595 MW and 1 089 MW retired.

3.6 Key points

- Between 2010 and 2019, lignite production dropped by 22 % with the closure of 19 mines. Since 2010, hard coal production has fallen by 43 % with the closure of 63 mines. Between 2010 and 2018, coal mining jobs decreased from 239 400 to 161 930, a decline of 32 %. Spain accounts for the largest decrease in mining employees over that period (-71 %), followed by Germany, Greece and Slovakia (about -50 % each). Bulgaria (-21 %), Poland, Romania and Slovenia (about -30 % each) experienced the lowest workforce reduction.
- Poland remains by far the largest employer in Europe despite the significant reduction of mining capacity over the last decade.
- Between 2015 and 2018, 37 mines closed in Bulgaria, Czechia, Germany, Poland, Romania, Slovakia and Spain.
- Lignite production diminished by 8 % over the period considered and hard coal sales declined by 20 %.
- The number of employees in hard coal mining decreased from 110 269 in 2015 to 98 480 at the end of 2018, a decline of 11 %. Over the same period, the number of jobs in lignite mining decreased by 5 %, from 64 001 in 2015 to 60 787 in 2018.
- The decrease in employment between 2015 and 2018 was sharpest in Castilla-La Mancha (ES42), Sardegna (ITG2), Asturias (ES12), Münster (DEA3), Vest (RO42), Moravskoslezsko (CZ08) and Wielkopolskie (PL41).
- Overall, 15 000 jobs were lost in the key coal-producing countries of the EU. The highest shares are in Germany and in Czechia, at 32 % and 27 %, respectively.
- During the last four years (2020 included), more than 26 GW of coal-fired generation capacity was retired.
- Germany (9.3 GW), Spain (5.3 GW), Poland (3.2 GW), Czechia (1.3 GW) and Italy (1.3 GW) were among the Member States with the highest capacity retirement.
- Between 2016 and 2020, Castilla y León (ES41), Düsseldorf (DEA1), Wielkopolskie (PL41), Severozápad (CZ04) and Arnsberg (DEA5) encountered the highest number of jobs already affected by power plant decommissioning.

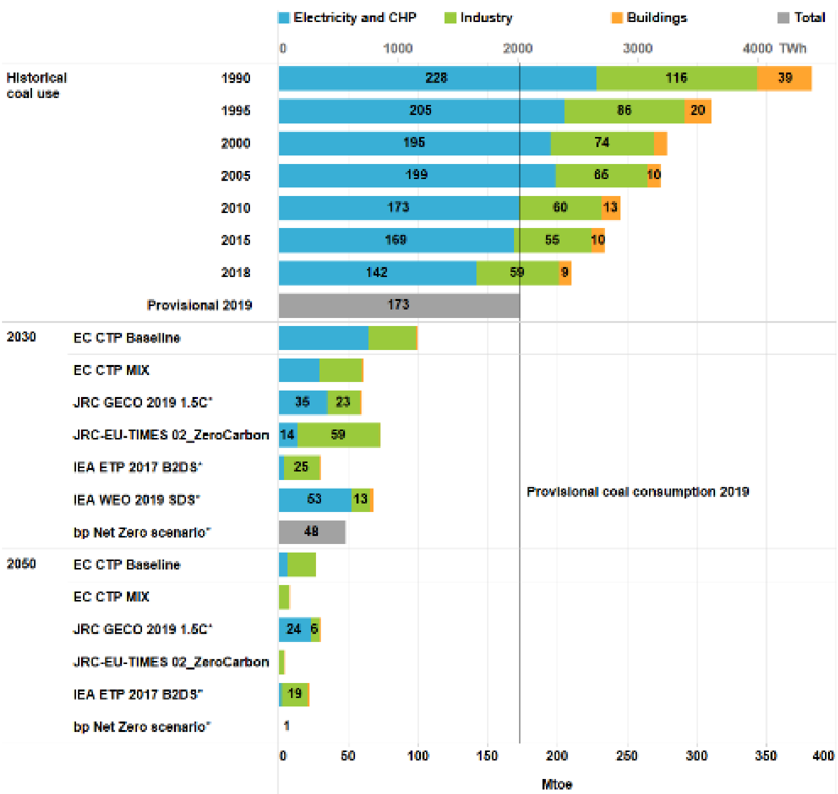
4 Possible future developments of coal, peat and oil shale activities

4.1 Coal, peat and oil shale use in energy scenarios

This chapter presents a comparison of historical and future coal use. The projected coal consumption for 2030 and 2050 is taken from the baseline scenario in the impact analysis for the 2030 Climate Target Plan,[41] i.e. an evolution if governments make no changes to their existing policies and measures, and from six carbon and energy policy scenarios). Unlike the 2018 study, we only consider in this comparison scenarios that aim to limit the global temperature increase to 1.5 °C and to curb greenhouse gas (GHG) emissions to zero. This selection is following the ambition from the European Green Deal (European Commission, 2019) to achieve climate neutrality by 2050 while transforming the EU into a fair and prosperous society with a modern, resource-efficient and competitive economy. Another difference from the previous study is that we look at trends for the EU-27. A regional correction was used where only EU28- numbers are available.

The role of coal

Figure 42. Historical[42] and projected use of coal in EU-27



Source: 1) Historical: (Eurostat, 2020a) there is no sectoral detail available for provisional 2019 data 2) EC CTP Baseline and EC CTP MIX: (European Commission, 2020d) 3) IEA ETP-B2DS: (IEA, 2017) 4) IEA WEO 2019 SDS: (International Energy Agency (IEA), 2020) 5) JRC GECO 2019 1.5C: (Keramidas et al., 2020) 6) JRC-EU-TIMES 02_ZeroCarbon: result from the open model, (Nijs & Ruiz, 2019).

[41] https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en

[42] *For these scenarios a regional correction was used that is based on historical sectoral coal use for both EU-27 and EU28 (2015 Eurostat values).

Figure 43 shows the use of coal in its three main applications: (1) heating in buildings, (2) energy and material production in industry and (3) power generation and production of heat (for district heating or as combined heat and power plants – CHPs). Power generation and CHPs are by far the biggest consumers of coal and are responsible for two thirds of total coal use in 2018. Lignite, almost exclusively used in power generation and CHPs, makes up more than one third of total coal demand.

Between 1990 and 2018, the use of coal in EU-27 decreased by 45 %, from 383 Mtoe to 210 Mtoe. This is equivalent to an average annual reduction of 2.1 %, assuming a constant relative reduction from year to year. Between 2015 and 2018, coal consumption decreased by 10 %, which is equivalent to an average annual reduction of 3.5 %, pointing towards increasing decarbonisation efforts. Even more strikingly, when comparing provisional data for 2019 with 2018 one can observe a reduction of total coal use of 18 %.

Most decarbonisation scenarios show that the consumption of coal in 2030 is in the range of 50-75 Mtoe. This implies a reduction of between 60 % and 70 %, even when compared to 2019. During this decade, the coal and lignite sector may experience a reduction of between 8 % and 10 % annually. This conclusion is in line with findings from a recent JRC study (Tsiropoulos et al., 2020). Looking into the sectoral use of coal in 2030, there are clear differences for the sectoral shifts in coal use. In IEA WEO 2019 SDS and JRC GECO 2019 1.5C, the power sector remains the main user of coal, while in IEA ETP 2017 B2DS and JEC-EU-TIMES 02_Zero carbon, the industry becomes the main user of coal.

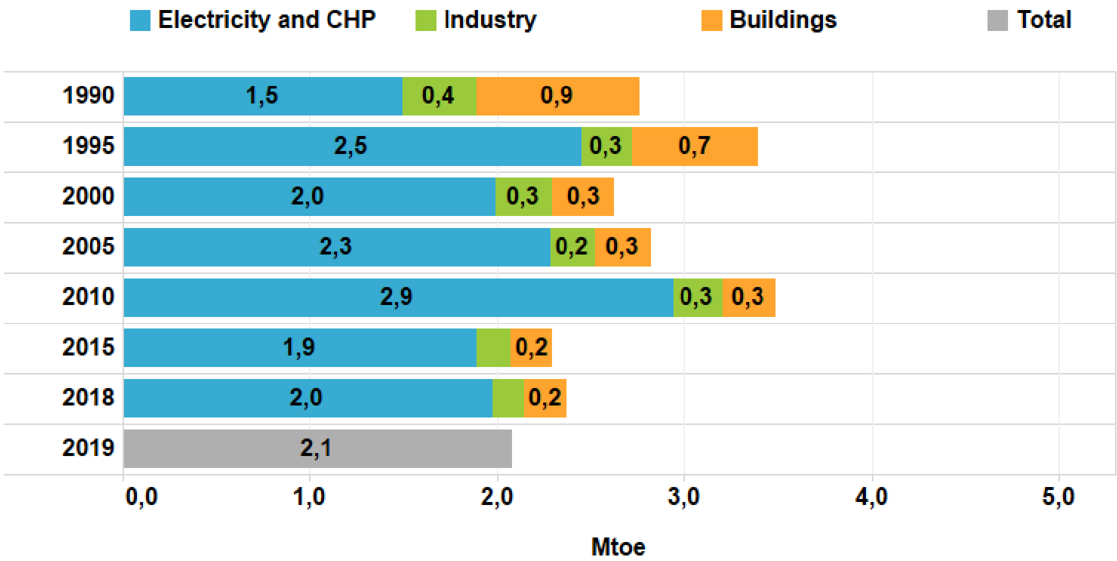
For 2050 there are two main groups of scenarios. In the first group, there is an almost complete phase-out of coal. In the second, there is still a small role for coal as an energy source (20-30 Mtoe). This range can be explained by the different assumptions on technology availability, mainly Carbon Capture and Storage (CCS) and/or Carbon Capture and Utilisation (CCU).

All scenarios show rapid changes in the coal sector from a seven-fold reduction (in the scenarios where coal still plays a role in EU-27) down to an almost complete phase-out (in the scenarios dominated by renewables, electrification and alternative fuels).

The role of peat and oil shale

In EU-27, solid fossil fuels like peat and oil shale do not play a significant role in the energy sector. In 2018, only around 2 Mtoe of each were consumed in power and heat production and accounted for only around 1.7 % (each) of the total fuel input for power and heat production. The historical trend shows a decreasing consumption of peat: a 32 % reduction from its peak in 2010 to 2018, and another reduction of 12 % in the last year. The energy use of peat is currently almost exclusively for power and heat production. The three countries with the highest consumption are Finland (63 % of total use), Ireland (26 %) and Sweden (8 %). It is likely that in the future, the role of peat will continue to decrease (Jenni, 2020; Swedish Energy Agency, 2019).

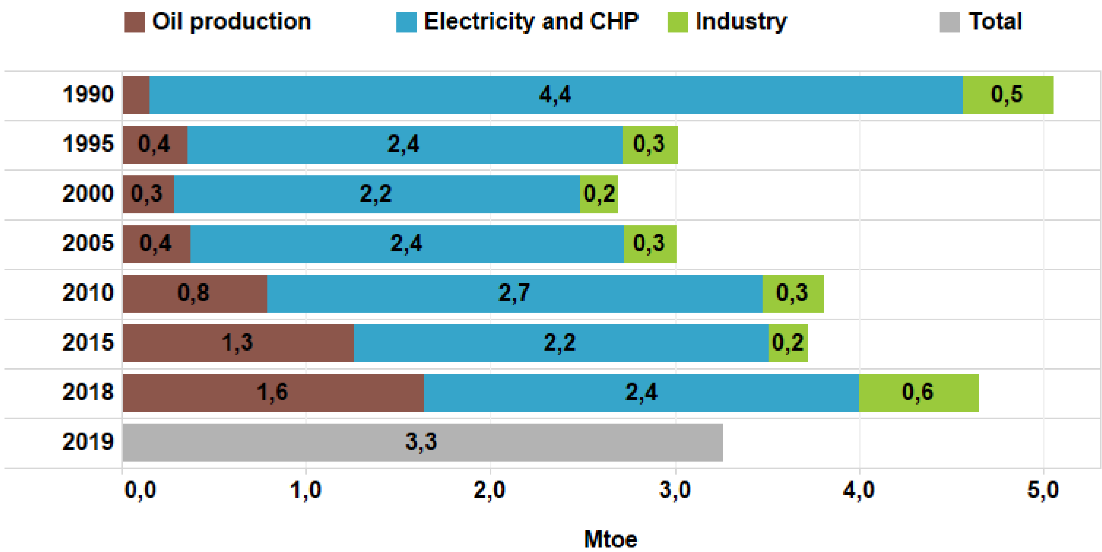
Figure 43. Historical use of peat in EU-27 (Eurostat)



Source: Eurostat, 2020.

Oil shale, despite available resources in several EU-27 countries, is used only in Estonia, where it remains one of the main fuels for power production. There is one 300 MW oil shale power plant (built in 2015) that can use up to 50 % of biomass. Oil shale has increasingly been used for the production of liquids like diesel. The future role of oil shale in Estonia is uncertain. Long-term energy scenarios do not report peat or oil shale separately.

Figure 44. Historical use of oil shale in EU-27 (all Estonia, Eurostat)



Source: Eurostat, 2020.

4.2 Coal mines, peat and oil shale extraction sites

4.2.1 Coal mines

Lignite is used mainly for power and occasionally heat generation in power stations and combined heat and power (CHP) plants constructed very close to the mine site (also referred to as mine-mouth power stations). Over 95 % of lignite is consumed in power generation (Ernst & Young, 2014). The characteristics of this solid fuel make it unsuitable for trade unless the distances involved are very short –, it deteriorates rapidly and its high water content makes it excessively expensive to ship (Ernst & Young, 2014).

As a result, the phase-out of coal-fired-power plants will render unnecessary most lignite mines, leading in the short-to-medium term to their closure. This can either be aligned with the decommissioning horizons of power plants or can occur due to the depletion of their reserves, or a lack of profitability and competitiveness.

Hard coal, on the other hand, is traded around the world and benefits from a wider range of applications, which includes the steel industry. Hard coal deposits can provide different coal qualities, including steam (also referred to as thermal coal, mainly used in heating and power generation) and coking coal used in the steel-making process. At each mine, the extracted coal is processed in preparation plants where it is graded as coking coal or steam coal, based on certain quality parameters. Although most hard coals possess the relevant properties for use in the steel industry, not all produce a coke of desirable quality (American Iron and Steel Institute, 2017). The properties of coals used in the steel-making process are tightly regulated, given the effects of coking coal on the quality of the resulting steel (Coking Coal Factsheet, 2017).

The tight linkage between steam coal and the power sector allows the anticipation of important losses in the asset value of low-quality hard coal mines as a consequence of changes in the EU power sector, under the energy transition. Coking coal usage in the steel sector, on the other hand, can provide new possibilities for extraction and prolonged years of life at least for some mines capable of producing high-rank coals, with consequent employment and distribution advantages, at least in conditions of growing prices.

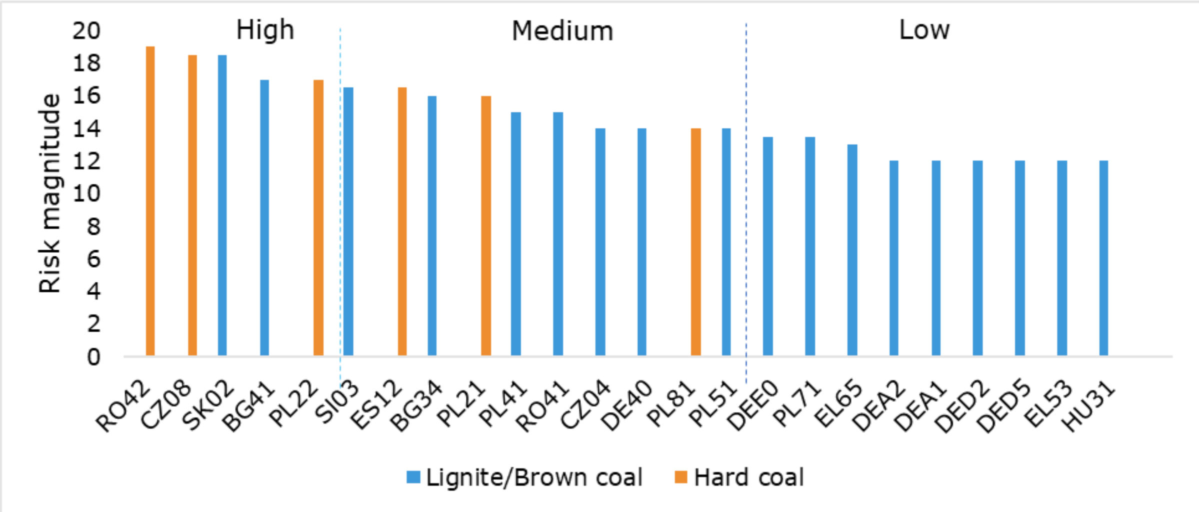
4.2.1.1 Performance of operating coal mines and potential impacts on employment[43]

Some criteria influencing the competitiveness of EU coal mines were assessed with the purpose of establishing risk ratings for the regions hosting coal mining activities. The indicators and arguments for the analysis are given in Annex I together with the assessment scales.[44] For each region an overall risk of closure was determined by adding the results of each indicator. Results are presented in Figure 45 and Annex J. Figure 45 presents coal mining regions ranked according to the risk of mine(s) closure based on competitiveness criteria (least competitive regions are allocated a higher risk rate).

[43] The risk on jobs explored in this section takes into account mine competitiveness criteria only. Decommissioning announcements in each region/country are not factored in.

[44] The regions' competitiveness assessment takes into account the following criteria described in annex I: mine productivity, type of coal produced, type of mining (surface or underground), depth, reserves-to-production ratio, coal quality, closure plans in place.

Figure 45. Risk ratings of coal mining regions



Source: JRC, 2020.

The analysis shows that regions in Romania, Czechia, Slovakia, Bulgaria and Poland (RO42, CZ08, BG41 and PL22) are assigned, in decreasing order, a higher risk rating (equal and above 16.5). The least risky regions include DEE0, DEA2, DEA1, DED2 and DED5 in Germany, PL71 in Poland, EL65 and EL53 in Greece and HU31 in Hungary.

In accordance with the fact that most hard coal production takes place at underground operations, the risk exposure of the hard coal regions concerned is also increased. Lignite mines are, on the other hand, generally more competitive, with apparent exceptions in Slovakia and Bulgaria.

Table 10 summarises the number of jobs exposed to high, medium and low risk with regard to a potential closure of coal mines based on the risk analysis presented above.

Table 10. Jobs at risk calculated based on mine competitiveness criteria

High risk	**Medium risk**	**Low risk**
85 590	46 252	22 697

Source: JRC, 2020.

The analysis shows that around 86 000 coal mining jobs face a high risk of redundancy due to the potential closure of the least competitive mines. This represents around 54 % of the total workforce in the EU-27 coal mining sector.

4.2.1.2 Announced mine closures and impacts of power plant decommissioning on mining employment

Employment losses related to coal mine closures were estimated within the following time horizons:

The time between 2018 and 2020, covering:

- Employment losses related to mines ending operations in 2018 through to their final decommissioning, as in Spain (ES12, ES24, ES41), Italy (ITG2) and Germany (DEA3).

- Employment losses reported in 2019 by public institutions or reported to the Platform for Coal Regions in Transition, as in Germany, Slovakia, Bulgaria and Romania.
- Employment losses resulting from the planned closure of mines by 2020, as in Poland (PL41).
- Employment losses from the closure of uncompetitive coal mines beyond 2018, as in Romania (RO42).

A mid-term time horizon of one decade, from 2020 to 2030, covering:

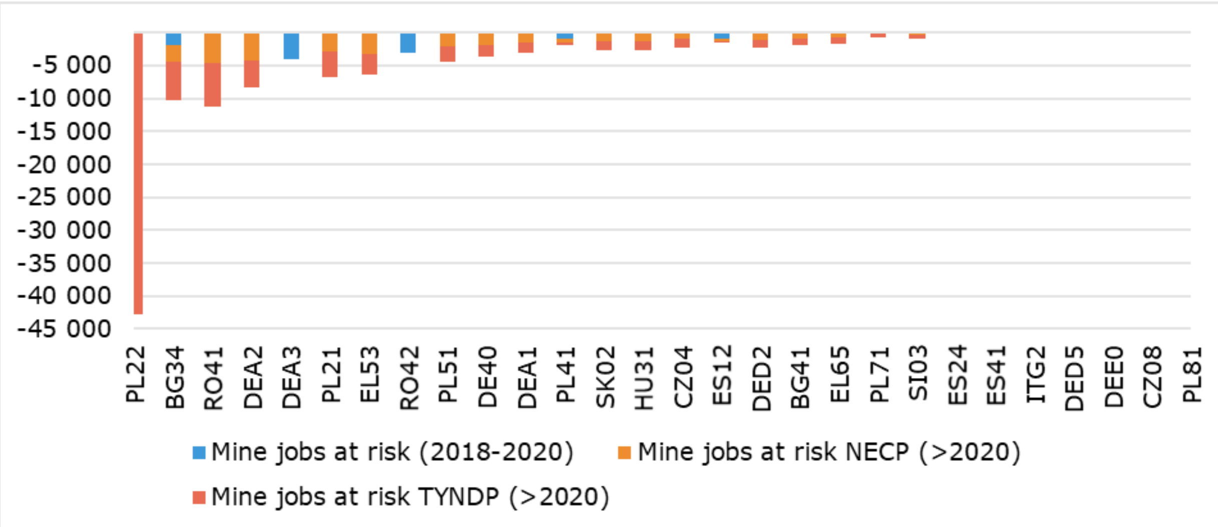
- Projected employment losses under the main assumption that coal-fired power plant decommissioning will be the main driver for mine closures, independently of their competitiveness. Power plant decommissioning is thought to influence jobs in the same region where lignite or hard coal is extracted, to the extent of the dependency assumed between the mining and the power sector. Lignite is used entirely in power stations constructed very close to the mine site; hard coal is used to the extent of the region's steam coal production (see Table 1). Mining employment losses are estimated based on the decommissioning rates of power plants by 2030 under the National Energy and Climate Plans (NECP) and the Ten-Year Network Development Plans (TYNDP) coal phase-out scenarios, applied to the workforce remaining after 2020.

Based on the above, it is estimated that from 2018 to 2020, there are 12 149 jobs at risk of being lost in coal mining across 15 regions (Figure 46).

After 2020, this number could rise to 30 839, given the application of national coal phase-out policies in electricity generation or to 80 848 if TYNDP coal phase-out scenarios are considered. Under the TYNDP scenario, half of the estimated current coal mining workforce (81 000 out of 160 000 jobs) could be directly affected by the power sector during the next decade.

