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RECENT TRENDS IN COAL AND PEAT REGIONS IN THE WESTERN BALKANS AND UKRAINE

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RECENT TRENDS IN COAL AND PEAT REGIONS IN THE WESTERN BALKANS AND UKRAINE

Contents

Abstract

The purpose of this report is to investigate the future of solid fossil fuels in the Western Balkans and Ukraine and the impact of the energy transition on the number of jobs related to these activities.

This research covers the use of solid fossil fuels (namely coal, peat and oil shale) in the Western Balkans and Ukraine in 2018, at NUTS-2-equivalent level. Evidence shows that there is no registered use of shale oil, and very limited of peat, only in Ukraine. The analysis then focuses on coal use, covering the mining and related power production sectors, evaluating their corresponding direct and indirect employment. It further evaluates the potential impact on the identified employment due to existing decarbonisation strategies. On top of mining and power sectors, distribution of carbon intensive industries across the regional scope is also covered.

Coal is by far the most used fossil fuel in the Western Balkans and Ukraine, followed by peat, which is used only marginally in Ukraine. Shale oil is not used at all. There were 65 coal mines in the area in 2018, producing 93 Mt of hard coal and lignite – which equals around 20% of the coal produced in the European Union. Ukraine hosts by far the biggest mining industry in terms of employment, with 47 mines and more than 55 500 jobs, but Serbia produces almost 50% more coal in just two large open-pit mines, employing 12 500 workers.

The Ukrainian power sector consists of 38 coal power plants, adding up to a capacity of 26 GW. Serbia counts six plants totalling 4.3 GW, Bosnia and Herzegovina reaches 2 GW with five plants. Kosovo* ([1]) and North Macedonia have two plants each with total capacity of 1.2 GW and 0.8 GW respectively. There is one 0.2 GW coal power plant in Montenegro. Kosovo* has the power generation with the highest dependence on coal (95%), followed by Serbia (67%), Bosnia and Herzegovina (65%), North Macedonia (51%), Montenegro (41%) and Ukraine (30%). Albania, relying on hydropower supplemented by imports for its electricity supply, does not use coal or peat for domestic power generation.

There is a total of 138 000 direct jobs associated with the sectors analysed (almost 89 500 jobs in mining and close to 48 500 jobs in coal-based power plants). Seen as a proportion of the total workforce, these employment levels range from 0.4% in Montenegro to 1.4% in Kosovo*, with Ukraine (0.5%), North Macedonia (0.5%), Serbia (0.6%) and Bosnia and Herzegovina (1.3%) in between. For purposes of comparison, the EU's largest coal sector, in Poland, constitutes 0.7% of its national labour force.

If the scenarios we considered in the corresponding energy strategies were to be realised by 2030, between 29 000 and 64 000 jobs would be at risk in coal mines and power plants in the Western Balkans and Ukraine.

([1]) This designation is without prejudice to positions on status and is in line with UN Security Council Resolution 1244 and the ICJ Opinion on the Kosovo Declaration of Independence. The use of asterisk (*) throughout the document is a reference to this footnote.

Acknowledgements

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Executive summary

Policy context

Ensuring a fair and just transition to a decarbonised economy and energy system is deeply enshrined in the energy policy of the European Union. In December 2017, as an enabling action under the "Clean energy for all Europeans" package ([2]), the European Commission launched the Initiative for Coal Regions in Transition ([3]). Since its launch, the initiative has supported public administrations and other relevant stakeholders by connecting them, delivering technical assistance and providing supportive resources.

With the European Green Deal ([4]) (European Commission 2019) the European Union has increased its ambition for reducing greenhouse gas emissions by 2030, aiming to achieve a 55% reduction with respect to 1990 emission levels by 2030, enabling the European Union to become carbon neutral by 2050. The Green Deal must also 'put people first, and pay attention to the regions, industries and workers who will face the greatest challenges.'

The Western Balkans and Ukraine are contracting parties of the Energy Community. By adopting the Energy Community Treaty, the Contracting Parties made legally binding commitments to adopt core EU energy legislation ([5]) and prepare strategic documents, among others National Energy and Climate Plans. The 21st EU-Ukraine Summit in 2019 updated the energy annex of the Association Agreement, moving closer to progressive integration with the EU energy market ([6]). The Guidelines for the Implementation of the Green Agenda for the Western Balkans ([7]) were fully endorsed in the Sofia Declaration at the Western Balkans Summit of 2020, committing the region to working towards the 2050 target of a carbon-neutral continent together with the EU.

Within this context, and building on the experience of the Initiative for Coal Regions in Transition, the European Commission has launched additional instruments such as the Just Transition Platform ([8]) and the Initiative for Coal Regions in Transition in the Western Balkans and Ukraine ([9]).

The Joint Research Centre has produced a series of Science for Policy Reports on coal regions in transition which have provided scientific and technical support for the development of related policies ([10]), ([11]), ([12]). Building on this experience, the current report analyses the use of solid fossil fuels and their related industries in the Western Balkans and Ukraine. Such analysis is carried out at facility level, and presented at NUTS 2-equivalent and NUTS 0-equivalent aggregation level. It also assesses the future of solid fossil fuels in the Western Balkans and Ukraine, and the potential impact of the energy transition on the number of jobs related to these activities.

Recent trends

The analysis presented below is built on 2018 as a base year. **Coal** is the most used solid fossil fuel in both the Western Balkans and Ukraine. **Peat** plays only a minor role in the energy supply of Ukraine, and there is no registered use of **shale oil** in the energy systems analysed.

([2]) Clean energy for all Europeans package (https://ec.europa.eu/energy/topics/energy-strategy/clean-energy-all-europeans_en)

([3]) Initiative for coal regions in transition (https://ec.europa.eu/energy/topics/oil-gas-and-coal/EU-coal-regions/initiative-for-coal-regions-in-transition_en)

([4]) Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. The European green deal. COM/2019/640 final

([5]) Energy Community (https://www.energy-community.org/aboutus/whoweare.html)

([6]) Advancing mutual commitment: joint statement following the 21st EU-Ukraine Summit, Kyiv, 8 July 2019 https://www.consilium.europa.eu/media/40278/eu-ua-joint-statement-final.pdf

([7]) Guidelines for the Implementation of the Green Agenda for the Western Balkans: SWD(2020) 223 final (https://ec.europa.eu/neighbourhood-enlargement/guidelines-implementation-green-agenda-western-balkans_en)

([8]) Just Transition Platform (https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism/just-transition-platform_en)

([9]) Initiative for coal regions in transition in the Western Balkans and Ukraine (https://ec.europa.eu/energy/topics/oil-gas-and-coal/coal-regions-in-the-western-balkans-and-ukraine/initiative-coal-regions-transition-western-balkans-and-ukraine_en)