Over the same period, additional employment losses may ascend to 2 400 in Czechia and Germany; this might be the consequence of the planned closure of mines reaching the end of their operational life within approved mining limits.

Figure 46. Mining employment at risk estimated based on announced mine closures and influenced by power plant decommissioning



Source: JRC, 2020.

4.2.1.3 Announced expansions and exploration developments

Few investments in new mining capacity have been made over recent years, as policies to phase out coal from the energy market have put pressure on the remaining EU coal producers. Some projects targeting high-rank coking coal products will lay the groundwork for industrial development as global steel demand is expected to grow. Other projects aiming at lignite/brown coal or hard steam coal production, however, seem to be enabled in countries that do not (yet) have coal-fired power generation phase-out plans, such as in Czechia or Poland, or where coal phase-out plans lie in the future, as in Germany.

There is one mine planned for construction in the EU, and there are a further five projects in the exploration stage, representing a total portfolio of six undertakings to bring forward new mines in Czechia and Poland (Table 11).

Table 11. Active coal exploration projects in the EU in 2020

Country (region)	Number of projects	Development Stage/s	Total In-situ Value (€M)	Planned production (Mt/year)	Coal type/ use
Czechia (CZ08)	1	Reserves Development	107 000	NA	Hard coal (Thermal)
Poland (PL81)	2	Feasibility Started	128 000	17.3	Hard coal (Thermal, Metallurgical)
Poland (PL22)	2	Reserves Development; Prefeasibility/Scoping	20 000	2.6	Hard coal (Thermal, Metallurgical)
Poland (PL51)	1	Construction Planned	5 800	NA	Hard coal (Metallurgical)

Source: S&P Market Intelligence, 2020

The most advanced exploration project is located in South-Western Poland (PL51). The project is being developed by Balamara Resources Ltd., which has demonstrated potential for high quality coking coal production. Balamara was granted environmental approval for Nowa Ruda in 2018 and is now expecting the conclusion of licensing procedures for the commencement of mine construction (Balamara Resources, 2020).

Of the five remaining projects capable of producing thermal and/or metallurgical coal, two have been locked in disputes with the licensing authority, which may result in the commencement of proceedings to limit or withdraw the mining concessions. In January 2019, Prairie Mining Ltd. received a final decision that denied its amendment application to extend the time given for first production of coal at Debiensko (PL22) from 2018 to 2025. In January 2020, Prairie's application for the Jan Karski concession (formerly Lublin Coal Project) in PL31 was still under litigation (S&P Market Intelligence, 2020).

Mine expansions at existing sites have also occurred. For example, in 2015, the Czech government decided to lift brown coal mining limits at Bilina (CZ04) and begin permitting for extended coal mining (S&P Market Intelligence, 2020).

At the end of 2016, Lubelski Wegiel "BOGDANKA" SA (PL81) planned to extend the mine life from 2042 to 2080 by obtaining new exploitable resources. In 2017 Bogdanka obtained a licence for mining in the Ostrów deposit (PL81) (Bogdanka, 2017).

In September 2016, Jastrzębska Spółka Węglowa SA announced an investment project in the coal mines of Budryk and Boars-Szczyglowice (PL22). The aim of these investments was to increase the volume of production of coking coal type 35 and to increase the share of coking coal in global production via the modernisation of processing plants in the years 2016 to 2018 (JSW, 2016).

In Slovakia, the BAŇA ČÁRY company reportedly plans to expand annual production at the Gbely mine (SK02) from 170 000 to 500 000 tonnes (Euracoal, 2020a).

Other expansions have been contested. In 2016, a decision was made to scale back the Garzweiler opencast mine in Germany (DEA1) after plans to complete a third resettlement segment of the mine, requiring the relocation of 1 400 people, were dropped following protests (e.g. S&P Market Intelligence, 2020).

In 2018, the main operating plan for the open-pit mine, Hambach, in Germany (DEA2), covering the 2018-2020 period, entailed the expansion of the mine and the consequent clearing of the Hambach forest. A legal complaint against the plan's approval was filed by the German Federation for the Environment and Nature Conservation and a final decision on the case is expected by the end of 2020.

In 2019, a Romanian court stalled expansion at Rosia mine (RO41) following a legal challenge to the mine's environmental permit lodged by Bankwatch Romania. Expansions at the nearby Jilț and Rosiuta mines were carried out in 2015 and 2018 (Bankwatch, 2019).

4.2.2 Peat and oil shale sites

In Estonia, oil shale closures have been ongoing since 2002, with the closure of Tammiku mine, Aidu open-cast mine in 2012 and Viru mine in 2013. Nevertheless, there are huge resources left and depending on oil shale demand, new mining permits were acquired and new mines, mainly underground ones, were (and are being) opened. For example, the latest four permits acquired in 2019 will expire in 2034 (one permit) and in 2049 (three permits). At the same time, as of August 2020, there were already three applications submitted to the Environmental Board for new oil shale mining permits. At present, several new mining areas for oil shale are in the exploration phase, e.g. Estonia 2, Sonda, Sonda II and Oandu.

As regards peat, Estonia has recently seen announcements regarding the closure of 4 out of 26 of their peat extraction sites (Sangla Turvas in 2017, Põlva Maaparandus AS in 2018, Turvas AS in 2019 and ERA Turvas OÜ for 2020). There are no more announcements of future closures and the current extraction permits will be in force until 2050. There are currently 25 registered new exploitation solicitations for latent deposits. As the reserves far exceed the current demand, there is no clear risk of employment reduction in any link of the peat value chain.

Finland's National Energy and Climate Plan (NECP) foresees halving the use of peat in energy production by 2030. According to the Finnish government programme, "the use of peat primarily as an energy source will be discontinued during the 2030s as the cost of the emissions allowance rises, although it will remain in use to ensure security of supply" (Finnish Government, 2019). However, a peat-favourable taxation scheme remains in force. According to the Organisation for Economic Co-operation and Development (OECD), Vapo Oy (50.1 % state-owned and one of the world's largest peat producers) is expected to halve its peat production in the next 10 to 15 years. In December 2019, it decided to discontinue energy peat production in about 90 of its sites. Thermal end uses can mostly find substitutes for peat, depending on the local conditions.

In Ireland, the current government includes in its Programme for Government a target of cutting carbon emissions by 7 % each year through 2030. Bord na Móna, the semi-state-owned company established under the Turf Development Act 1946, has ceased the harvesting of peat for energy since June 2020. It has also closed two of the power stations burning peat since April 2020, with a plan to close the third power station in 2023. The company has allocated EUR 18 million for peatland restoration and rehabilitation measures. Within the Just Transition Programme in the Midlands, there is a EUR 108 million fund for Bord na Móna's large-scale peatlands restoration project. The plan is expected to ensure the storage of 100 MtCO2 and to sequester 3.2 MtCO2 out to 2050 while creating 350 jobs.

In Sweden, while the current climate law in force has clear emission reduction targets for 2030 (-63 % from 1990) and 2040 (-75 % from 1990), there are no specific provisions or complementary plans regarding the use of peat (Swedish Environmental Protection Agency, 2020). This is also the case for the country's NECP, where peat is only mentioned very briefly and without any context for future use.

The almost purely agricultural peat producers, Lithuania and Latvia, do not address specific programmes to their contained fuel peat use. Lithuania has no plans to reduce fuel peat use due to its very reduced weight in total energy consumption. In Latvia, fuel peat is hardly mentioned in planning documents. The Energy Development Guidelines for 2016-2020 (Republic of Latvia, 2016) mention that extraction of peat provides certain potential for ensuring energy independence. Concurrently, it states that it is important that the use of peat does not endanger achievement of the GHG emission reduction targets. Latvia's NECP mentions that peat was produced in Latvia on a small scale but sets a task to abolish the CO_2 natural resource tax exemption for peat fuel by 2030.

4.3 Impacts of power plant retirement on employment

4.3.1 A snapshot of European coal power plants – age and new entries

Coal-fired power plants are typically designed for a service life of more than 25 years without significant upgrades. However, the service life can be significantly extended beyond that timeframe by replacing or upgrading components.

The average age of a coal power plant in the EU is 35 years, with an estimated efficiency of 35 %[45]. The vast majority of coal-fired plants in Europe started their operation more than 30 years ago.

The new coal-fired capacity under construction or expected to come online until 2025 is shown at country level in Table 12. However, Greece is reportedly planning to phase out the use of coal in power generation by 2028.

Table 12. Coal power plant capacity under construction or expected to come online before 2025[46]

Country	Capacity (MW)
Greece	660
Poland	1 479

Source: JRC, 2020.

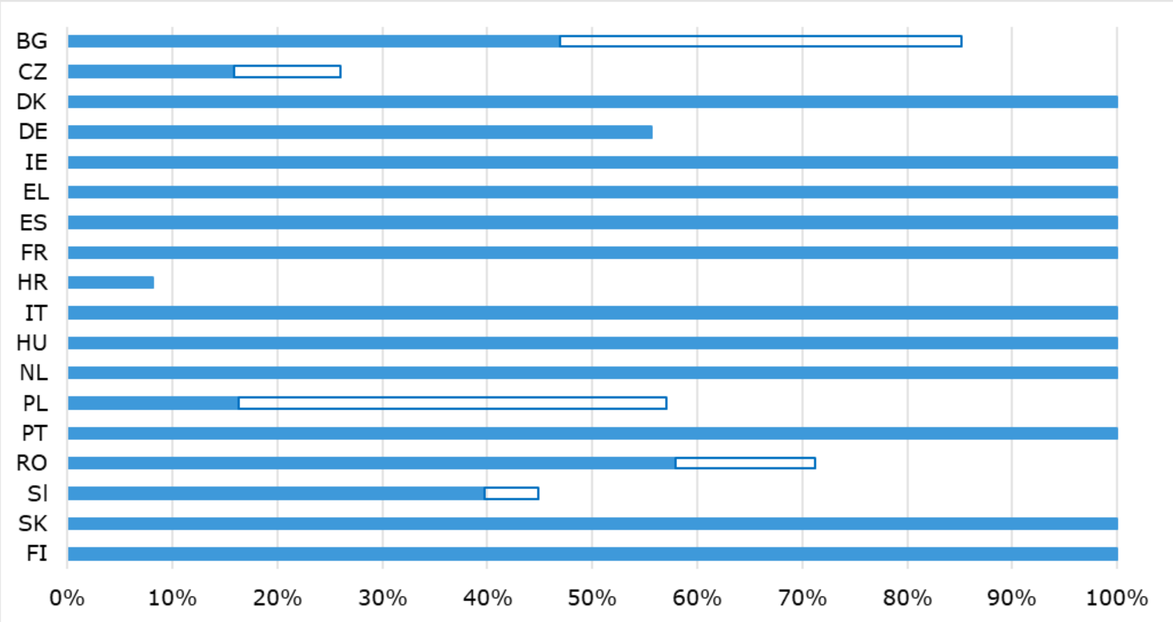
[45] JRC-PPDB: weighted average of class-based or real data efficiency
[46] See Annex 7 for details.

4.3.2 Expected coal fleet decommissioning

We used information from the NECP reports provided by Members States containing their expectations on future coal- and lignite-fuelled capacity in 2030. We complemented this information with 2030 installed capacity data based on ENTSO-E's TYNDP 2016 – vision 4 scenario[47]. The latter are compatible with the assumptions used in the 2018 JRC report (Alves Dias, P., et al., 2018). Calculated decommissioning rates of existing coal-fired power plants per country are provided in the figure below.

The white bars in Figure 47 provide the corresponding increase in decommissioning rate if accelerated decommissioning resembling anything like ENTSO-E's vision 4 scenario takes place.

Figure 47. Calculated decommissioning fractions for existing (2020) coal fleets by 2030



Source: JRC, 2020.

4.3.3 Risk for job losses in power plants at national level

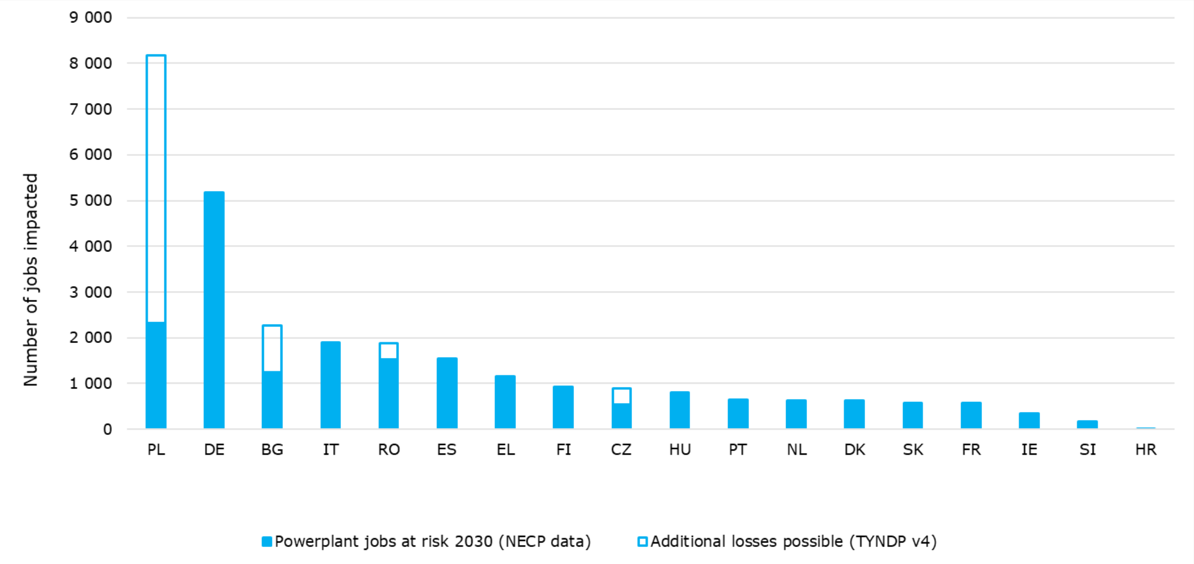
In the previous section, the analysis revealed the level of coal capacity in each Member State that is likely to retire within the coming decade. In this section, this is translated into direct job losses. Direct job losses are calculated based on the country coefficients presented in section 2.1.3.1 and provided in Annex D. These coefficients are directly applied to the capacity expected to be decommissioned and not replaced by new capacity, under the assumption that plant personnel from decommissioned units are re-deployed to new power plants to meet the new employment needs (no productivity improvements are considered).

Some Member States provided information on installed capacities of power plants using coal in 2030 in their National Energy and Climate Plans (NECPs). For several Member States, we calculated the installed capacity in 2030 based on planned power generation from coal. Based on the relevant information provided by Member States in their respective NECPs, the expected direct job losses in power plant operation due to coal-

[47] https://tyndp.entsoe.eu/2016/insight-reports/future-system/

fired power plant decommissioning by 2030 could reach 21 000 jobs – that is half of the estimated current employment in this activity. The probable impact at country level is presented in Figure 48. The white bars provide the corresponding increase in job losses if the decommissioning takes place as described in ENTSO-E's[48] vision 4[49] scenario.

Figure 48. Probable impact of power plant decommissioning on jobs at country level (NECP data)



Source: JRC, 2020.

The countries most impacted are Germany, Poland, Italy, Romania, Spain and Bulgaria. The white bars denote the potential impact on employment in power generation caused by a possible decision to adopt a more ambitious decarbonisation pathway involving less coal, similar to the one analysed in ENTSO-E's vision 4.

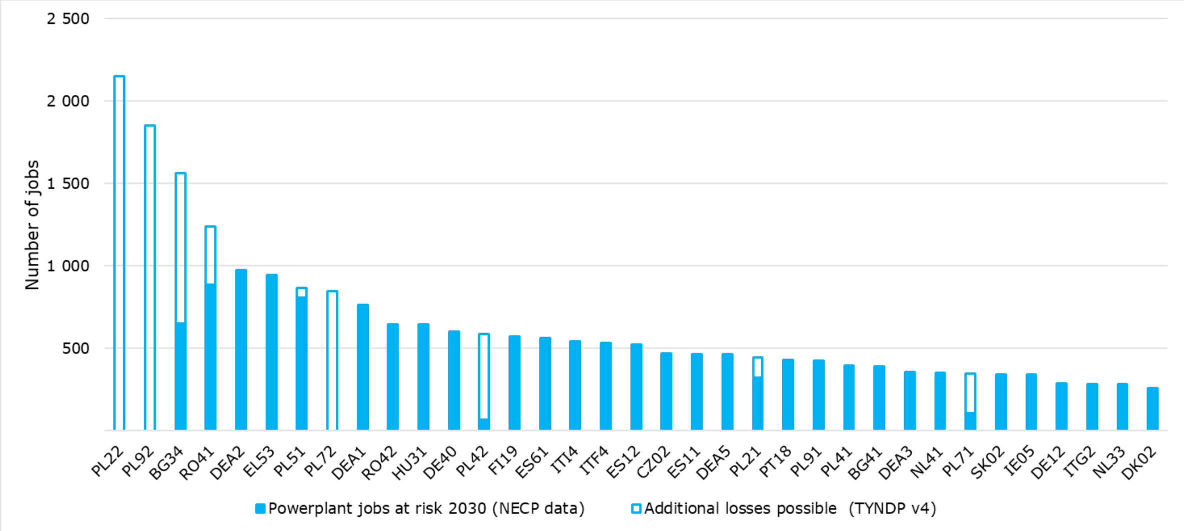
4.3.4 Risk for job losses in power plants at NUTS 2 regional level

To distribute the considered job loss potential to regions, the decommissioning rates calculated at country level are applied to the plant fleet in a "survival-of-the-fittest" assessment based on efficiency and age criteria. Through this approach we assume that the most modern units will be in operation in 2030 with a total capacity equal to or marginally exceeding (due to the last plant block) the coal fleet capacity provided in the NECP reports. The methodology was identical to that applied in the 2018 report (Alves Dias, P., et al., 2018).

The probable impact at NUTS 2 regional level is shown in Figure 49 for the regions with the highest impact (loss of more than 350 jobs).

[48] ENTSO-E, the European Network of Transmission System Operators for Electricity.
[49] https://tyndp.entsoe.eu/2016/insight-reports/future-system/

Figure 49. Probable impact of power plant decommissioning on jobs at NUTS 2 regional level (NECP data)



Source: JRC, 2020.

The most affected regions, losing close to 1 000 jobs, will be in Germany and Greece, followed by Romania, Poland and Bulgaria: Köln (DEA2), Dytiki Makedonia (EL53), Sud-Vest Oltenia (RO41), Dolnośląskie (PL51), Düsseldorf (DEA1) and Yugoiztochen (BG34) are the regions with the highest potential losses.

As above, the white bars denote the deviation of expected job losses if the coal phase-out is realised according to the NECPs, as opposed to a more ambitious scenario (in this case TYNDP 2016 – vision 4). The two Polish regions PL22 and PL92[50] would be impacted in a more profound coal phase-out plan. This appears not to be the case under the current Polish energy and climate plan.

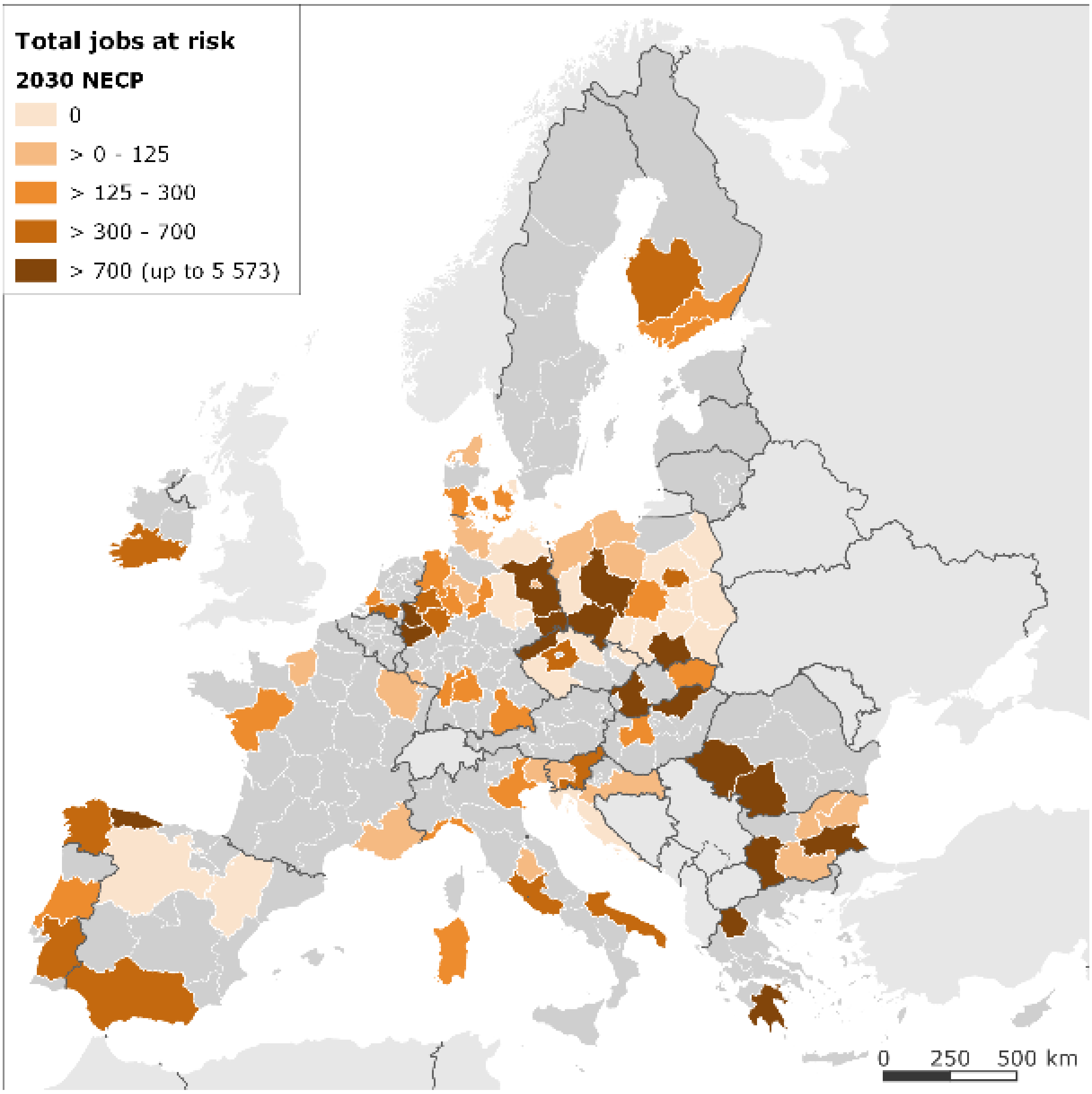
4.4 Impacts on overall direct employment in the coal sector

4.4.1 Potential job losses between 2020 and 2030

Potential job losses over time were estimated at NUTS 2 level as the sum of power plant and mining jobs at risk. Results obtained for each one of the two coal phase-out scenarios (NECP and TYNDP) are presented in Figure 50 and Figure 51.

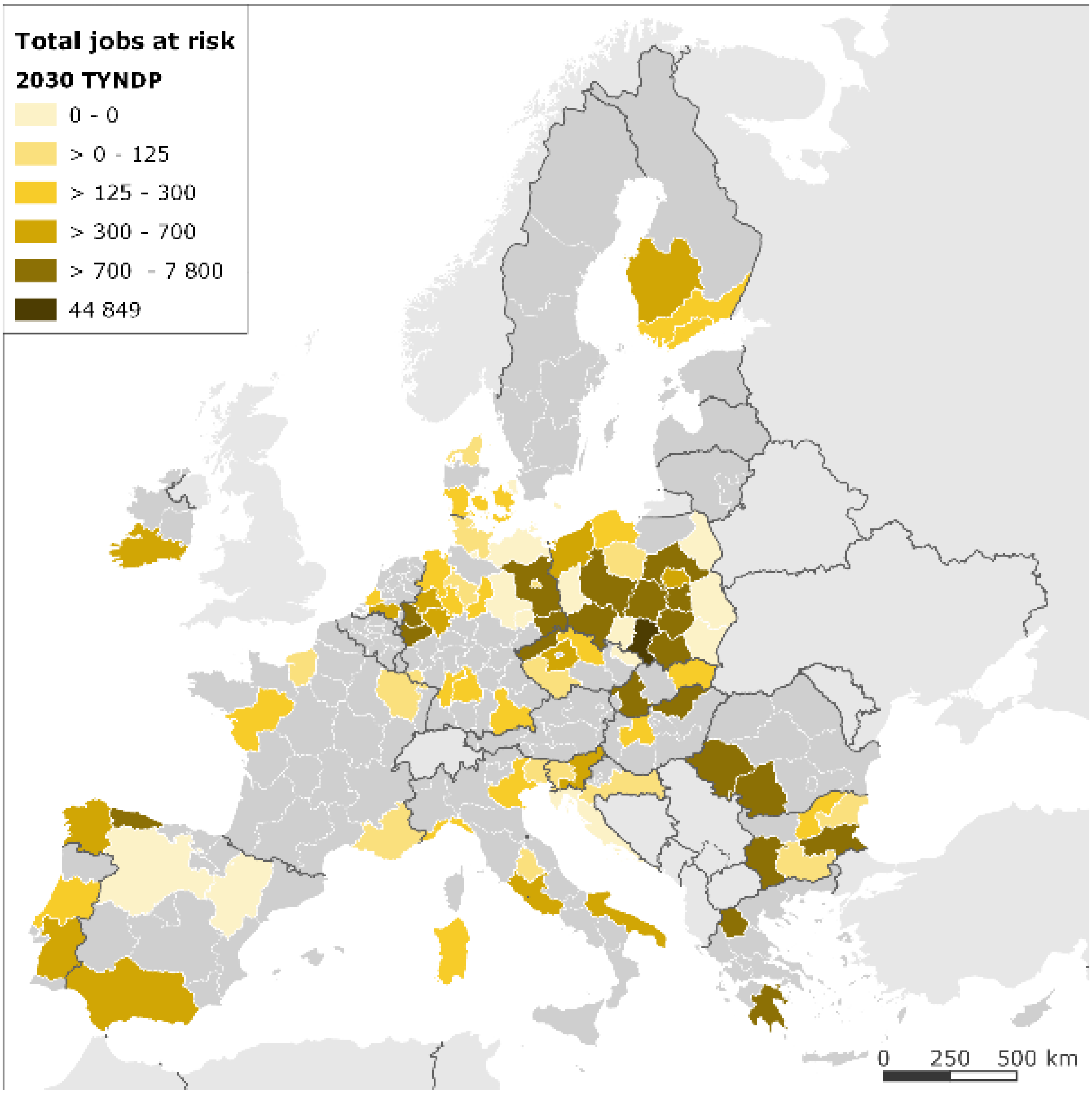
[50] Previously part of PL12 according to the 2013 NUTS2 classification.

Figure 50. Potential job losses in 2020-2030 in the coal sector (including coal mines and power plants) based on the NECP coal phase-out scenario



Source: JRC, 2020.

Figure 51. Potential job losses in 2020-2030 in the coal sector (including coal mines and power plants) based on the TYNDP coal phase-out scenario



Source: JRC, 2020.

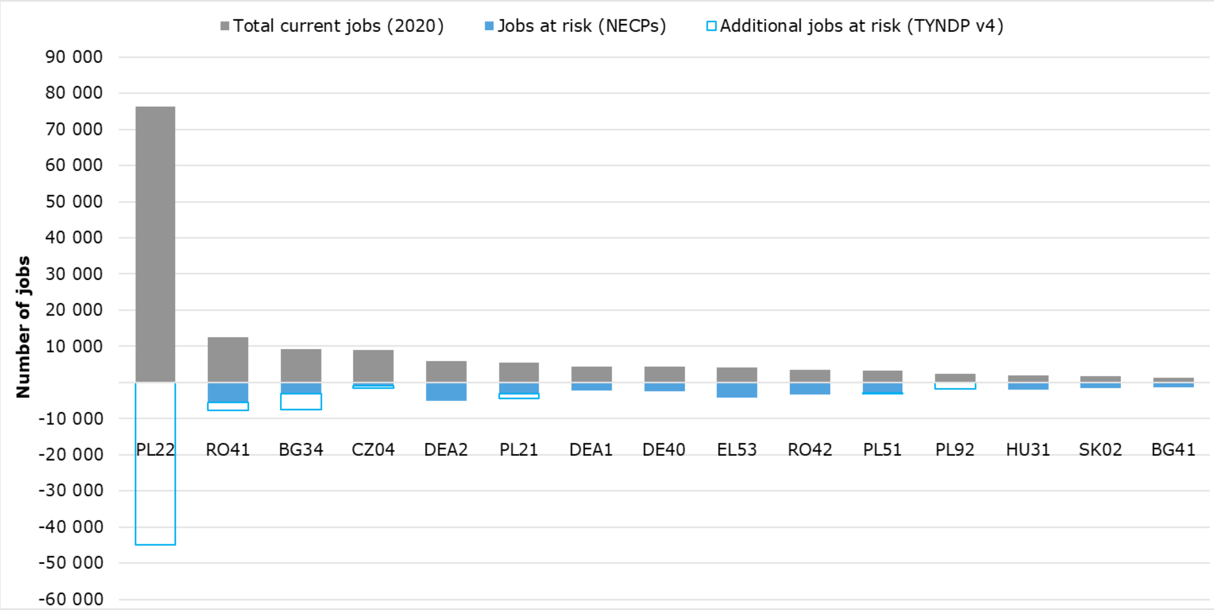
Between 2020 and 2030, the most significant job losses are expected in Romania (RO41 and RO42), Germany (DEA2), Greece (EL53), Poland (PL21) and Bulgaria (BG34), with more than 3 000 potential losses each under both coal phase-out scenarios. Under the TYNDP scenario, regions PL22 and PL51 could also accumulate losses of a comparable magnitude. In particular, PL22 could sustain the highest number of potential losses in power plants and mines: up to 45 000 in total.

Under both scenarios, between 1 000 and 3 000 jobs could become redundant in Poland, Germany, Hungary, Slovakia, Bulgaria, Greece and Czechia.

4.4.2 Potential job losses against total current jobs

Figure 52 presents potential employment losses against total current employment in coal activities in each region. The blue bar portrays coal jobs at risk (potential employment losses) by 2030, based on the coal fleet status in 2030 provided by Member States in their NECPs. The white-filled bars provide the additional potential losses after the realisation of a phase-out scenario similar to the one outlined in the TYNDP V4 scenario. Grey bars show the total estimated coal-related jobs for 2020.

Figure 52. Jobs at risk in 2030 in the coal sector at regional level



Source: JRC, 2020.

The loss of a significant proportion of current jobs related to coal activities (total employment) will have an impact on regions in Romania, Bulgaria, Greece and Germany. However, one region, Śląskie (PL22), stands out due to the sheer number of jobs (currently above 75 000), and consequently the exposure to risk if a coal phase-out plan takes place. A coal fleet reduction similar the one outlined in the TYNDP V4 scenario could affect 45 000 direct coal-related jobs in Śląskie.

The total estimated number of direct coal-related jobs at risk by 2030, according to the NECPs, amounts to 54 000. This number could increase to 112 000 in a scenario involving a faster transition away from coal.

4.5 Peat and oil shale: potential impacts on employment

Peat

The fuel peat value chain is distributed across different sectors. Peat extraction can produce output for agriculture and fuel peat can be used in power plants and district heating networks or distributed as fuel briquettes. However, it is very often the case that foresight scenarios do not model explicitly the evolution of peat or oil shale.

Therefore, the possible future impacts of the evolution of peat and oil shale are classified according to the following categories:

- Certain (2): known impacts based on current knowledge. Derived from the announcement of extraction site closures, impending end of life of energy plants and assumed policy targets.
- Likely (1): impacts for which the level of certainty cannot be established. For example, switching fuel use may not have any impact on the employment level of a co-firing plant, but purely on its supply chain.

- Unlikely (0): there is no evidence of a definite risk for the type of activity and employment considered.

In assessing the risk to existing employment we have considered the possible influence of public, private and market forces.

Table 13. Risk scoring for total direct employment averaged for public, private and market factor for each scope country

2018	FTE	% Active population	RISK 2020-2025	RISK 2025-2030	RISK 2030-2040
EE	781	0.124	0	0	1
FI	4 106	0.167	1	2	2
IE	326	0.015	2	2	2
LT	37	0.003	0	0	1
LV	26	0.003	0	0	1
SE	1 038	0.021	0	0	1

Source: JRC, 2020.

Table 13 shows that Ireland's employment is the most clearly exposed to risk, given the unambiguous measures taken by the government and implemented by market and private forces. The direct employment impacted accounts for 0.015 % of the economically active population nationally. The risk has no national dimension, but local measures are required. Finland, the biggest employer at 0.167 % of its active population, sees a growing exposure at the maximum level of certainty, as announced targets for 2030 come into force. While this is not an issue in the short term, the sooner corrective measures are put in place, the easier it will be to ensure a just transition in local terms. For the remaining countries in the analysis, i.e. Estonia, Latvia, Lithuania and Sweden, current conditions do not reveal a high risk for registered employment. Only as EU-wide targets become more stringent will the peat sector start to be influenced.

Oil Shale

In Estonia, due to stricter new environmental requirements, particularly for air emissions (sulphur compounds, nitrogen compounds, fine particles, etc.), the older oil shale energy units that no longer comply with the new requirements are gradually being decommissioned from 2016 to 2024, reducing capacity by 619 MW. The remaining pulverised combustion units will close down by 2031, leaving three units based on fluidised bed combustion technology in operation, with a total capacity of 700 MW. It should be noted that these data on potential closures are based on very preliminary information/estimations.

According to the Development Plan for the Energy Sector until 2030 (Estonian Goverment, 2017), the reduction in capacity of oil shale-fuelled power plants would correlate with oil shale production. While the general projected trend in electricity generation is an increasing share of generation capacities based on renewable sources such as wind and biomass, no clear plans can be found in Estonia's NECP for supplanting peat or oil shale. As such, there is no risk that can be assessed with any level of certainty as regards current levels of employment.

4.6 Key points

- Nine regions face an estimated job loss potential exceeding 1 000 direct jobs in coal-fired power plants, while for one region more than 2 000 jobs could be at risk.
- By 2030, depending on the scenario, 60-75 GW of coal-fired capacity (half to two-thirds of_the EU coal-fired fleet in 2020) is expected to retire. The lower value is based on information published by Member States in their national energy and climate plans. Most of the capacity due for retirement is present in Germany, Italy, Spain, Poland and the Netherlands.
- The analysis based on mine competitiveness criteria indicates that around 86 000 coal mining jobs face a high risk of redundancy due to the potential closure of uncompetitive mines.
- It is estimated that from 2018 to 2020, 12 149 jobs are at risk in coal mining across 15 regions. After 2020, this number could rise to 30 839, given the application of national coal phase-out policies in electricity generation, or up to 80 848 if TYNDP coal phase-out scenarios are considered. Over the same period, additional employment losses resulting from the planned closure of mines reaching the end of their operational life within approved mining limits may reach 2 400 in Czechia and Germany.
- Few investments in new mining capacity have been made over recent years. In the EU-27, there is one mine planned for construction targeting high-rank coking coal products. Mine expansions at existing sites have also been limited and contested in many cases.
- Between 2020 and 2030, total job losses in power plants and mines are likely to increase to 54 000 jobs under the NECP scenario and to around 112 000 jobs under the TYNDP coal phase-out scenario.
- One region in Poland may lose up to 45 000 jobs, and three other regions in Romania, Bulgaria and Germany more than 5 000 jobs each.
- Peat production for energy use is prominent only in Finland and Ireland. The substantial agricultural industry of Estonia, Latvia, Lithuania and Sweden should not be affected by the energy transition at first.
- The risk assessment of jobs associated with peat use for energy shows an immediate risk only for Ireland, where a decision to stop using peat has already been made. In the other countries, the risk is very low, on a very low share of the working population.

5 Mapping of carbon-intensive industries

5.1 Overall coal consumption in carbon-intensive industry

Besides the energy sectors, the carbon-intensive industries also use coal as feedstock and fuel. Carbon-intensive industries (CII) produce steel, cement, chemicals, paper and other primary industrial products, and together account for 96 % of coal use in industry. In the Eurostat energy balances (Eurostat, 2020b), the industry sectors are grouped into iron and steel; non-metallic minerals; chemical and petrochemical; paper, pulp and printing; and non-ferrous metals. In the EU-27 in 2018, all these sectors used some 49 000 ktoe of coal. The biggest coal user by far is the iron and steel industry, accounting for 85 % of the total coal used by carbon-intensive industry. The share of coal use in carbon intensive industries represents 23 % of the overall coal use in the total EU economy.[51]

Table 14. EU-27 coal use in carbon-intensive industry in 2018

EU-27 (2018)	**Total solid fossil fuels (ktoe)**
Iron & steel	41 560
of which coking coal	*29 913*
Non-metallic minerals	3 907
Chemical & petrochemical	2 623
Paper, pulp & printing	754
Non-ferrous metals	338

Source: JRC with data from Eurostat [nrg_bal_c], 2020.

Iron and steel

Currently in the EU, 60 % of steel is produced via the integrated blast furnace route. In this production process, coal and coke are extensively used both as a fuel source and as a reducing agent. In the blast furnace, coke reduces iron oxides into liquid iron by removing oxygen, forming CO_2 as a side product.

Coke is produced from a specific type of high-grade coal, called coking coal, in coke oven plants, usually on the same site as the blast furnace. Due to its reducing properties, as well as its physical properties as a support material in the blast furnace, coke cannot be wholly replaced by other fuels or coal.

Table **15** shows the use of coal (including coke) in the iron and steel industry at national level in 2018. Germany is the largest steel producer in the EU (Eurofer, 2019) and produces 70 % of its steel via the integrated route (WV Stahl, 2020), consequently it is also the largest user of coal in the iron and steel industry.

[51] "Total energy supply" in Eurostat.

Table 15. Coal use by Member State in the iron and steel industry[52]

Iron and steel (2018)	Solid fossil fuels (ktoe)	% of EU-27
Germany	13 191	32 %
France	5 138	12 %
Netherlands	2 864	7 %
Poland	2 702	7 %
Belgium	2 362	6 %
Italy	2 236	5 %
Czechia	2 225	5 %
Slovakia	2 217	5 %
Austria	2 139	5 %
Spain	1 683	4 %
Sweden	1 334	3 %
Finland	1 069	3 %
6 countries[53]	1 490	4 %
EU-27	**41 560**	

Source: JRC with data from Eurostat [nrg_bal_c], 2020.

Non-metallic minerals

Non-metallic mineral products in Eurostat comprise the production of cement, lime, glass and ceramics. About 3 900 ktoe of coal was used in this sector in the EU-27 in 2018. The largest use of coal in this sector is in thermal energy consumption for the manufacture of cement and lime. In the cement industry, coal and pet coke are the primary fossil fuels used. The fuel mix, however, varies widely country by country, as a number of other fuels (natural gas, waste fuels, biomass) are also used (Somers & Moya, 2020).

In glass manufacturing, coal is mainly used in stone wool fabrication, which represents a small share of the glass industry (Schorcht, F., Kourti, I., Scalet, B. M., Roudier, S., & Delgado Sancho, 2013). In the ceramics industry, most kilns are gas-fired, but top feeding with oil or coal is occasionally practised for specialised brickworks. Due to the limited use of coal in the glass and ceramics sector, the scope of this analysis is restricted to the cement and lime industries.

[52] Includes the share of solid fossil fuels used in coke ovens for the steel industry; solid fossil fuels used in blast furnaces; solid fossil fuels use for final energy consumption in the iron and steel sector.
[53] Hungary (740 ktoe), Romania (731 ktoe), Portugal, Slovenia, Croatia & Luxembourg (<10 ktoe each).

Table 16 shows that Germany is the largest user of coal in the non-metallic minerals sector, however all countries, with the exception of Malta, use some amount of coal in this sector.

Table 16. Coal use by Member State in the non-metallic metals industry

Non-metallic minerals (2018)	**Solid fossil fuels (ktoe)**	**% of EU-27**
Germany	1 322	34 %
Poland	585	15 %
Belgium	348	9 %
France	268	7 %
Czechia	173	4 %
Italy	169	4 %
Sweden	154	4 %
Greece	115	3 %
Rest of EU-27[54]	773	20 %
EU-27	**3 907**	

Source: JRC with data from Eurostat [nrg_bal_c], 2020.

Chemical and petrochemical

In the chemical and petrochemical sector, about 2 600 ktoe of coal was used in the EU-27 in 2018. The coal used in the sector is principally bituminous coal (70 %), with some lignite (14 %) and some anthracite (10 %).

Coal can be used as a fuel source in the production of chemicals, for instance fertilisers and nitrogen compounds.

Table **17** shows that six countries represent 95 % of total EU coal use in this sector, and Poland alone is responsible for nearly half (46 %) of all coal consumption.

Table 17. Coal use by Member State in the chemicals and petrochemicals industry

Chemicals and petrochemicals (2018)	**Solid fossil fuels (ktoe)**	**% of EU-27**
Poland	1 215	46 %
Germany	383	15 %
France	362	14 %

[54] Rest of EU-27: 18 Member States (rest of EU-27 excluding Malta).

Czechia	276	11 %
Bulgaria	169	6 %
Spain	137	5 %
5 countries[55]	81	3 %
EU-27	**2 623**	

Source: JRC, Eurostat [nrg_bal_c], 2020.

Paper, pulp and printing

The pulp and paper industry is a very carbon-intensive sector and relies heavily on biofuels: around 60 % of primary energy consumption comes from biomass. Natural gas accounts for another 33 %, while coal use only represents around 3 % of final energy consumption (Confederation of European Paper Industries, 2019).

Table 18 shows that the use of coal in the pulp and paper industry is mainly restricted to Germany, Poland and Austria.

[55] Romania (35 ktoe), Austria (22 ktoe), Denmark (14 ktoe), Belgium (9 ktoe), Italy (1 ktoe).

Table 18. Coal use by Member State in the paper, pulp and printing industry

Paper, pulp and printing final energy consumption (2018)	**Solid fossil fuels (ktoe)**	**% of EU-27**
Germany	308	41 %
Poland	168	22 %
Austria	88	12 %
Hungary	50	7 %
Finland	37	5 %
Czechia	33	4 %
Belgium	32	4 %
4 countries[56]	39	5 %
EU-27	**754**	

Source: JRC, Eurostat [nrg_bal_c], 2020.

5.2 Coal consumption by industry in coal regions

The list of industrial facilities was obtained from the Emissions Trading System (ETS) registry, extracted on 15 April 2020 (European Commission, 2020). The facilities were geolocated using existing geolocation data within the JRC and when not available, the locations were obtained using web-crawling techniques based on the Google Maps Platform[57].

The coal consumption per country and industry sector was obtained from Eurostat's final energy balances, using the most recently available 2018 data (Eurostat, 2020b). In order to allocate the national coal consumption to individual facilities, the verified emissions per facility in the ETS registry were used as a proxy. The total national coal consumption in each sector was allocated proportionally to the emissions of each facility in the respective sector and country.

The industry sector for each of the facilities was determined based on their ETS registry activity code. The scope of this analysis covers the production of iron and steel, cement and lime, chemicals, and pulp and paper. As the ETS activity codes delimit industrial activity differently from the NACE activities[58] used in the Eurostat final energy balances, where possible the final list of facilities was further refined by their NACE codes to produce a better sectoral correspondence between the facilities from the ETS registry and the Eurostat energy balances.

Table 19 below shows coal use by industrial activity in the EU-27 coal regions.

[56] Slovenia (22 ktoe), France (11 ktoe), Sweden (5 ktoe), Bulgaria (1 ktoe).
[57] https://cloud.google.com/maps-platform
[58] NACE is the statistical classification of economic activities in the European Union.

Table 19. Coal use in carbon-intensive industry by current and former coal region

Country code	NUTS 2	Cement and lime (ktoe)	Chemicals (ktoe)	Pulp and paper (ktoe)	Iron and steel (ktoe)	Total CIIs (ktoe)
DE	DEA1	94	8	6	5 792	5 899
DE	DEC0	-	-	-	2 553	2 553
CZ	CZ08	7	81	10	2 200	2 298
PL	PL22	35	-	-	1 662	1 697
ES	ES12	1	1	-	1 249	1 251
DE	DE40	72	-	-	653	725
PL	PL21	1	104	14	537	656
PL	PL81	48	415	57	-	520
DE	DEE0	122	79	64	32	296
DE	DEA3[a)]	120	13	10	151	294
DE	DEA2	-	110	88	52	250
ES	ES21[a)]	1	-	-	140	141
SK	SK02	13	-	-	84	97
DE	DED5	-	38	30	-	68
PL	PL71	68	-	-	-	68
DE	DED2	-	-	-	66	66
HU	HU31	-	-	32	23	55
RO	RO41	1	27	-	11	39
PL	PL51	1	-	-	38	38
RO	RO42	7	-	-	13	20
CZ	CZ04	19	-	-	-	19
ES	ES42[a)]	1	13	-	-	13
ES	ES24[a)]	0	-	-	8	8.3
ES	ES41[a)]	1	1	-	6	7.8

Country code	NUTS 2	Cement and lime (ktoe)	Chemicals (ktoe)	Pulp and paper (ktoe)	Iron and steel (ktoe)	Total CIIs (ktoe)
IT	ITG2[a)]	5	0	-	-	4.9
BG	BG41	3	-	-	-	3.3
BG	BG34	1	-	-	-	0.6
GR	EL65	0	-	-	-	0.4

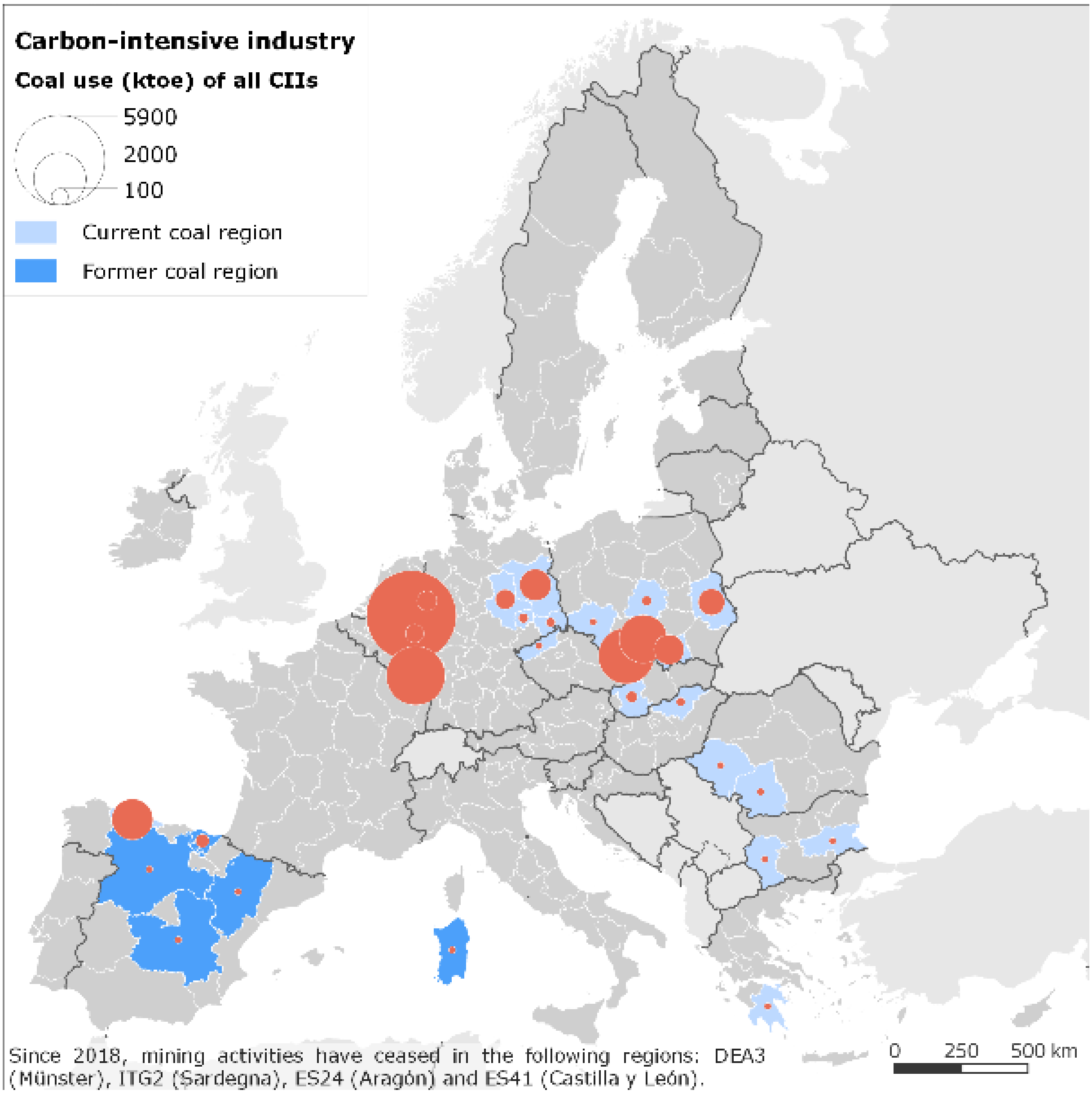
a) Formerly identified as a coal region – production terminated.

Source: JRC, 2020.

The coal consumption by carbon-intensive industries in current and former coal regions.

In the coal region DEA1 (Düsseldorf), the steel industry alone accounts for 34 % of the coal consumption of all carbon-intensive industries in all coal regions combined. This is due to the Thyssenkrupp steelmaking site in Duisburg, which is the largest steelmaking site in the EU.

Figure 53. Coal consumption by carbon-intensive industries in current and former coal regions



Source: JRC, 2020.

5.3 Peat and oil shale consumption by industry

Peat and oil shale are used for energy purposes in specific industry sectors in only two EU Member States. Peat is used in Finland in the pulp and paper industry, while oil shale is used only in Estonia, in the non-metallic minerals sector.

Table 20. Peat and oil shale use in carbon-intensive industry in 2018

	Peat	Oil shale
ktoe	**Paper, pulp and printing**	**Non-metallic minerals**
Finland	157	
Estonia		22

Source: JRC, 2020.

Peat and oil shale use was assigned to the regions at NUTS 2 level in these two countries using the same methodology as for coal use.

Peat use in the pulp and paper industry in the peat regions of Finland is shown at NUTS 2 level in Table 21 below.

Table 21*.* Peat use for industry in Finnish peat regions in 2018

Country code	NUTS ID	Peat use in pulp and paper (ktoe)
FI	FI1C	72
FI	FI1D	54
FI	FI19	28

Source: JRC, 2020.

Oil shale use in industry in Estonia is shown at NUTS 2 level in Table 22 below.

Table 22. Oil shale use for industry in Estonian oil shale region in 2018

Country code	NUTS 2	Oil shale use in cement and lime (ktoe)
EE	EE00	22

Source: JRC, 2020.

5.4 Key points

- Coking coal is a vital ingredient for the steel industry and is identified as a critical raw material by the EC.
- Poland and Czechia lead the production of coking coal in EU.
- Coking coal (or anthracite) mines in these countries are located in ŚlaskieŚląskie (PL22), and Moravskoskezsko (CZ08), which are identified as high risk for competitiveness reasons.
- The biggest coal user by far is the iron and steel industry, accounting for 85 % of the total coal used. Germany is the largest user of coal in the iron and steel industry.
- Germany is the largest user of coal in the non-metallic minerals sector, but all

EU-27 countries, with the exception of Malta, use some amount of coal in this sector.

- Poland is responsible for nearly half (46 %) of all coal consumption in the chemicals and petrochemicals sector.
- Use of coal in the pulp and paper industry is mainly restricted to Germany, Poland and Austria.
- 25 out of the 29 regions with operating coal mines by 2018-19 use coal in their carbon-intensive industry.
- Peat and oil shale are used in Finnish and Estonian pulp and paper and cement and lime industries, respectively.

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List of abbreviations and definitions

CII – Carbon Intensive Industry

CCS – Carbon Capture and Storage

CCU – Carbon Capture and Use

CHP – Combined Heat and Power

DG COMP – Directorate General for Competition

DG ENER – Directorate General for Energy

JRC – Directorate General Joint Research Centre

EU – European Union

EURACOAL – European Association for coal and lignite

ENTSO-E – European network of transmission system operators for electricity

FTE – Full Time Equivalent

GAE – Gross Available Energy

GHG – Green house gas

GW – gigawatt

IEA – International energy Agency

IO – Input/Output

JRC-PPDB – JRC Power Plant Database

JTM – Just Transition Mechanism

Mt – Million tonnes

MW – megawatt

NEP – National Experts Pool

NECP – National Energy and Climate Plans

NUTS – Nomenclature of territorial units for statistics

NUTS-2 – Basic regions for the application of regional policies

NUTS-3 – Small regions for specific analysis

OECD – Organisation for Economic Co-operation and Development

OP – Open-pit or opencast mine

TJ - Terrajoule

TYNDP – Ten-Year Network Development Plans

UG – Underground mine

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Appendices

A. Coal-fired power plant capacity in EU Member States, aggregated at NUTS 2 level

NUTS 2	NUTS name	Country	Type	Capacity (MW)	Average age (yrs)
BG32	Severen tsentralen	Bulgaria	Hard coal	290	45
BG33	Severoiztochen	Bulgaria	Hard coal	132	11
BG34	Yugoiztochen	Bulgaria	Lignite	3 398	40
BG41	Yugozapaden	Bulgaria	Lignite	675	52
BG42	Yuzhen tsentralen	Bulgaria	Lignite	120	49
CZ02	Střední Čechy	Czechia	Lignite	1 261	34
CZ03	Jihozápad	Czechia	Lignite	111	51
CZ04	Severozápad	Czechia	Lignite	3 269	44
CZ05	Severovýchod	Czechia	Lignite	1 116	42
CZ05	Severovýchod	Czechia	Hard Coal	149	42
CZ08	Moravskoslezsko	Czechia	Hard coal	549	37
DE11	Stuttgart	Germany	Hard coal	1 114	29
DE12	Karlsruhe	Germany	Hard coal	3 318	20
DE21	Oberbayern	Germany	Hard coal	805	32
DE30	Berlin	Germany	Hard coal	371	32
DE40	Brandenburg	Germany	Lignite	4 508	32
DE50	Bremen	Germany	Hard coal	769	33
DE60	Hamburg	Germany	Hard coal	1 600	6
DE80	Mecklenburg-	Germany	Hard coal	514	26
DE91	Braunschweig	Germany	Lignite	0	31
DE91	Braunschweig	Germany	Hard coal	1 090	31
DE92	Hannover	Germany	Hard coal	272	31
DE94	Weser-Ems	Germany	Hard coal	1 483	25
DEA1	Düsseldorf	Germany	Lignite	4 212	45
DEA1	Düsseldorf	Germany	Coal-	705	45
DEA1	Düsseldorf	Germany	Hard coal	1 095	45
DEA2	Köln	Germany	Lignite	4 964	42
DEA3	Münster	Germany	Hard coal	2 533	35
DEA4	Detmold	Germany	Hard coal	875	33
DEA5	Arnsberg	Germany	Hard coal	2 703	39
DEC0	Saarland	Germany	Hard coal	390	38
DED2	Dresden	Germany	Lignite	2 470	27
DED5	Leipzig	Germany	Lignite	1 782	21
DEE0	Sachsen-Anhalt	Germany	Lignite	900	25
DEF0	Schleswig-Holstein	Germany	Hard coal	250	53
DK01	Hovedstaden	Denmark	Hard coal	0	31
DK02	Sjælland	Denmark	Hard coal	787	49

NUTS 2	NUTS name	Country	Type	Capacity (MW)	Average age (yrs)
DK03	Syddanmark	Denmark	Hard coal	749	29
DK05	Nordjylland	Denmark	Hard coal	380	43
EL53	Dytiki Makedonia	Greece	Lignite	2 305	33
EL65	Peloponnisos	Greece	Lignite	511	29
ES11	Galicia	Spain	Hard coal	1 403	42
ES12	Principado de Asturias	Spain	Hard coal	1 571	43
ES24	Aragón	Spain	Hard coal	0	41
ES41	Castilla y León	Spain	Hard coal	0	42
ES61	Andalucía	Spain	Hard coal	1 690	33
FI19	Länsi-Suomi	Finland	Hard coal	948	32
FI1B	Helsinki-Uusimaa	Finland	Hard coal	365	43
FI1C	Etelä-Suomi	Finland	Hard coal	220	56
FRD2	Haute-Normandie	France	Hard coal	580	37
FRF3	Lorraine	France	Hard coal	595	39
FRG0	Pays de la Loire	France	Hard coal	1 160	37
FRL0	Provence-Alpes-Côte	France	Hard coal	595	36
HR03	Jadranska Hrvatska	Croatia	Hard coal	210	20
HR02	Panonska Hrvatska	Croatia	Hard coal	19	30
HU21	Közép-Dunántúl	Hungary	Lignite	220	58
HU31	Észak-Magyarország	Hungary	Lignite	853	44
IE05	Southern	Ireland	Hard coal	855	34
ITC3	Liguria	Italy	Hard coal	520	21
ITF4	Puglia	Italy	Hard coal	1 815	28
ITG2	Sardegna	Italy	Hard coal	966	36
ITH3	Veneto	Italy	Hard coal	860	49
ITH4	Friuli-Venezia Giulia	Italy	Hard coal	315	53
ITI2	Umbria	Italy	Hard coal	130	31
ITI4	Lazio	Italy	Hard coal	1 845	10
NL33	Zuid-Holland	Netherlands	Hard coal	1 801	7
NL41	Noord-Brabant	Netherlands	Hard coal	2 223	17
PL21	Małopolskie	Poland	Hard coal	1 074	51
PL22	Śląskie	Poland	Lignite	113	38
PL22	Śląskie	Poland	Coal-	114	38
PL22	Śląskie	Poland	Hard coal	5 414	38
PL41	Wielkopolskie	Poland	Lignite	1 246	42
PL41	Wielkopolskie	Poland	Hard coal	261	42
PL42	Zachodniopomorskie	Poland	Hard coal	1 143	46
PL51	Dolnośląskie	Poland	Lignite	1 488	50
PL51	Dolnośląskie	Poland	Hard coal	310	50
PL52	Opolskie	Poland	Hard coal	3 332	17
PL61	Kujawsko-pomorskie	Poland	Hard coal	394	52
PL63	Pomorskie	Poland	Hard coal	323	48

NUTS 2	NUTS name	Country	Type	Capacity (MW)	Average age (yrs)
PL71	Łódzkie	Poland	Hard coal	5 102	35
PL72	Świętokrzyskie	Poland	Hard coal	305	35
PL82	Podkarpackie	Poland	Hard coal	1 657	39
PL84	Podlaskie	Poland	Hard coal	0	62
PL91	Warszawski stołeczny	Poland	Hard coal	157	29
PL92	Mazowiecki regionalny	Poland	Hard coal	827	60
PT16	Centro (PT)	Portugal	Hard coal	4 697	43
PT18	Alentejo	Portugal	Hard coal	576	26
RO41	Sud-Vest Oltenia	Romania	Lignite	1 180	33
RO42	Vest	Romania	Hard coal	3 545	37
SI03	Vzhodna Slovenija	Slovenia	Lignite	1 150	48
SI04	Zahodna Slovenija	Slovenia	Lignite	844	24
SK02	Západné Slovensko	Slovakia	Lignite	134	48
SK04	Východné Slovensko	Slovakia	Hard coal	330	35

B. Coal mines in EU Member States by NUTS 2 region

NUTS 2	Region name	Country	Type of coal	Mine type	Production (Mt) (2018)	Productivity 2018 (tonnes/employee)	Depth (m)	No. active mines (2018)
BG34	Yugoiztochen	Bulgaria	Lignite, Hard coal insignificant	OP, UG	28.0	3 014	70-300	4
BG41	Yugozapaden	Bulgaria	Lignite, Brown coal	OP, UG	3.4	3 486	<830	9
CZ08	Moravskoslezsko	Czechia	Hard coal	UG	4,5	666	1300	3
CZ04	Severozápad	Czechia	Brown coal	OP	39.3	5 499	<400	5
DEA2	Köln	Germany	Lignite	OP	53.1	11 084	NA	2
DEA1	Düsseldorf	Germany	Lignite	OP	33.2	11 084	NA	1
DE40	Brandenburg	Germany	Lignite	OP	33.0	9 745	110	2
DED2	Dresden	Germany	Lignite	OP	27.7	9 745	NA	2
DEE0	Sachsen-Anhalt	Germany	Lignite	OP, UG	9.3	10 863	NA	2
DED5	Leipzig	Germany	Lignite	OP	10.4	10 318	NA	1
DEA3 (*)	Münster	Germany	Hard coal, Anthracite	UG	2.8	679	800	2
EL53	Dytiki Makedonia	Greece	Lignite	OP	29.1	8 942	150-200	5
EL65	Peloponnisos	Greece	Lignite	OP	7.4	8 942	150-200	1
HU31	Észak-Magyarország	Hungary	Lignite	OP	7.9	5 643	70-270	2
ITG2 (*)	Sardegna	Italy	Lignite	UG	0.0	2	499	1
PL22	Śląskie	Poland	Hard coal	UG	49.4	673	770	16
PL21	Małopolskie	Poland	Hard coal	UG	5.0	1 019	NA	2
PL81	Lubelskie	Poland	Hard coal	UG	9,0	1 998	NA	1
PL71	Łódzkie	Poland	Lignite	OP	44.3	9 375	300	1
PL51	Dolnośląskie	Poland	Lignite	OP	6.5	2 696	NA	1
PL43 (**)	Lubuskie	Poland	Lignite	OP	0.1	NA	NA	1
PL41	Wielkopolskie	Poland	Lignite	OP	7,6	5 254	25-80	2
RO41	Sud-Vest Oltenia	Romania	Lignite	OP	23.5	2 217	NA	6
RO42	Vest	Romania	Hard coal	UG	0.7	232	600	4
SK02	Západné	Slovakia	Brown coal,	UG	1.5	1 069	40-700	3

NUTS 2	Region name	Country	Type of coal	Mine type	Production (Mt) (2018)	Productivity 2018 (tonnes/employee)	Depth (m)	No. active mines (2018)
	Slovensko		lignite					
SI03	Vzhodna Slovenija	Slovenia	Lignite	UG	3.2	2 569	200-500	1
ES12	Principado de Asturias	Spain	Hard coal, Anthracite	OP, UG	0,3	248	450	3 (b)
ES41 (*)	Castilla y León	Spain	Hard coal, Anthracite	OP, UG	0.5	2 098	NA	5 (b)
ES24 (*)	Aragón	Spain	Hard coal	OP, UG (insignificant)	1.6	7 245	NA	2 (b)

(*) extinguished as coal region; production terminated in 2018/2019
(**) Region identified in addition to the 2018 report because information was lacking
(***) Region ES42 is extinguished; production terminated in 2015
(****) Region DE91 is extinguished; production terminated in 2016 (not considered in the previous assessment).

C. Distribution of 2018 direct jobs in coal activities in the NUTS 2 regions

NUTS 2	Name	Country	Power plant jobs	Coal mining jobs	Overall jobs
AT12	Niederösterreich	Austria	202	0	202
AT22	Steiermark	Austria	120	0	120
AT31	Oberösterreich	Austria	0	0	0
BE22	Limburg	Belgium	0	0	0
BG32	Severen tsentralen	Bulgaria	167	0	167
BG33	Severoiztochen	Bulgaria	76	0	76
BG34	Yugoiztochen	Bulgaria	1 959	9 303	11 262
BG41	Yugozapaden	Bulgaria	389	981	1 370
BG42	Yuzhen tsentralen	Bulgaria	69	0	69
CZ02	Střední Čechy	Czechia	667	0	667
CZ03	Jihozápad	Czechia	59	0	59
CZ04	Severozápad	Czechia	2 041	7 147	9 188
CZ05	Severovýchod	Czechia	670	0	670
CZ08	Moravskoslezsko	Czechia	488	6 757	7 245
DE11	Stuttgart	Germany	433	0	433
DE12	Karlsruhe	Germany	799	0	799
DE21	Oberbayern	Germany	194	0	194
DE30	Berlin	Germany	187	0	187
DE40	Brandenburg	Germany	1 085	3 386	4 471
DE50	Bremen	Germany	185	0	185
DE60	Hamburg	Germany	385	0	385
DE80	Mecklenburg-Vorpommern	Germany	124	0	124
DE91	Braunschweig	Germany	347	0	347
DE92	Hannover	Germany	65	0	65
DE94	Weser-Ems	Germany	357	0	357
DEA1	Düsseldorf	Germany	1 447	2 995	4 442
DEA2	Köln	Germany	1 414	4 791	6 205
DEA3	Münster	Germany	356	4 125	4 481
DEA4	Detmold	Germany	211	0	211
DEA5	Arnsberg	Germany	990	0	990
DEC0	Saarland	Germany	427	NA	427
DED2	Dresden	Germany	595	2 843	3 438
DED5	Leipzig	Germany	429	1 006	1 435
DEE0	Sachsen-Anhalt	Germany	217	855	1 072
DEF0	Schleswig-Holstein	Germany	138	0	138
DK01	Hovedstaden	Denmark	82	0	82
DK02	Sjælland	Denmark	258	0	258
DK03	Syddanmark	Denmark	246	0	246
DK05	Nordjylland	Denmark	125	0	125
EL53	Dytiki Makedonia	Greece	1 395	3 254	4 649
EL65	Peloponnisos	Greece	210	828	1 038
ES11	Galicia	Spain	651	0	651

ES12	Principado de Asturias	Spain	688	1 290	1 978
ES24	Aragón	Spain	350	225	575
ES41	Castilla y León	Spain	861	218	1 079
ES42	Castilla-La Mancha	Spain	0	0	0
ES61	Andalucía	Spain	660	0	660
FI19	Länsi-Suomi	Finland	574	0	574
FI1B	Helsinki-Uusimaa	Finland	221	0	221
FI1C	Etelä-Suomi	Finland	300	0	300
FRD2	Haute-Normandie	France	113	0	113
FRE1	Nord-Pas de Calais	France	0	0	0
FRF3	Lorraine	France	115	0	115
FRG0	Pays de la Loire	France	225	0	225
FRL0	Provence-Alpes-Côte d'Azur	France	115	0	115
HR02	Panonska Hrvatska	Croatia	13	0	13
HR03	Jadranska Hrvatska	Croatia	144	0	144
HU21	Közép-Dunántúl	Hungary	166	0	166
HU31	Észak-Magyarország	Hungary	645	1 400	2 045
IE05	Southern	Ireland	342	0	342
ITC3	Liguria	Italy	153	0	153
ITF4	Puglia	Italy	713	0	713
ITG2	Sardegna	Italy	285	160	445
ITH3	Veneto	Italy	253	0	253
ITH4	Friuli-Venezia Giulia	Italy	93	0	93
ITI2	Umbria	Italy	38	0	38
ITI4	Lazio	Italy	544	0	544
NL32	Noord-Holland	Netherlands	173	0	173
NL33	Zuid-Holland	Netherlands	285	0	285
NL41	Noord-Brabant	Netherlands	352	0	352
PL21	Małopolskie	Poland	791	4 908	5 699
PL22	Śląskie	Poland	3 137	73 427	76 564
PL41	Wielkopolskie	Poland	1 078	1 447	2 525
PL42	Zachodniopomorskie	Poland	817	0	817
PL43	Lubuskie	Poland	0	0	0
PL51	Dolnośląskie	Poland	920	2 411	3 331
PL52	Opolskie	Poland	1 705	0	1 705
PL61	Kujawsko-pomorskie	Poland	202	0	202
PL63	Pomorskie	Poland	165	0	165
PL71	Łódzkie	Poland	2 956	4 725	7 681
PL72	Świętokrzyskie	Poland	848	0	848
PL81	Lubelskie	Poland	0	4 508	4 508
PL82	Podkarpackie	Poland	128	0	128
PL84	Podlaskie	Poland	80	0	80
PL91	Warszawski stołeczny	Poland	423	0	423
PL92	Mazowiecki regionalny	Poland	2 403	0	2 403

PT16	Centro (PT)	Portugal	211	0	211
PT18	Alentejo	Portugal	432	0	432
RO41	Sud-Vest Oltenia	Romania	2 360	10 600	12 960
RO42	Vest	Romania	648	3 022	3 670
SI03	Vzhodna Slovenija	Slovenia	491	1 252	1 743
SI04	Zahodna Slovenija	Slovenia	54	0	54
SK02	Západné Slovensko	Slovakia	344	1 403	1 747
SK04	Východné Slovensko	Slovakia	229	0	229

D. Coefficient used in determining direct jobs in power plants

Country	Average unit size (MW)	Country coefficient (Jobs/MW)
Bulgaria	199	**0.58**
Czechia	217	**0.53**
Denmark	349	**0.33**
Germany	476	**0.24**
Ireland	287	**0.40**
Greece	279	**0.41**
Spain	345	**0.33**
France	591	**0.19**
Croatia	168	**0.68**
Italy	389	**0.29**
Hungary	152	**0.76**
Netherlands	724	**0.16**
Austria	191	**0.60**
Poland	224	**0.51**
Portugal	313	**0.37**
Romania	203	**0.56**
Slovenia	284	**0.40**
Slovakia	110	**1.04**
Finland	189	**0.61**

E. Methodology behind the estimation of indirect employment

The IO tables can be defined as a set of sectorally disaggregated regional or national economic accounts. It is a snapshot of flows of products and services in the economy for a single year. The basic principle of the IO table is to identify and disaggregate all of the monetary flows between industries (inter-industry expenditure flows), consumers and industries, and industries with supplies of factors in the economy (Miller & Blair, 2009).

The Input-Output modelling approach is commonly used to assess the economic benefits/losses induced by a given project or investment and it can be very useful whenever the aim is to evaluate the impacts generated by linkages along supply chains. Thus, under a number of assumptions, IO accounts can be used as the basis for economic modelling where exogenous final demands drive total output. The transmission mechanisms linking changes in exogenous demands to changes in aggregate and sectoral activity are called multipliers.

The two key assumptions in IO modelling are: (a) the supply-side of the economy is entirely passive to the level of demand and, (b) the production technology for all sectors is represented by fixed coefficients (i.e. an increase/decrease in the production of any one sector's output means a proportional increase (or decrease) in that sector's input requirements.

A key output from IO analysis is the calculation of the industry linkages (defined as multipliers) used to study the knock-on effects throughout the economy of a change in final demand. IO multipliers allow us to measure how an increase/decrease in the final demand of one sector entails expansionary (or the opposite) effects on the output of intermediate sectors which, correspondingly, increase demand for their own intermediate inputs, and so on. The activity generated by the sum of these demands for intermediate inputs is known as the indirect effect. In this analysis, with some transformations, multipliers are related to changes in employment instead of in the final demand. In other words, indirect job loss/increase can be calculated using direct jobs (without needing to convert jobs into monetary values).

Notice that IO multipliers, describing average effects, do not take account of economies of scale, unused capacity or technological change. Thus, IO multipliers could be used to quantify the economic impact derived from a demand-shock, assuming that the average relationships in the IO table apply at the margin.

The database of IO tables with the regional detail we used is quite unique and the construction methodology has been improved since 2018. Furthermore, since 2018 we have included the EUROSTAT updates of the official national accounts data (value added, employment etc.) to correct statistic discrepancies. Finally, as the system needs to be in equilibrium, all changes made to the data lead to a re-balance process and, thus, new values which have an impact in the employment multipliers calculations.

F. Number of coal indirect jobs at NUTS 2

Region NUTS 2	Country	Intra-regional	Inter-regional	Total
AT12	AT	190	257	447
AT22	AT	156	186	342
BG32	BG	26	32	58
BG33	BG	20	35	55
BG34	BG	2 459	2 277	4 736
BG41	BG	433	254	687
BG42	BG	26	22	48
CZ02	CZ	500	798	1 298
CZ03	CZ	43	40	83
CZ04	CZ	3 123	2 631	5 754
CZ05	CZ	405	502	907
CZ08	CZ	953	882	1 835
DE11	DE	299	323	622
DE12	DE	325	355	680
DE21	DE	145	123	268
DE30	DE	158	105	263
DE40	DE	11 839	16 498	28 337
DE50	DE	25	49	74
DE60	DE	119	219	338
DE80	DE	15	12	27
DE91	DE	104	133	237
DE92	DE	19	21	40
DE94	DE	71	69	140
DEA1	DE	1 133	1 186	2 319
DEA2	DE	1 549	1 984	3 533
DEA3	DE	102	97	199
DEA4	DE	58	72	130
DEA5	DE	425	521	946
DEC0	DE	154	229	383
DED2	DE	298	237	535
DED5	DE	246	342	588
DEE0	DE	101	90	191
DEF0	DE	41	39	80
DK01	DK	11	14	25
DK02	DK	57	110	167
DK03	DK	49	73	122
DK05	DK	27	39	66
EL53	EL	3 002	1 572	4 574
EL65	EL	92	144	236
ES11	ES	1 105	662	1 767
ES12	ES	1 126	824	1 950
ES24	ES	304	323	627
ES41	ES	888	683	1 571

ES61	ES	453	333	786
FI19	FI	526	713	1 239
FI1B	FI	31	22	53
FI1C	FI	26	25	51
FRD2	FR	45	53	98
FRF3	FR	58	55	113
FRG0	FR	142	156	298
FRL0	FR	65	62	127
HR02	HRV	10	1	10
HR03	HRV	109	6	115
HU21	HU	99	176	275
HU31	HU	745	1 149	1 894
IE05	IE	179	49	228
ITC3	IT	5	15	20
ITF4	IT	72	101	173
ITG2	IT	22	20	42
ITH3	IT	355	671	1 026
ITH4	IT	151	773	924
ITI2	IT	67	424	491
ITI4	IT	292	417	709
NL32	NL	115	177	292
NL33	NL	189	277	466
NL41	NL	294	350	644
PL21	PL	827	838	1 665
PL22	PL	7 545	6 363	13 908
PL41	PL	894	1 471	2 365
PL42	PL	421	731	1 152
PL51	PL	845	870	1 715
PL52	PL	898	2 080	2 978
PL61	PL	111	170	281
PL63	PL	105	147	252
PL71	PL	3 355	3 977	7 332
PL72	PL	476	904	1 380
PL81	PL	493	661	1 154
PL82	PL	128	162	290
PL84	PL	48	57	105
PL91	PL	220	226	446
PL92	PL	1 251	1 285	2 536
PT16	PT	268	330	598
PT18	PT	190	237	427
RO41	RO	4 184	2 243	6 427
RO42	RO	3 901	1 536	5 437
SI03	SI	547	275	822
SI04	SI	35	23	58
SK02	SK	754	719	1 473

G. Coal power plants under construction

Unit	Company	Capacity (MW)	Country	Region	Commis-sioning	Status
Constructed since 2017						
Deven 2	Solvay	53	Bulgaria	Yuzhen tsentralen	2017	Operational
Kozienice Unit 11	Elektrownia Wytwarzanie S.A.	1075	Poland	Mazowieckie	2017	Operational
Zabrze	Fortum	220	Poland	Śląskie	2018	Operational
Opole Unit 5	PGE	900	Poland	Opolskie	2019	Operational
Opole Unit 6	PGE	900	Poland	Opolskie	2019	Operational
Ledvice III NZ	CEZ	660	Czechia	Severozápad	2020	Operational
Datteln 4	Uniper Kraftwerke GmbH	1100	Germany	North Rhine-Westphalia	2020	Operational
Under construction						
Jaworzno III unit 7	Tauron	910	Poland	Śląskie	2020	Construction
Turów Unit 11	PGE	460	Poland	Dolnośląskie	2020	Construction
Ptolemaida-V	PPC	660	Greece	Dytiki Macedonia	2021	Construction
Pulawy	Grupa Azoty	109	Poland	Lubelskie	2022	Construction
Planned						
Karvina 2	Veolia	70	Czechia	Moravskoslezsko	2022	Permitted
Rovinari Unit 7	Complexul Energetic Oltenia	600	Romania	Sud-Vest Oltenia	2020	Pre-permit development
Leczna	Enea	500	Poland	Lubelskie	NA	Pre-permit development

Source: https://beyond-coal.eu/database/

H. Potential impact of power plants decommissioning on jobs at NUTS 2 level

NUTS 2	NUTS2 name	Country	Capacity likely to retire 2020-2030 [MW]		Direct power plant jobs potentially impacted	
			NECPs	TYNDP V4	NECPs	TYNDP V4
BG32	Severen tsentralen	Bulgaria	110	290	63	167
BG33	Severoiztochen	Bulgaria	132	132	76	76
BG34	Yugoiztochen	Bulgaria	1 126	2 712	649	1 564
BG41	Yugozapaden	Bulgaria	675	675	389	389
BG42	Yuzhen tsentralen	Bulgaria	120	120	69	69
CZ02	Střední Čechy	Czechia	886	886	469	469
CZ03	Jihozápad	Czechia	0	111	0	59
CZ04	Severozápad	Czechia	141	333	75	176
CZ05	Severovýchod	Czechia	0	348	0	184
CZ08	Moravskoslezsko	Czechia	0	0	0	0
DE11	Stuttgart	Germany	778	778	187	187
DE12	Karlsruhe	Germany	1 196	1 196	288	288
DE21	Oberbayern	Germany	805	805	194	194
DE30	Berlin	Germany	371	371	89	89
DE40	Brandenburg	Germany	2 500	2 500	602	602
DE50	Bremen	Germany	769	769	185	185
DE60	Hamburg	Germany	0	0	0	0
DE80	Mecklenburg-Vorpommern	Germany	0	0	0	0
DE91	Braunschweig	Germany	967	967	232	232
DE92	Hannover	Germany	272	272	65	65
DE94	Weser-Ems	Germany	757	757	182	182
DEA1	Düsseldorf	Germany	3167	3167	763	763
DEA2	Köln	Germany	4 040	4 040	973	973
DEA3	Münster	Germany	1 481	1 481	357	357

DEA4	Detmold	Germany	875	875	211	211
DEA5	Arnsberg	Germany	1 923	1 923	463	463
DEC0	Saarland	Germany	390	390	94	94
DED2	Dresden	Germany	1 000	1 000	241	241
DED5	Leipzig	Germany	0	0	0	0
DEE0	Sachsen-Anhalt	Germany	0	0	0	0
DEF0	Schleswig-Holstein	Germany	250	250	60	60
DK01	Hovedstaden	Denmark	0	0	0	0
DK02	Sjælland	Denmark	787	787	258	258
DK03	Syddanmark	Denmark	749	749	246	246
DK05	Nordjylland	Denmark	380	380	125	125
EL53	Dytiki Makedonia	Greece	2 305	2 305	947	947
EL65	Peloponnisos	Greece	511	511	210	210
ES11	Galicia	Spain	1403	1403	466	466
ES12	Principado de Asturias	Spain	1 571	1 571	522	522
ES24	Aragón	Spain	0	0	0	0
ES41	Castilla y León	Spain	0	0	0	0
ES61	Andalucía	Spain	1690	1690	561	561
FI19	Länsi-Suomi	Finland	948	948	574	574
FI1B	Helsinki-Uusimaa	Finland	365	365	221	221
FI1C	Etelä-Suomi	Finland	220	220	133	133
FRD2	Haute-Normandie	France	580	580	113	113
FRF3	Lorraine	France	595	595	115	115
FRG0	Pays de la Loire	France	1 160	1 160	225	225
FRL0	Provence-Alpes-Côte d'Azur	France	595	595	115	115
HR03	Jadranska Hrvatska	Croatia	0	0	0	0
HR04	#N/A	Croatia	19	19	13	13

HU21	Közép-Dunántúl	Hungary	220	220	166	166
HU31	Észak-Magyarország	Hungary	853	853	645	645
IE05	Southern	Ireland	855	855	342	342
ITC3	Liguria	Italy	520	520	153	153
ITF4	Puglia	Italy	1 815	1 815	535	535
ITG2	Sardegna	Italy	966	966	285	285
ITH3	Veneto	Italy	860	860	253	253
ITH4	Friuli-Venezia Giulia	Italy	315	315	93	93
ITI2	Umbria	Italy	130	130	38	38
ITI4	Lazio	Italy	1 845	1 845	544	544
NL33	Zuid-Holland	Netherlands	1 801	1 801	285	285
NL41	Noord-Brabant	Netherlands	2 223	2 223	352	352
PL21	Małopolskie	Poland	628	864	322	443
PL22	Śląskie	Poland	0	4206	0	2152
PL41	Wielkopolskie	Poland	772	772	396	396
PL42	Zachodniopomorskie	Poland	134	1143	69	585
PL51	Dolnośląskie	Poland	1 582	1 690	809	865
PL52	Opolskie	Poland	0	0	0	0
PL61	Kujawsko-pomorskie	Poland	183	183	94	94
PL63	Pomorskie	Poland	217	323	111	165
PL71	Łódzkie	Poland	205	675	105	345
PL72	Świętokrzyskie	Poland	0	1 657	0	848
PL82	Podkarpackie	Poland	0	0	0	0
PL84	Podlaskie	Poland	0	0	0	0
PL91	Warszawski stołeczny	Poland	827	827	423	423
PL92	Mazowiecki regionalny	Poland	0	3622	0	1853
PT16	Centro (PT)	Portugal	576	576	211	211

PT18	Alentejo	Portugal	1 180	1 180	432	432
RO41	Sud-Vest Oltenia	Romania	1 568	2 194	884	1 237
RO42	Vest	Romania	1 150	1 150	648	648
SI03	Vzhodna Slovenija	Slovenia	305	305	123	123
SI04	Zahodna Slovenija	Slovenia	84	134	34	54
SK02	Západné Slovensko	Slovakia	330	330	344	344
SK04	Východné Slovensko	Slovakia	220	220	229	229
Total			60 973	75 479	20 745	28 321

I. Assessment of the performance of mining regions – ranking criteria

As introduced in our previous work, the following criteria influencing the competitiveness of EU coal mines were assessed with the purpose of establishing risk ratings for the regions hosting coal mining activities. The indicators and arguments for the analysis are given below. Their ranking followed a 1 to 3 point assessment scale, as shown in the table.

- Mine productivity – In order to assess productivity in mines, the metric of annual production per employee was evaluated across NUTS 2 regions. The results were used to organise the regions into five classes. The highest attribute (3) was given to the least productive while the lowest score (1) was allocated to the more productive mines. Due to its impact in cost-effectiveness metrics, mine productivity ranks were assigned a weight of 2 in the overall risk assessment.

- Type of coal produced – types of coal broken down into lignite or brown coal and hard coal were used as a benchmark for competitiveness. Hard coal has a higher price in comparison with lignite, and this is highest for anthracite. For this reason, lignite and brown coal mines were given the highest possible ranking in terms of risk of closure (3); hard coal mines were given the lowest (1). The ranking did not take into account national policy regarding security of energy supply.

- Mine sub-type – surface and underground mining. Stemming among other aspects from the fact that surface mining methods recover a higher proportion of the deposit than underground mining – 90 % and above, according to the (World Coal Association, 2017) – surface-mined coal is normally cheaper than underground-mined coal (IEA ETSAP, 2014). In this way, underground mines pose in general more significant economic challenges and were given a higher risk rating (3).

- Mine depth – although mining costs vary substantially, depending on factors such as the seam thickness, stripping ratio and mining techniques[59], deeper mines are in general more costly (IEA ETSAP, 2014). As a result, the highest depths (above 1 000 m) were given the highest risk rating (3), while surface mines (< 200 m) were given the lowest possible rank (1).

- Reserves to production ratio[60] – the remaining amount of the mining resource, calculated based on current production levels and expressed in years, was also used as a criterion for the performance assessment. Higher ratios, representing over 50 years of lasting resources, were given a lower risk rating (1).

- Coal quality – the average coal quality measured in terms of calorific value (KJ/Kg) and obtained from Euracoal country-level statistics, disaggregated for lignite and hard coal, was also used as a performance criterion. An average lower calorific value of < 15 000 KJ/Kg was given a higher rank (3).

- Closure plans in place – Regions hosting mines that have closed between 2015 and 2018 and/or that will be closed by the end of 2020 were rated highly (3).

[59] Relevant cost effectiveness metrics should consider the impacts of stripping ratios. JRC-CMDB offers some information on this parameter which, however, is insufficient from which to derive an indicator.

[60] The reserves-to-production ratio (R/P) is the remaining amount of a non-renewable resource, expressed in time. R/P ratios represent the length of time that remaining reserves would last at a given production rate.

Indicator	Scores
Productivity (production per person employed, tonnes)	
<500	3
500-1000	2.5
1000-2500	2
2500-5000	1.5
>5000	1
Type of coal	
Lignite and brown coal	3
Hard coal (including steam, coking, anthracite)	1
Mine sub-type	
OP	1
OP,UG	2
UG	3
Mine depth (m)	
<200	1
200-599	1.5
600-999	2
>1000	3
Closures (recent and announced, between 2015 and 2020)	
Yes	3
No	1
Reserves to production ratio (years)	
<10; NA	3
10-50	2
>50	1
Coal quality (calorific value, KJ/Kg)	
<15000	3
15000-25000	2
>250000	1

J. Risk ratings for the coal regions hosting mining activities and associated jobs at NUTS 2 level

NUTS 2	Region name	Type of coal	Jobs, 2018	Risk rate	Risk zone
RO42	Vest	Hard coal	3022	19	High
CZ08	Moravskoslezsko	Hard coal	6757	18,5	High
SK02	Západné Slovensko	Brown coal, lignite	1403	18,5	High
BG41	Yugozapaden	Lignite, Brown coal	981	17	High
PL22	Śląskie	Hard coal	73427	17	High
SI03	Vzhodna Slovenija	Lignite	1252	16,5	Medium
ES12	Principado de Asturias	Hard coal	1290	16,5	Medium
BG34	Yugoiztochen	Lignite	9303	16	Medium
PL21	Małopolskie	Hard coal	4908	16	Medium
PL41	Wielkopolskie	Lignite	1447	15	Medium
RO41	Sud-Vest Oltenia	Lignite	10600	15	Medium
CZ04	Severozápad	Brown coal	7147	14	Medium
DE40	Brandenburg	Lignite	3386	14	Medium
PL81	Lubelskie	Hard coal	4508	14	Medium
PL51	Dolnośląskie	Lignite	2411	14	Medium
DEE0	Sachsen-Anhalt	Lignite	855	13,5	Low
PL71	Łódzkie	Lignite	4725	13,5	Low
EL65	Peloponnisos	Lignite	828	13	Low
DEA2	Köln	Lignite	4791	12	Low
DEA1	Düsseldorf	Lignite	2995	12	Low
DED2	Dresden	Lignite	2843	12	Low
DED5	Leipzig	Lignite	1006	12	Low
EL53	Dytiki Makedonia	Lignite	3254	12	Low
HU31	Észak-Magyarország	Lignite	1400	12	Low

K. Peat and oil shale report relevant data

Estimation for peat production, energy and overall jobs

NUTS 2	Name/County	Peat production 2019[a)] (kt)	Peat fired energy plants[b)] (TJ)	Overall jobs 2019
EE00	Eesti	415	1 230	776
FI19	Länsi-Suomi	2 541	29 065	1 276
FI1B	Helsinki-Uusimaa	0	1 008	21
FI1C	Etelä-Suomi	489	6 131	259
FI1D	Pohjois- ja Itä-Suomi	2 966	25 618	1 315
IE05[c)]	Southern	1 743	18 602	90
IE06[c)]	Eastern and Midland	1 743	13 177	176
LV00	Livanu	26	85	26
LT01	Sostinės regionas	7	0	32
LT02	Vidurio ir vakarų Lietuvos regionas	18	544	31
SE11	Stockholm	0	357	40
SE12	Östra Mellansverige	99	2 335	305
SE21	Småland med öarna	77	265	65
SE22	Sydsverige	0	74	8
SE23	Västsverige	30	0	65
SE31	Norra Mellansverige	63	455	79
SE32	Mellersta Norrland	43	1 056	137
SE33	Övre Norrland	191	1 789	286

a) Data on peat production provided by the experts are scattered for the different years. As such, we provide 2019 data as a reference year for consistency.

b) This table is primarily based on data received from experts for the respective countries. In some cases, data was in terms of generation (Watt-hours) and others in capacity (Watt). For consistency, all values are transformed where necessary to conform to energy terms (thermal and/or electric).

c) Stations will cease generation of electricity at the end of December 2020 and in 2023.

Data provided by experts

NUTS 2	Name	Peat production (kt)					
		2014	2015	2016	2017	2018	2019
EE00	Eesti	421	283	195	240	415	335
FI1C	Etelä-Suomi	N/A	253	218	219	423	247
FI1D	Pohjois- ja Itä-Suomi	N/A	1 547	1 324	1 337	2 754	1 606
FI19	Länsi-Suomi	N/A	1 415	2 779	1 294	1 282	1 491
IE06	Eastern and Midland	N/A	2 736	2 711	2 467	2 440	1 092
LV00	Livanu	41	46	30	19	26	10
LT01	Sostinės regionas	N/A	7	7	9	6	7
LT02	Vidurio ir vakarų Lietuvos regionas	N/A	59	14	13	20	17
SE12	Östra Mellansverige	12	7	5	5	10	9
SE21	Småland med öarna	52	26	32	18	52	35
SE22	Sydsverige	6	0	8	0	4	0
SE23	Västsverige☺	16	13	8	4	23	14
SE31	Norra Mellansverige	39	23	22	21	12	29
SE32	Mellersta Norrland	30	19	20	17	24	20
SE33	Övre Norrland	125	30	34	59	82	86

Name/Country[a)]	Direct employment peat extraction sites and energy plants					
	2015	2016	2017	2018	2019	2020
Estonia	N/A	N/A	927	954	945	927
Ireland	N/A	N/A	300	280	220	180
Latvia	N/A	N/A	N/A	N/A	N/A	N/A
Lithuania	634	551	561	560	529	N/A

a) No data were provided for Finland and Sweden regarding end use.

NUTS 2	Name	Oil shale production (kt)					
		2014	2015	2016	2017	2018	2019
EE00	Estonia	14 960	14 908	12 692	15 634	15 945	12 128

NUTS 2	Name	Oil shale energy plants capacity (MWth)	Oil shale energy plants capacity (MWe)	Energy plant type
EE00	Estonia	634	2 338	CHP, Boiler

NUTS 2	Name/Country	Direct employment oil shale extraction sites			
		2017	2018	2019	2020
EE00	Ida-Viru	2 290	2 074	1 646	938
	Ida-Viru	592	577	577	536
	Ida-Viru	527	535	520	496
	Lääne-Viru	191	189	175	134

NUTS 2	Name/Country	Direct employment oil shale extraction plants			
		2017	2018	2019	2020
EE00	Ida-Viru	901	964	930	789
	Ida-Viru	592	577	577	536
	Ida-Viru	152	138	139	140
	Lääne-Viru	191	189	175	134

L. CO_2 emissions from fuel combustion (coal, peat and oil shale) in the scope countries

2018	**CO_2 fuel combustion (kt CO_2)**		
Country	**Coal**	**Peat**	**Oil shale**
Bulgaria	22 099	0	0
Czechia	62 196	0	0
Estonia	844	129	10 356
Finland	10 889	6 398	0
Germany	273 068	0	0
Greece	19 762	0	0
Hungary	8 106	0	0
Ireland	2 884	2 943	0
Italy	34 333	0	0
Latvia	178	12	0
Lithuania	692	163	0
Poland	191 855	0	0
Portugal	10 677	0	0
Romania	21 815	66	0
Slovakia	12 323	0	0
Slovenia	4 623	0	0
Spain	43 327	0	0
Sweden	6 312	665	0
EU-27	826 398	10 377	10 356

Based on IEA (2021), "Detailed CO2 estimates", IEA CO2 Emissions from Fuel Combustion Statistics (database), https://doi.org/10.1787/data-00429-en (accessed on 17 February 2021), www.iea.org/statistics, All rights reserved; as modified by European Commission, Joint Research Centre.

M. Country factsheets

Country factsheets are provided in the following pages.

Bulgaria

Coal mines	Coal power plants	Estimated jobs
Number of mines **13**	Number of power plants **10**	Mining jobs **10 284**
Production **31.5 Mt**	Capacity **4 615 MW**	Power plant jobs **2 660**
		Total jobs **12 944**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
BG34	Lignite & brown coal (hard coal insignificant)	OP, UG	28.0	3 014	70-300	4	Maritsa East Coalfield; Sliven Coalfield
BG41	Lignite & brown coal	OP, UG	3.4	3 486	<830	9	Sofia; Bobov dol; Pernik; Oranovo; Gotsedelchev; Katrishte; Pirin

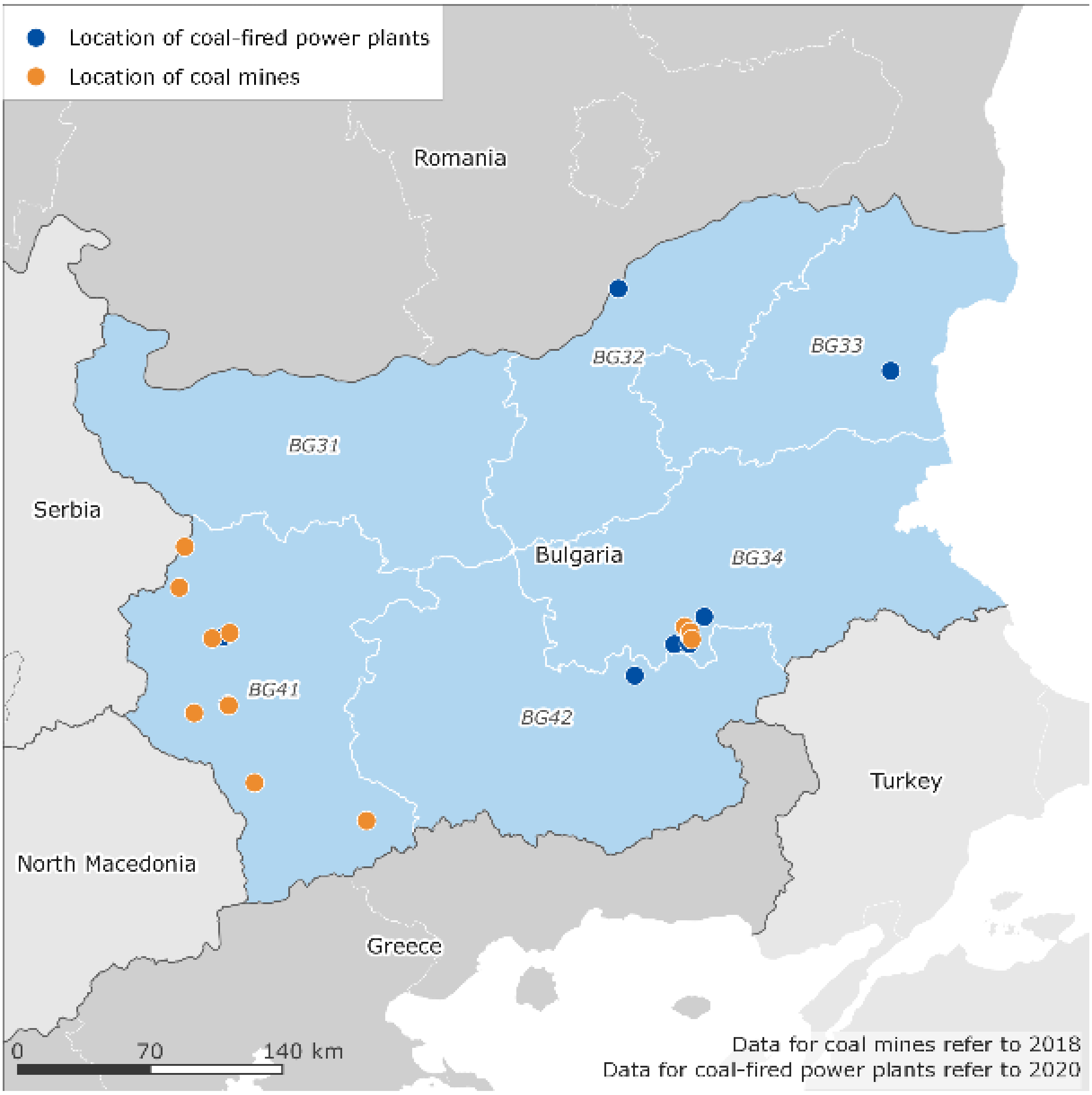
*OP - Open pit; UG - underground mine; Mt (million tonnes).

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
BG32	Severen tsentralen	290	29.5	45
BG33	Severoiztochen	132	27.0	11
BG34	Yugoiztochen	3 398	34.0	40
BG41	Yugozapaden	675	30.8	52
BG42	Yuzhen tsentralen	120	27.0	49

Estimates of employment in coal-related activities

NUTS 2	Location	Jobs in coal mines	Jobs in power plants	Total jobs
BG32	Severen tsentralen	0	167	202
BG33	Severoiztochen	0	76	76
BG34	Yugoiztochen	9 303	1 959	11 262
BG41	Yugozapaden	981	389	1 370
BG42	Yuzhen tsentralen	0	69	69


Location of coal-fired power plants
Location of coal mines
Romania
Serbia
Bulgaria
North Macedonia
Greece
Turkey
BG31
BG32
BG33
BG34
BG41
BG42
0
70
140 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Czechia

Coal mines	Coal power plants	Estimated jobs
Number of mines **8** Production **43.8 Mt**	Number of power plants **15** Capacity **7 415 MW**	Coal mine jobs **13 904** Power plant jobs **3 925** Total jobs **17 829**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
CZ08	Hard coal	UG	4.5	666	1 300	3	Ostrava-Karviná basin
CZ04	Lignite & Brown coal	OP	39.3	5 499	<400	5	North Bohemian Basin; Sokolov basin

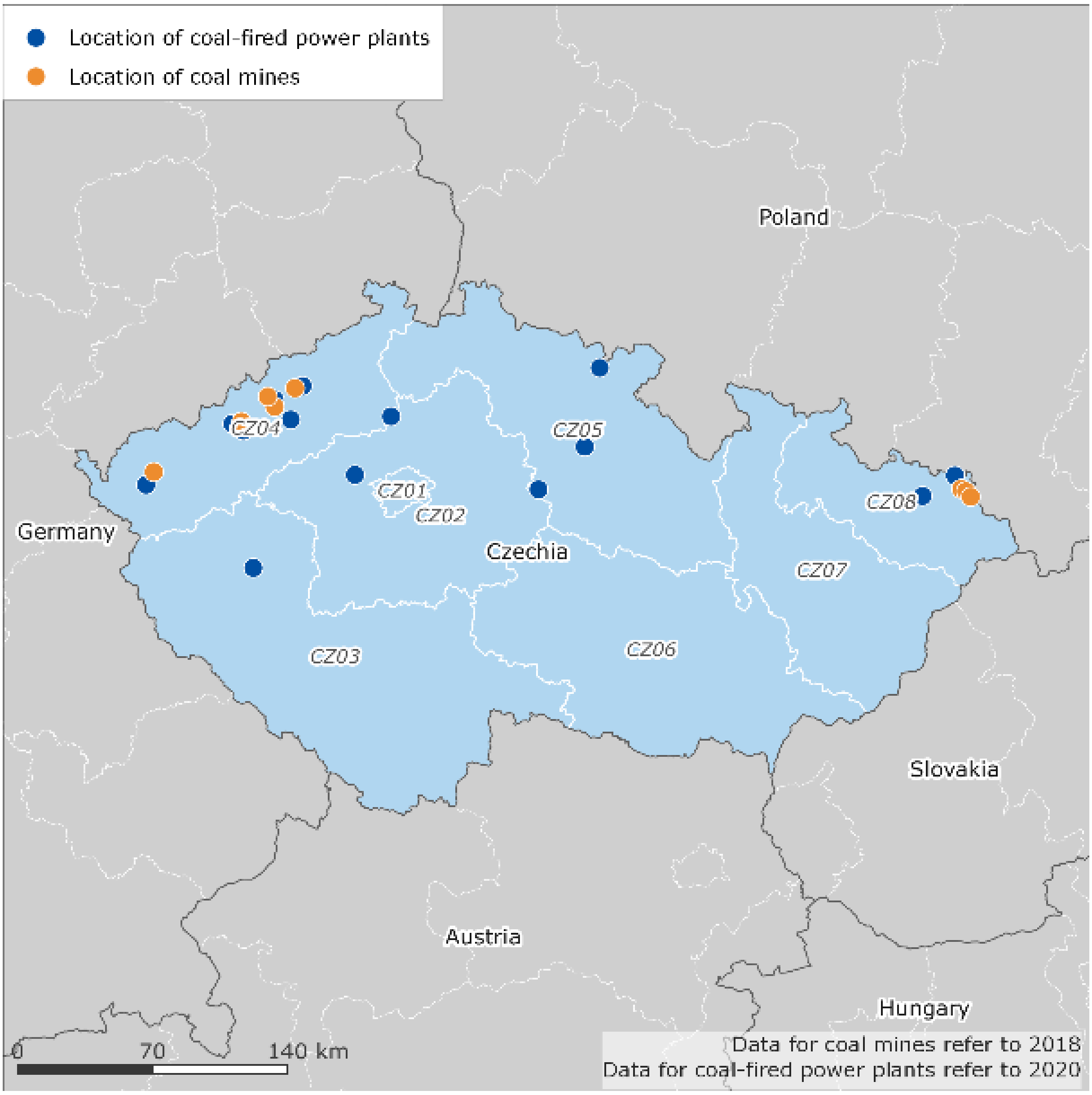
* OP Open pit mine; UG Underground mine; Mt (million tonnes); USCB - Upper Silesian Coal Basin.

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
CZ02	Střední Čechy	1 261	35.0	34
CZ03	Jihozápad	111	27.0	51
CZ04	Severozápad	3 269	35.5	44
CZ05	Severovýchod	1 116	32.9	42
CZ08	Moravskoslezsko	149	34.3	37

Estimates of employment in coal-related activities

NUTS 2	Location	Number of jobs in coal mines	Number of jobs in coal power plants	Total number of jobs
CZ02	Střední Čechy	0	667	667
CZ03	Jihozápad	0	59	59
CZ04	Severozápad	7 147	2 041	9 188
CZ05	Severovýchod	0	670	670
CZ08	Moravskoslezsko	6 757	488	7 245


Location of coal-fired power plants
Location of coal mines
Poland
Germany
Czechia
Slovakia
Austria
Hungary
CZ01
CZ02
CZ03
CZ04
CZ05
CZ06
CZ07
CZ08
0
70
140 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Germany

Coal mines	Coal power plants	Employment
Number of mines **12** Production **169.5 Mt**	Number of power plants **46** Capacity **34 414 MW**	Coal mine jobs **20 000** Power plant jobs **10 385** Total jobs **30 386**

Coal mines

NUTS 2	Type of coal	Mine type *	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
DEA3	Hard coal incl. Anthracite	UG	6.7	695	800	2	Ibbenbüren, Ruhr
	Hard coal	UG	2.8	679	800	2	Ruhr
DEA2	Lignite	OP	53.1	11084	NA	2	Rheinisches, Rhineland Lignite Basin (Rhineland Area)
DEA1	Lignite	OP	33.2	11084	NA	1	Rheinisches, Rhineland Lignite Basin (Rhineland Area)
DE40	Lignite	OP	33.0	9745	110	2	Lausitzer (Lusatian Area)
DED2	Lignite	OP	27.7	9745	NA	2	Lausitzer (Lusatian Area)
DEE0	Lignite	OP	9.3	10863	NA	2	Central German Area (Mitteldeutsches, Weißelsterbecken Basin)
DED5	Lignite	OP	10.4	10318	NA	1	Central German Area

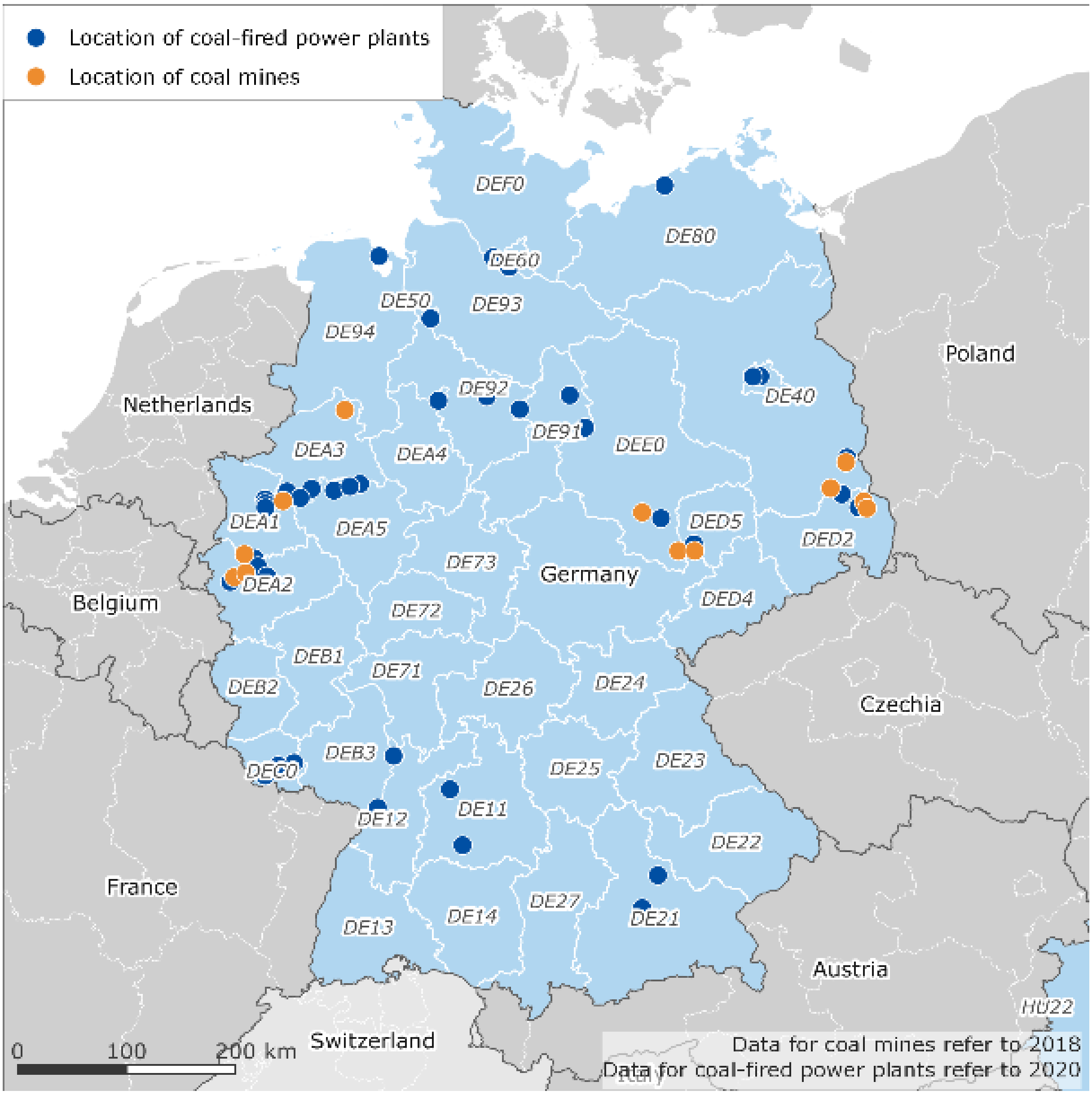
* OP Open pit mine; UG Underground mine; Mt (million tonnes)

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
DE11	Stuttgart	1 114	36.5	29
DE12	Karlsruhe	3 318	37.0	20
DE21	Oberbayern	805	37.0	32
DE30	Berlin	371	30.3	32
DE40	Brandenburg	4 508	33.5	32
DE50	Bremen	769	35.0	33
DE60	Hamburg	1 600	41.0	6
DE80	Mecklenburg-Vorpommern	514	41.0	26
DE91	Braunschweig	1 090	30.7	31
DE92	Hannover	272	33.0	31
DE94	Weser-Ems	1 483	39.0	25
DEA1	Düsseldorf	6 012	36.7	45
DEA2	Köln	4 964	32.9	42
DEA3	Münster	2 533	28.7	46
DEA4	Detmold	875	39.0	33
DEA5	Arnsberg	2 703	38.0	39
DEC0	Saarland	390	36.3	27
DED2	Dresden	2 470	42.0	21
DED5	Leipzig	1 782	31.0	25
DEE0	Sachsen-Anhalt	900	27.0	53
DEF0	Schleswig-Holstein	250	36.5	29

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in coal mines	Number of jobs in coal power plants	Total number of jobs
DE11	Stuttgart	0	433	433
DE12	Karlsruhe	0	799	799
DE21	Oberbayern	0	194	194
DE30	Berlin	0	187	187
DE40	Brandenburg	3 386	1 085	4 471
DE50	Bremen	0	185	185
DE60	Hamburg	0	385	385
DE80	Mecklenburg-Vorpommern	0	124	124
DE91	Braunschweig	0	347	347
DE92	Hannover	0	65	65
DE94	Weser-Ems	0	357	357
DEA1	Düsseldorf	2 995	1 447	4 442
DEA2	Köln	4 791	1 414	6 205
DEA3	Münster	4 125	356	4 481
DEA4	Detmold	0	211	211
DEA5	Arnsberg	0	990	990
DEC0	Saarland	0	427	427
DED2	Dresden	2 843	595	3 438
DED5	Leipzig	1 006	429	1 435
DEE0	Sachsen-Anhalt	855	217	1 072
DEF0	Schleswig-Holstein	0	138	138



Location of coal-fired power plants
Location of coal mines
Netherlands
Belgium
France
Switzerland
Austria
Czechia
Poland
Germany
DEF0
DE80
DE60
DE50
DE93
DE94
DE92
DE91
DE40
DEA3
DEA4
DEE0
DEA1
DEA5
DED5
DED2
DE73
DEA2
DED4
DE72
DEB1
DE71
DE26
DE24
DEB2
DEB3
DE23
DE25
DEC0
DE11
DE12
DE22
DE27
DE14
DE13
DE21
HU22
0
100
200 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Greece

Coal mines	Coal power plants	Employment
Number of mines **6** Production: **36.5 Mt**	Number of power plants **6** Capacity **3 905 MW**	Coal mine jobs **4 082** Power plant jobs **1 605** Total jobs **5 687**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Productivity	Coal depth (m)	No. mines	Coalfield (or company)
EL53	Lignite	OP	29.1	8 942	150-200	5	Ptolomais-Aminteon
EL65	Lignite	OP	7.4	8 942	150-200	1	Megalopolis

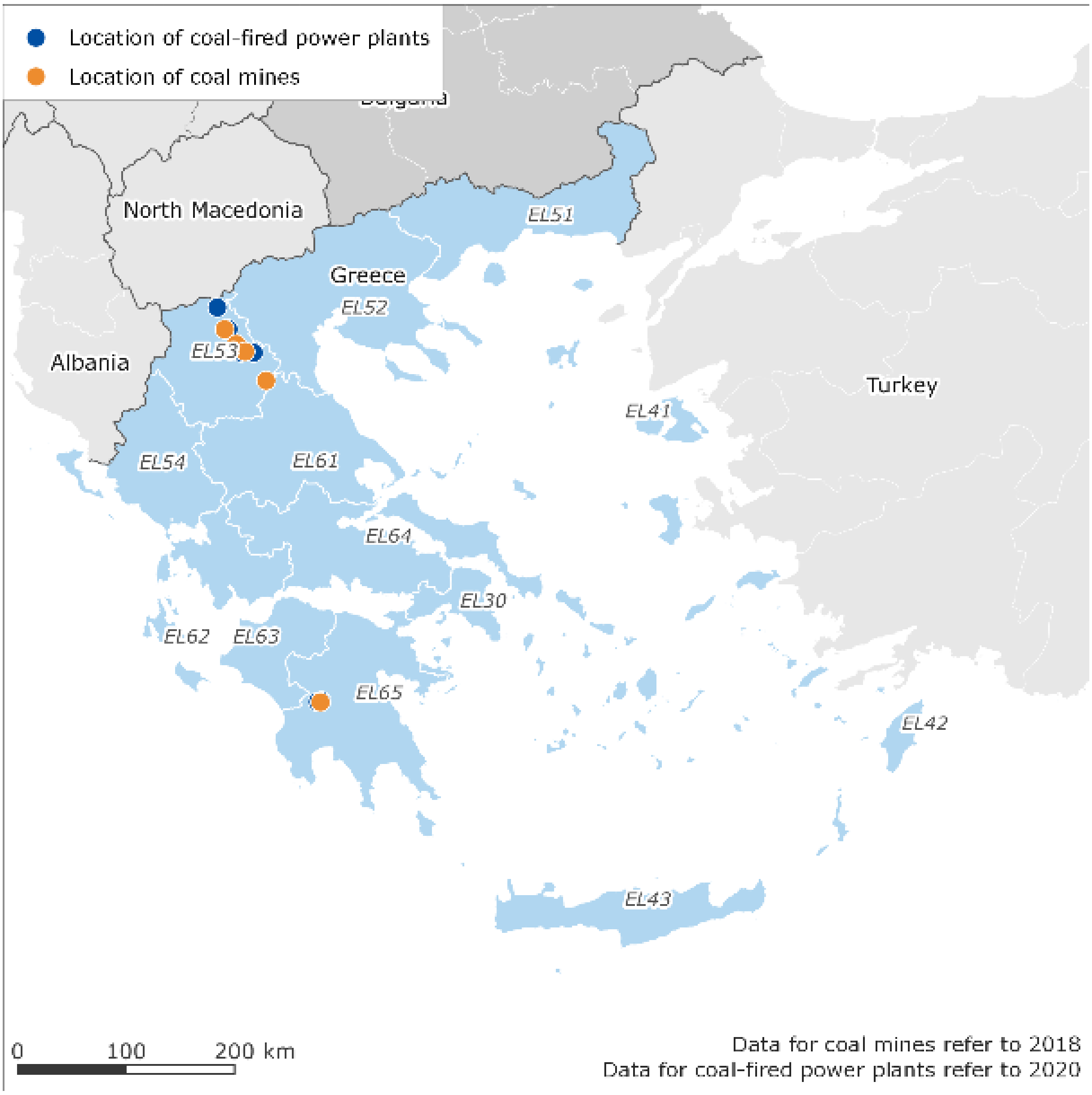
* OP Open-pit mine; Mt (million tonnes)

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
EL53	Dytiki Makedonia	3 394	30.1	33
EL65	Peloponnisos	511	33.0	29

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
EL53	Dytiki Makedonia	3 254	1 395	4 649
EL65	Peloponnisos	828	210	1 038


Location of coal-fired power plants
Location of coal mines
North Macedonia
Greece
Albania
Turkey
EL51
EL52
EL53
EL54
EL61
EL64
EL30
EL62
EL63
EL65
EL41
EL42
EL43
0
100
200 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Hungary

Coal mines
Number of mines **2**
Production **7.9 Mt**

Coal power plants
Number of power plants **2**
Capacity **1 073 MW**

Employment
Coal mine jobs **1 400**
Power plant jobs **811**
Total jobs **2 211**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Productivity	Coal depth (m)	No. mines	Coalfield (or company)
HU31	Lignite	OP	7.9	5 643	70-270	2	Mátraalja-Bükkalja

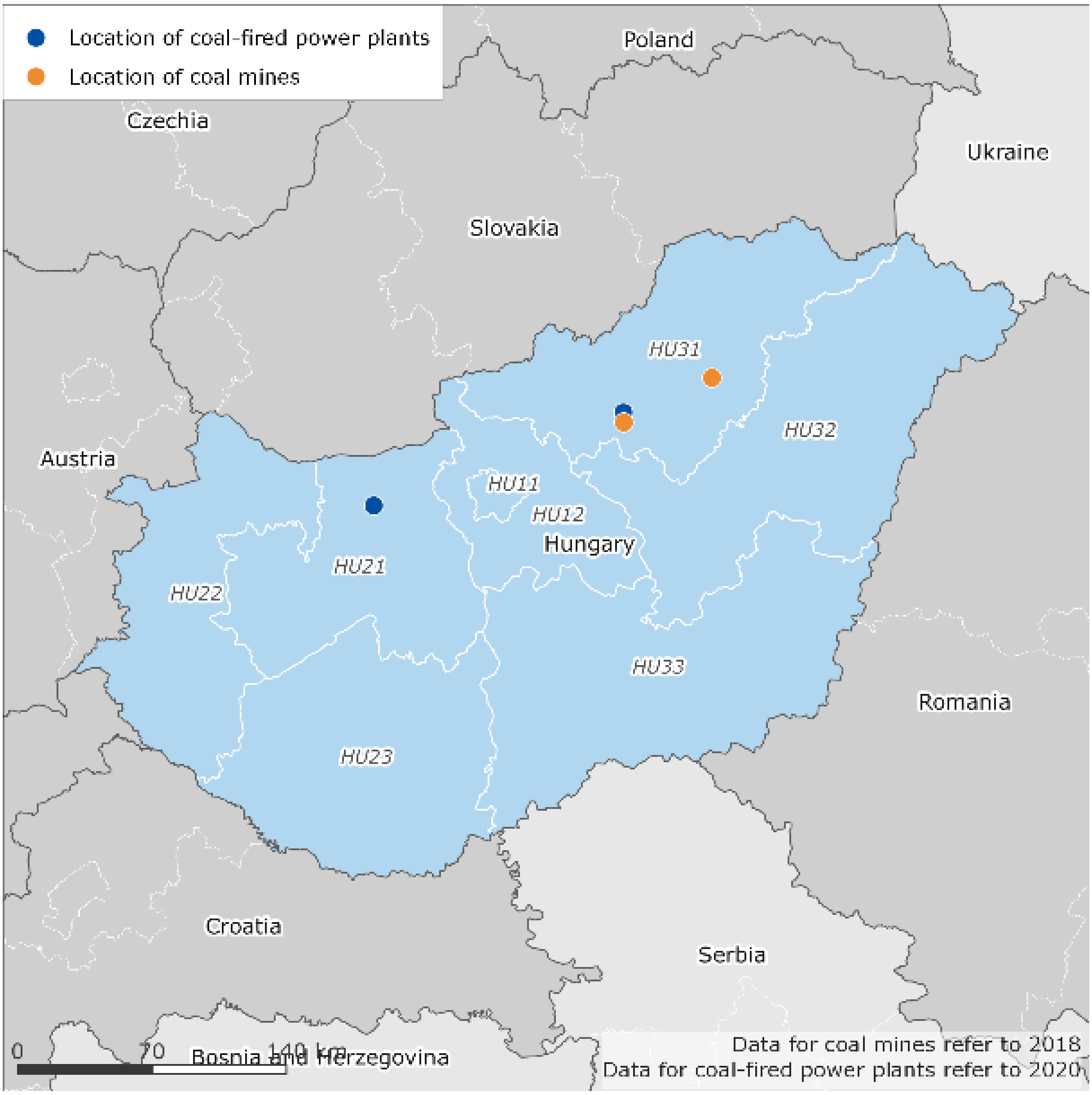
*OP - Open pit mine; Mt (million tonnes)

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
HU21	Közép-Dunántúl	220	27.0	58
HU31	Észak-Magyarország	853	30.7	44

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in Coal mines (operating)	Number jobs in coal power plants	Total number of jobs
HU21	Közép-Dunántúl	0	166	166
HU31	Észak-Magyarország	1 400	645	2 045


Location of coal-fired power plants
Location of coal mines
Czechia
Poland
Ukraine
Slovakia
Austria
HU31
HU32
HU11
HU12
Hungary
HU21
HU22
HU33
Romania
HU23
Croatia
Serbia
0
70
140 km
Bosnia and Herzegovina
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Italy

Coal mines	Coal power plants	Employment
Number of mines **1** Production **$2 \cdot 10^{-4}$ Mt** (left underground)	Number of power plants **9** Capacity **7 056 MW**	Coal mining jobs **160** Power plant jobs **2 079** Total jobs **2 239**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
ITG2	Lignite	UG	0.0002	(insignificant)	500	1	Sulcis Basin

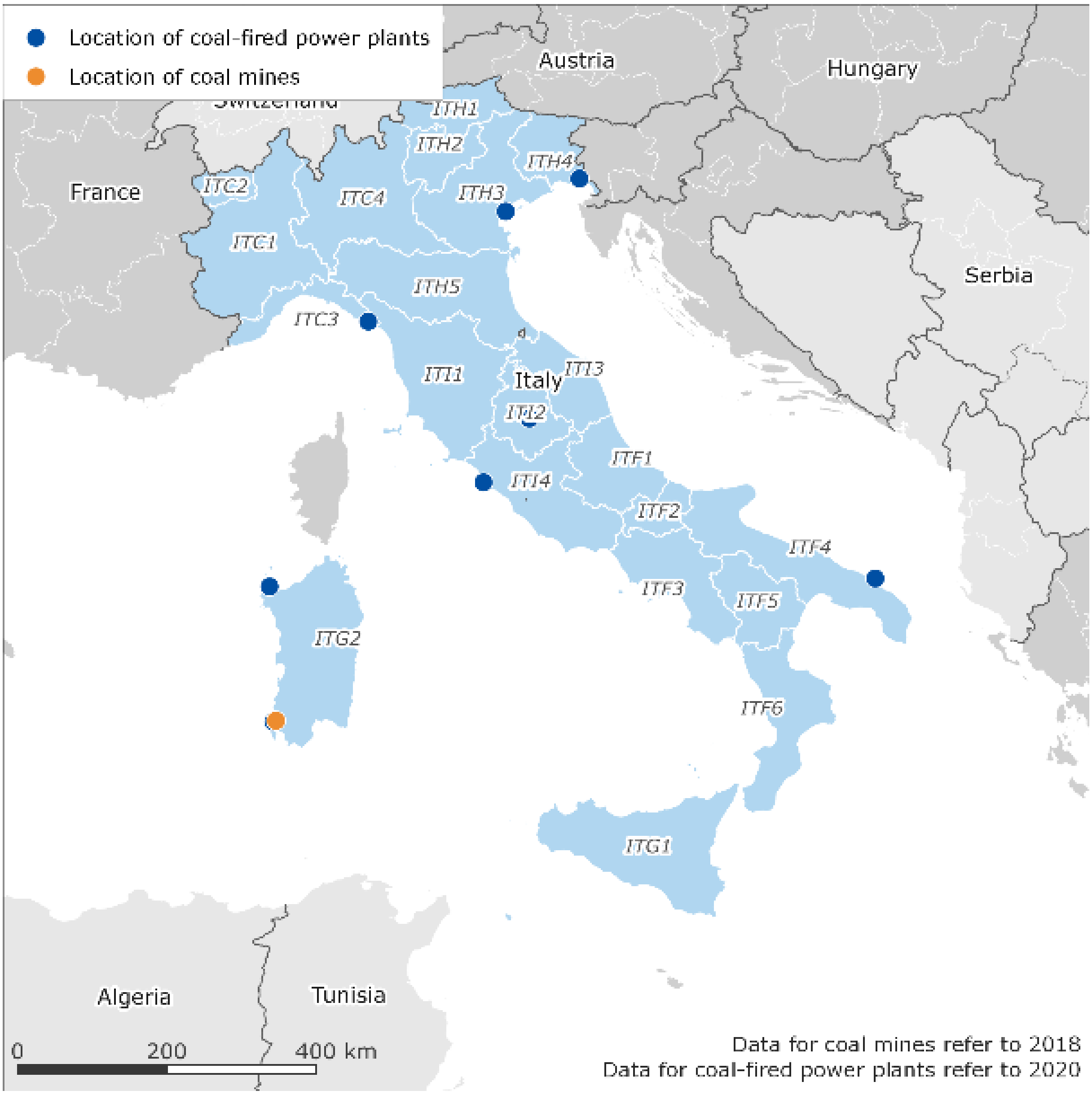
UG* underground mine; Mt (million tonnes)

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
ITC3	Liguria	520	40.0	21
ITF4	Puglia	2 420	34.0	28
ITG2	Sardegna	966	33.5	36
ITH3	Veneto	860	30.8	49
ITH4	Friuli-Venezia Giulia	315	35.0	53
ITI2	Umbria	130	27.0	31
ITI4	Lazio	1 845	38.0	10

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
ITC3	Liguria	0	153	153
ITF4	Puglia	0	713	713
ITG2	Sardegna	160	285	445
ITH3	Veneto	0	253	253
ITH4	Friuli-Venezia Giulia	0	93	93
ITI2	Umbria	0	38	38
ITI4	Lazio	0	544	544



Location of coal-fired power plants
Location of coal mines
Austria
Hungary
Switzerland
France
Serbia
Italy
ITH1
ITH2
ITH3
ITH4
ITH5
ITC1
ITC2
ITC3
ITC4
ITI1
ITI2
ITI3
ITI4
ITF1
ITF2
ITF3
ITF4
ITF5
ITF6
ITG1
ITG2
Algeria
Tunisia
0
200
400 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Poland

Coal mines

Number of mines **24**
Production **121.9 Mt**

Coal power plants

Number of power plants **43**
Capacity **30 591 MW**

Employment

Coal mine jobs **91 426**
Power plant jobs **15 653**
Total jobs **107 079**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
PL22	Hard coal	UG	49,4	673	770	16	Upper Silesian Basin
PL21	Hard coal	UG	5	1019	NA	2	Upper Silesian Basin
PL81	Hard coal	UG	9	1998	NA	1	Lublin Basin
PL71	Lignite	OP	44.3	9375	300	1	Belchatow-Szczercow Coalfield
PL51	Lignite	OP	6.5	2696	NA	1	Turoszow Basin
PL41	Lignite	OP	7.6	5254	25-80	2	Pątnów-Adamów-Konin (PAK) lignite basin
PL43	Lignite	OP	0.1	NA	NA	1	NA

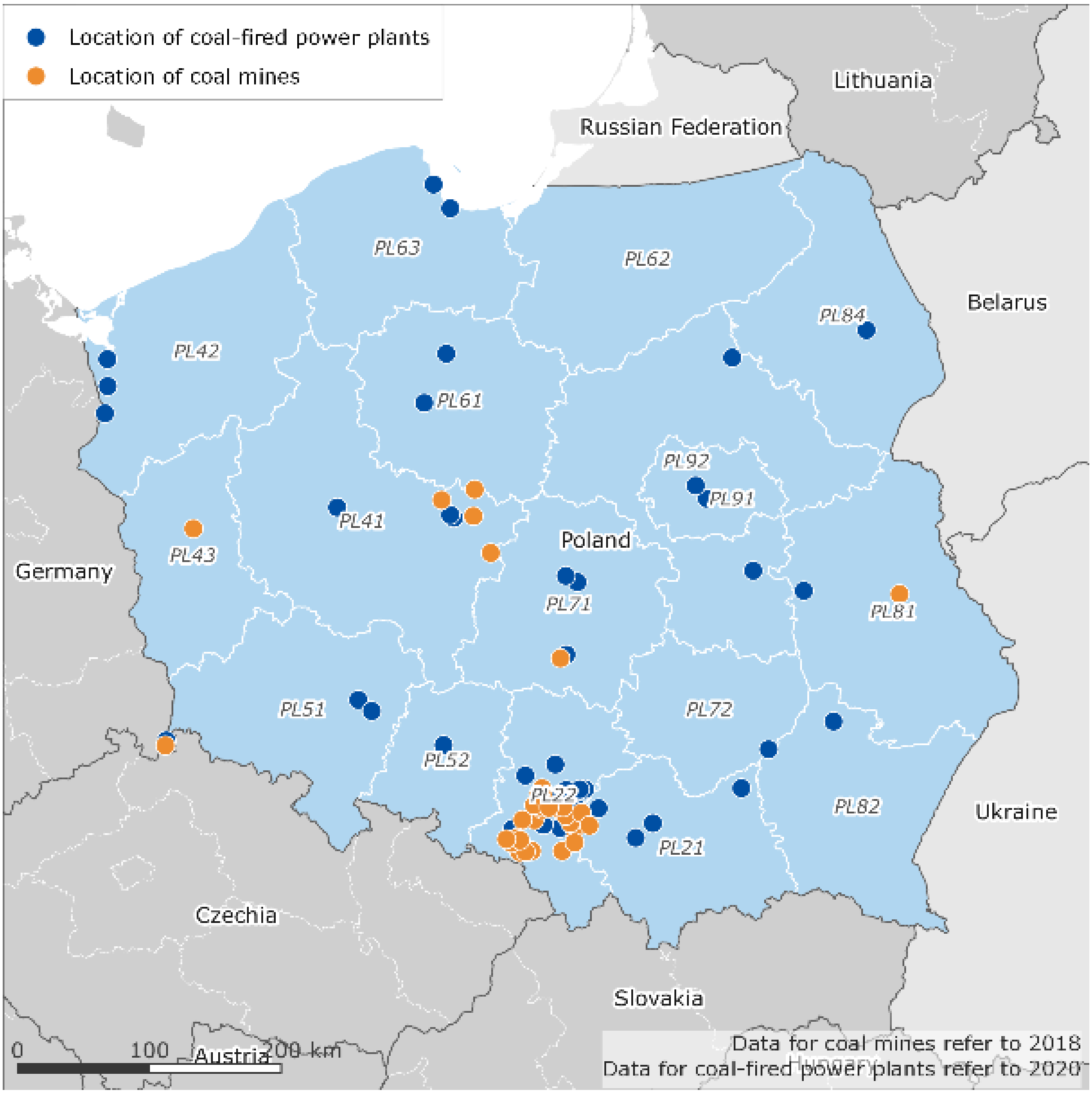
* OP - Open pit mine; UG - underground mine; Mt (million tonnes); n.a.* (not available data)

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
PL21	Małopolskie	1 545	29.1	51
PL22	Śląskie	6 131	31.9	38
PL41	Wielkopolskie	2 107	30.7	42
PL42	Zachodniopomorskie	1 597	35.2	46
PL51	Dolnośląskie	1 798	34.6	50
PL52	Opolskie	3 332	38.3	17
PL61	Kujawsko-pomorskie	394	32.0	52
PL63	Pomorskie	323	29.5	48
PL71	Łódzkie	5 777	33.4	35
PL72	Świętokrzyskie	1 657	33.0	39
PL82	Podkarpackie	250	27.0	62
PL84	Podlaskie	157	32.0	29
PL91	Warszawski stołeczny	827	28.0	60
PL92	Mazowiecki regionalny	4 697	35.6	43

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
PL21	Małopolskie	4 908	791	5 699
PL22	Śląskie	73 427	3137	76 564
PL41	Wielkopolskie	1 447	1078	2 525
PL42	Zachodniopomorskie	0	817	817
PL51	Dolnośląskie	2 411	920	3 331
PL52	Opolskie	0	1702	1 702
PL61	Kujawsko-pomorskie	0	202	202
PL63	Pomorskie	0	163	163
PL71	Łódzkie	4 725	2956	7 681
PL72	Świętokrzyskie	0	848	848
PL81	Lubelskie	4 508	0	4 508
PL82	Podkarpackie	128	0	128
PL84	Podlaskie	80	0	80
PL91	Warszawski stołeczny	423	0	423
PL92	Mazowiecki regionalny	2 403	0	2 403


Location of coal-fired power plants
Location of coal mines
Lithuania
Russian Federation
Belarus
Germany
Poland
Ukraine
Czechia
Slovakia
Austria
Hungary
PL63
PL62
PL84
PL42
PL61
PL92
PL91
PL41
PL43
PL71
PL81
PL51
PL72
PL52
PL22
PL82
PL21
0
100
200 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Romania

Coal mines
Number of mines **7**
Production **24.2 Mt**

Coal power plants
Number of power plants **7**
Capacity **5 338 MW**

Employment
Coal mine jobs **13 622**
Power plant jobs **3 008**
Total jobs **16 630**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
RO41	Lignite	OP	23,5	2217	NA	6	Oltenia Basin
RO42	Hard coal	UG	0,7	232	600	4	Jiu Valley

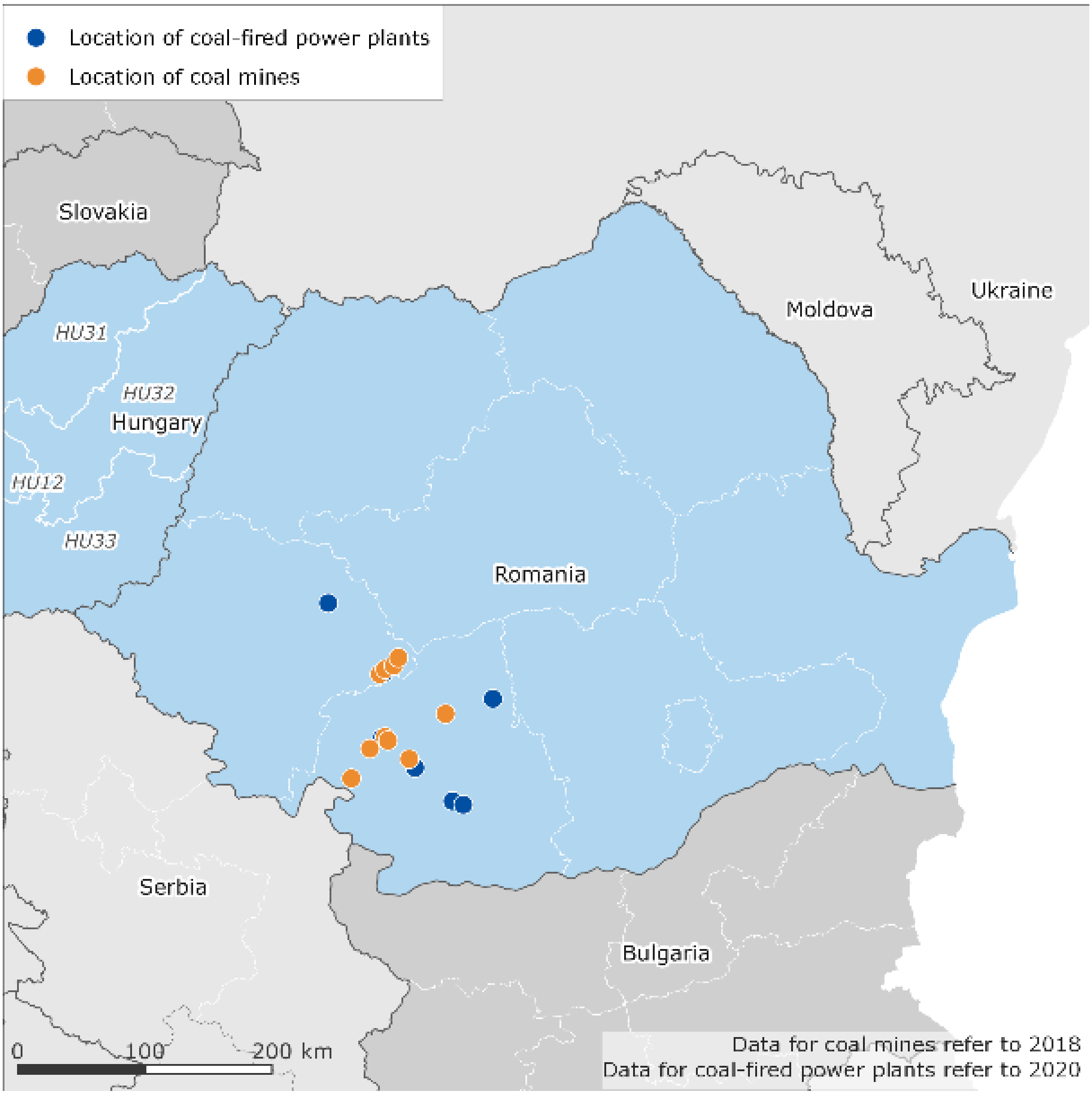
*OP Open pit mine; UG underground mine; Mt (million tonnes); NA not available/not analysed.

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Age (years)
RO41	Sud-Vest Oltenia	3 545	33.5	37
RO42	Vest	1 150	30.8	48

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
RO41	Sud-Vest Oltenia	10 600	2 360	12 960
RO42	Vest	3 022	648	3 670



Location of coal-fired power plants
Location of coal mines
Slovakia
HU31
HU32
Hungary
HU12
HU33
Romania
Moldova
Ukraine
Serbia
Bulgaria
0
100
200 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Slovakia

Coal mines	Coal power plants	Employment
Number of mines **3** Production **1.3 Mt**	Number of power plants **2** Capacity **550 MW**	Coal mine jobs **1 403** Power plant jobs **573** Total jobs **1 976**

Coal mines

NUTS 2	Type of coal	Mine type *	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
SK02	Brown coal, lignite	UG	1.5	1 069	40-700	3	Dubňanský sloj coalfield; Hornonitriansky hnedouhoľný revír coalfield

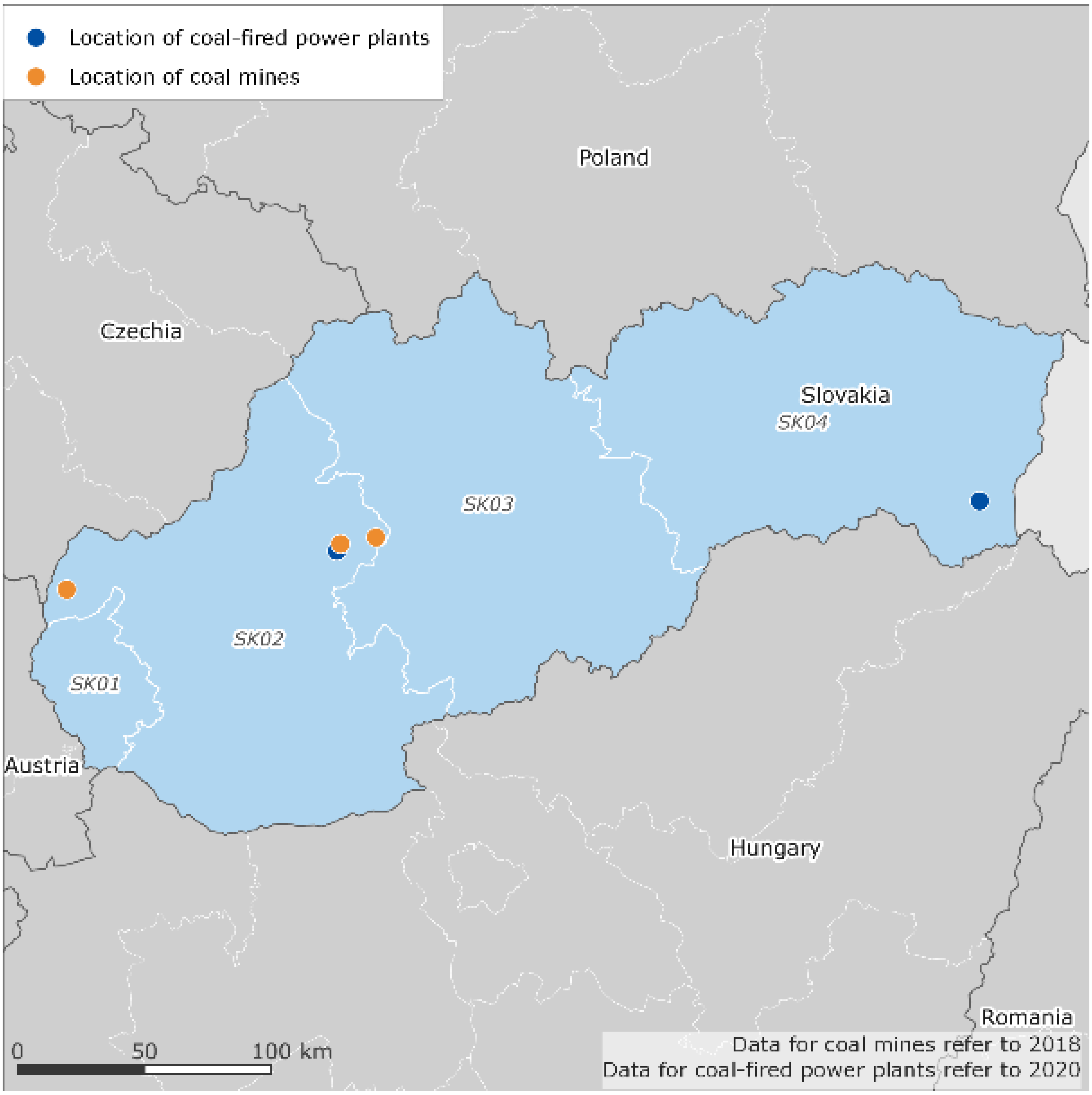
*UG underground mine; Mt (million tonnes).

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Age (years)
SK02	Západné Slovensko	330	26.7	35
SK04	Východné Slovensko	220	29.0	53

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
SK02	Západné Slovensko	1 403	344	1 747
SK04	Východné Slovensko	0	229	229


Location of coal-fired power plants
Location of coal mines
Poland
Czechia
Slovakia
SK04
SK03
SK02
SK01
Austria
Hungary
Romania
0
50
100 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Slovenia

Coal mines	Coal power plants	Employment
Number of mines **1** Production **3.2 Mt**	Number of power plants **2** Capacity **1 351 MW**	Coal mine jobs **1 252** Power plant jobs **545** Total jobs **1 797**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
SI03	Lignite	UG	3.2	2 569	200-500	1	Premogovnik Velenje

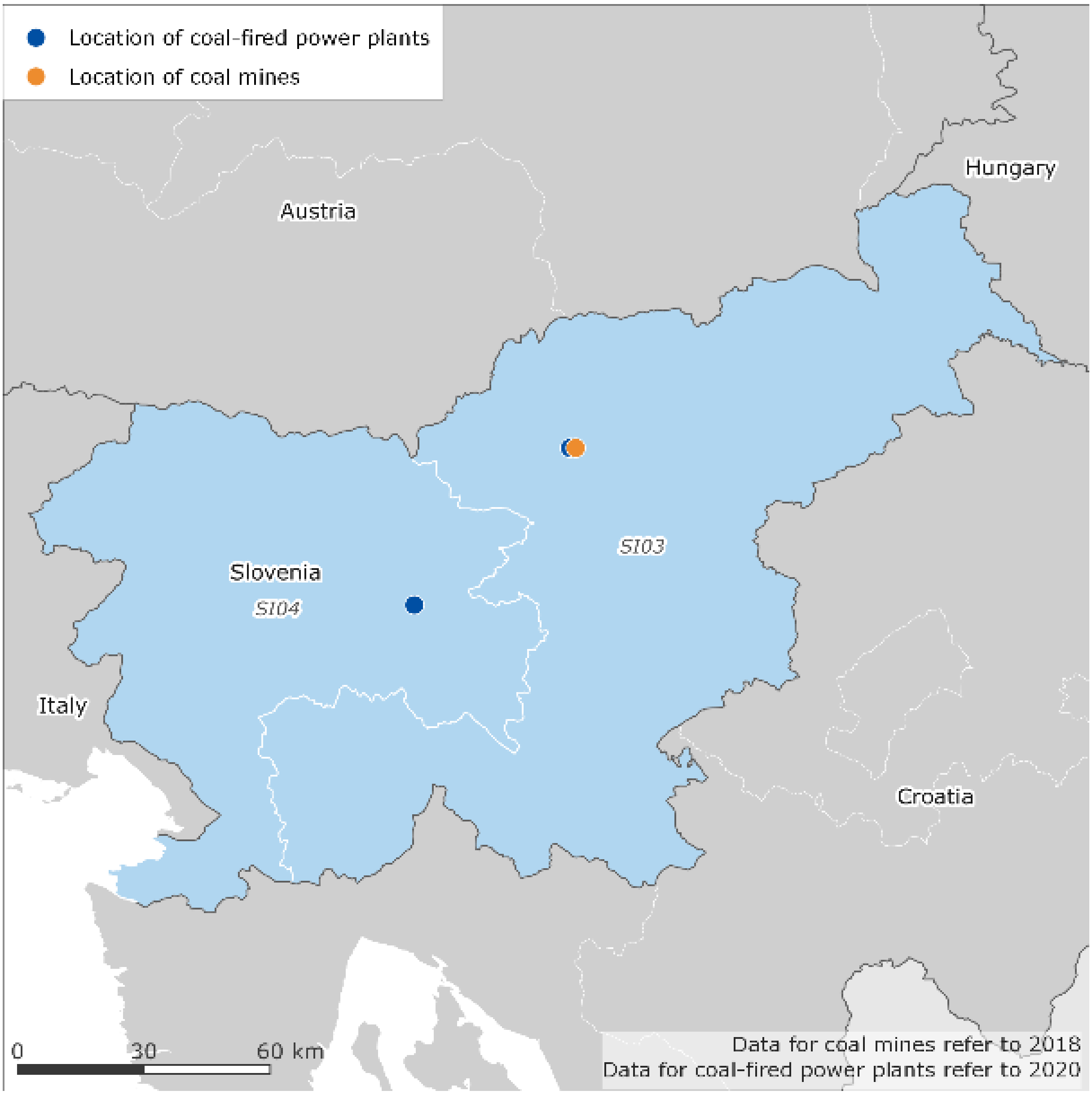
* UG underground mine; Mt (million tonnes).

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
SI03	Vzhodna Slovenija	1 217	34.5	24
SI04	Zahodna Slovenija	134	27.0	48

Estimates of employment in coal-related activities

NUTS 2	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
SI03	Vzhodna Slovenija	1 252	491	1 743
SI04	Zahodna Slovenija	0	54	54


Location of coal-fired power plants
Location of coal mines
Austria
Hungary
Slovenia
SI04
SI03
Italy
Croatia
0
30
60 km
Data for coal mines refer to 2018
Data for coal-fired power plants refer to 2020

Spain

Coal mines

Number of mines **10**
Production **2.4 Mt**

Coal power plants

Number of power plants **14**
Capacity **9 673 MW**

Employment

Coal mine jobs **1 733**
Power plant jobs **3 210**
Total jobs **4 943**

Coal mines

NUTS 2	Type of coal	Mine type*	Production (Mt)	Average productivity	Coal depth (m)	No. mines	Coalfield (or company)
ES24	Hard coal	OP, UG**	1.6	7 245	NA	2	TERUEL-MEQUINENZA
ES12	Hard coal, Anthracite	OP, UG	0.3	248	450	3	CENTRAL ASTURIANA (Nalón Valley); BIERZO-VILLABLINO
ES41	Hard coal, Anthracite	OP, UG	0.5	2 098	NA	5	Norte de Leon; BIERZO-VILLABLINO; SABERO-GUARDO-BARRUELO

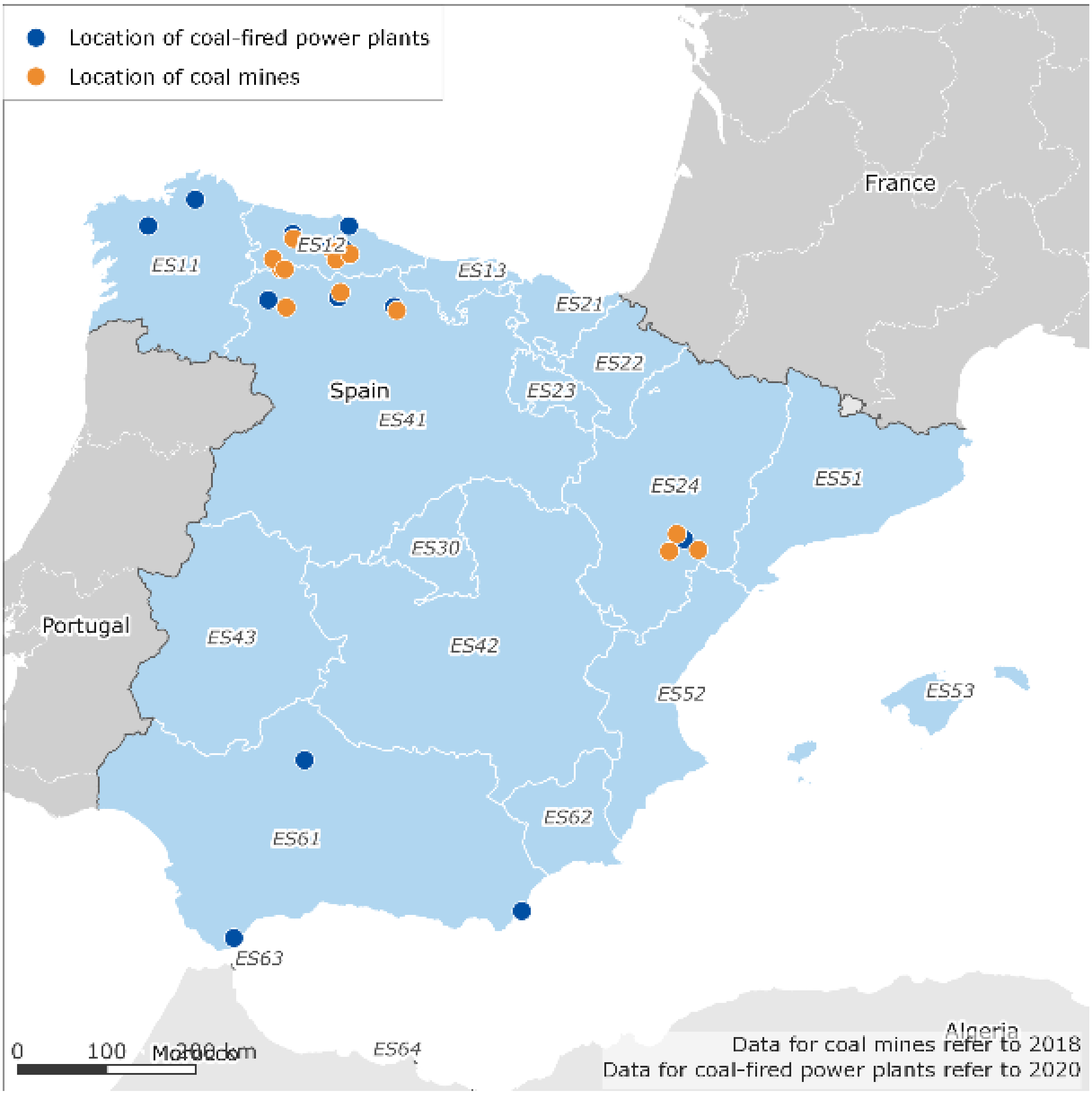
*OP Open pit mine; UG underground mine; Mt (million tonnes); NA (not available/not analysed)
** insignificant.

Coal power plants

NUTS 2	NUTS 2 name	Capacity (MW)	Average efficiency (%)	Average age (years)
ES11	Galicia	1 960	35.2	42
ES12	Principado de Asturias	2 073	32.8	43
ES24	Aragón	1 056	32.0	41
ES41	Castilla y León	2 595	32.9	42
ES61	Andalucía	1 989	36.0	33

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Number of jobs in coal mines	Number jobs in coal power plants	Total number of jobs
ES11	Galicia	NA	651	651
ES12	Principado de Asturias	1 290	688	1 978
ES24	Aragón	225	350	575
ES41	Castilla y León	218	861	1 079
ES61	Andalucía	0	660	660



Estonia

Oil shale sites*	Oil shale plants	Employment
Number **4** Production **15.9 Mt**	Number **5** Energy **36 715 TJ**	Oil shale site jobs **3 375** Energy plant jobs **1 012** Total jobs **4 387**
Peat sites	**Peat plants**	**Employment**
Number **26** Production **0.4 Mt**	Number of energy plants **17** Energy **1 230 TJ**	Peat site jobs **552** Energy plant jobs **230** Total jobs **782**

*May refer to companies

Oil shale sites / Peat sites

NUTS 2	Oil shale sites: Production (Mt)	Oil shale sites: No. sites	Peat sites: Production (Mt)	Peat sites: No. sites
EE00	15.9	4	0.4	26

Oil shale energy plants

NUTS 2	NUTS 2 name	Energy (TJ)	Average co-firing rate (%)	Average efficiency (%)	Average age (years)
EE00	Estonia	36 715	60	51	37

Peat energy plants

NUTS 2	NUTS 2 name	Energy (TJ)	Average co-firing rate (%)	Average efficiency (%)	Average age (years)
EE00	Estonia	1 230	64	83	13

Estimates of employment in oil shale-related activities

NUTS 2 Region	NUTS 2 name	Jobs in oil shale sites	Jobs in oil shale energy plants	Total number of jobs
EE00	Estonia	3 375	1 012	4 387

Estimates of employment in peat-related activities

NUTS 2 Region	NUTS 2 name	Jobs in peat sites	Jobs in peat energy plants	Total number of jobs
EE00	Estonia	552	230	782

Finland

Peat sites	Peat energy plants	Employment
Number **606** Production **6 Mt**	Number **121*** Energy **61 822 TJ**	Peat site jobs **2 806** Energy plant jobs **1 300** Total jobs **4 106**

*+139 smaller boiler units

Peat sites

NUTS 2	NUTS 2 name	Production (Mt)	No. sites
FI1C	South Finland	0.25	47
FI1D	North & East Finland	0.41	284
FI19	West Finland	0.49	275

Peat energy plants

NUTS 2 Region	NUTS 2 name	Energy (TJ)	Average efficiency (%)	Average age (years)
FI1B	Helsinki-Uusimaa	1 008	NA	NA
FI1C	South Finland	6 131	NA	NA
FI1D	North & East Finland	25 618	NA	NA
FI19	West Finland	29 065	NA	NA

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Jobs in peat sites	Jobs in peat energy plants	Total number of jobs
FI1B	Helsinki-Uusimaa	0	21	21
FI1C	South Finland	229	129	358
FI1D	North & East Finland	1 388	538	1 926
FI19	West Finland	1 189	611	1 800

Ireland

Peat sites	Peat energy plants	Employment
Number **6** Production **2.4 Mt**	Number **3** Energy **29 554 TJ**	Peat site jobs **280** Energy plant jobs **46** Total jobs **326**

Peat sites

NUTS 2	NUTS 2 name	Production (Mt)	No. sites
IE05	Southern	0.69	NA
IE06	Eastern and Midland	1.74	6

Peat energy plants

NUTS 2 Region	NUTS 2 name	Energy (TJ)	Average efficiency (%)	Average age (years)
IE05	Southern	18 602	NA	NA
IE06	Eastern and Midland	13 177	36	17

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Jobs in peat sites	Jobs in peat energy plants	Total number of jobs
IE05	Southern	80	27	107
IE06	Eastern and Midland	200	19	219

Latvia

Peat sites
Number **3**
Production **0.88 Mt**

Peat energy plants
Number **11**
Energy **85 TJ**

Employment
Peat site jobs **13**
Energy plant jobs **13**
Total jobs **26**

Peat sites

NUTS 2	NUTS 2 name	Production (Mt)	No. sites
LV00	Latvia	0.88	3

Peat energy plants

NUTS 2 Region	NUTS 2 name	Energy (TJ)	Average efficiency (%)	Average age (years)
LV00	Latvia	85	~90	5

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Jobs in peat sites	Jobs in peat energy plants	Total number of jobs
LV00	Latvia	13	13	26

Lithuania

Peat sites
Number **8**
Production **0.025 Mt**

Peat energy plants
Number **4**
Energy **629 TJ**

Employment
Peat site jobs **19**
Energy plant jobs **18**
Total jobs **37**

Peat sites

NUTS 2	NUTS 2 name	Production (Mt)	No. sites
LT01	Sostinės regionas	0.007	1
LT02	Vidurio ir vakarų Lietuvos regionas	0.018	7

Peat energy plants

NUTS 2 Region	NUTS 2 name	Energy (TJ)	Average co-firing rate (%)	Average efficiency (%)	Average age (years)
LT01	Sostinės regionas	85	38	76	11
LT02	Vidurio ir vakarų Lietuvos regionas	544	38	76	11

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Jobs in peat sites	Jobs in peat energy plants	Total number of jobs
LT01	Sostinės regionas	6	0	6
LT02	Vidurio ir vakarų Lietuvos regionas	14	18	32

Sweden

Peat sites
Number* **40**
Production **0.5 Mt**

Peat energy plants
Number **51**
Energy **5 974 TJ**

Employment
Peat site jobs **329**
Energy plant jobs **709**
Total jobs **1 038**

*Includes only sites from Neova company for which data are available.

Peat sites

NUTS 2	NUTS 2 name	Production (Mt)	No. sites*
SE12	East-Central Sweden	0.10	8
SE21	Småland and the islands	0.08	5
SE22	South Sweden	0.00	1
SE23	West Sweden	0.03	2
SE31	North-Central Sweden	0.06	8
SE32	Central Norrland	0.04	8
SE33	Upper Norrland	0.19	7

*Includes only sites from Neova company for which data are available.

Peat energy plants

NUTS 2 Region	NUTS 2 name	Energy (TJ)	Average efficiency (%)	Average age (years)
SE11	Stockholm	357	NA	NA
SE12	East-Central Sweden	2335	NA	NA
SE21	Småland and the islands	265	NA	NA
SE22	South Sweden	74	NA	NA
SE23	West Sweden	0	NA	NA
SE31	North-Central Sweden	455	NA	NA
SE32	Central Norrland	1 056	NA	NA
SE33	Upper Norrland	1 789	NA	NA

Estimates of employment in coal-related activities

NUTS 2 Region	NUTS 2 name	Jobs in peat sites	Jobs in peat energy plants	Total number of jobs
SE11	Stockholm	0	40	40
SE12	East-Central Sweden	64	261	312
SE21	Småland and the islands	50	30	80
SE22	South Sweden	0	8	8
SE23	West Sweden	20	0	20
SE31	North-Central Sweden	41	51	92
SE32	Central Norrland	28	118	146
SE33	Upper Norrland	125	200	325

KJ-NA-30618-EN-N

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Publications Office of the European Union

doi:10.2760/510714
ISBN 978-92-76-30987-1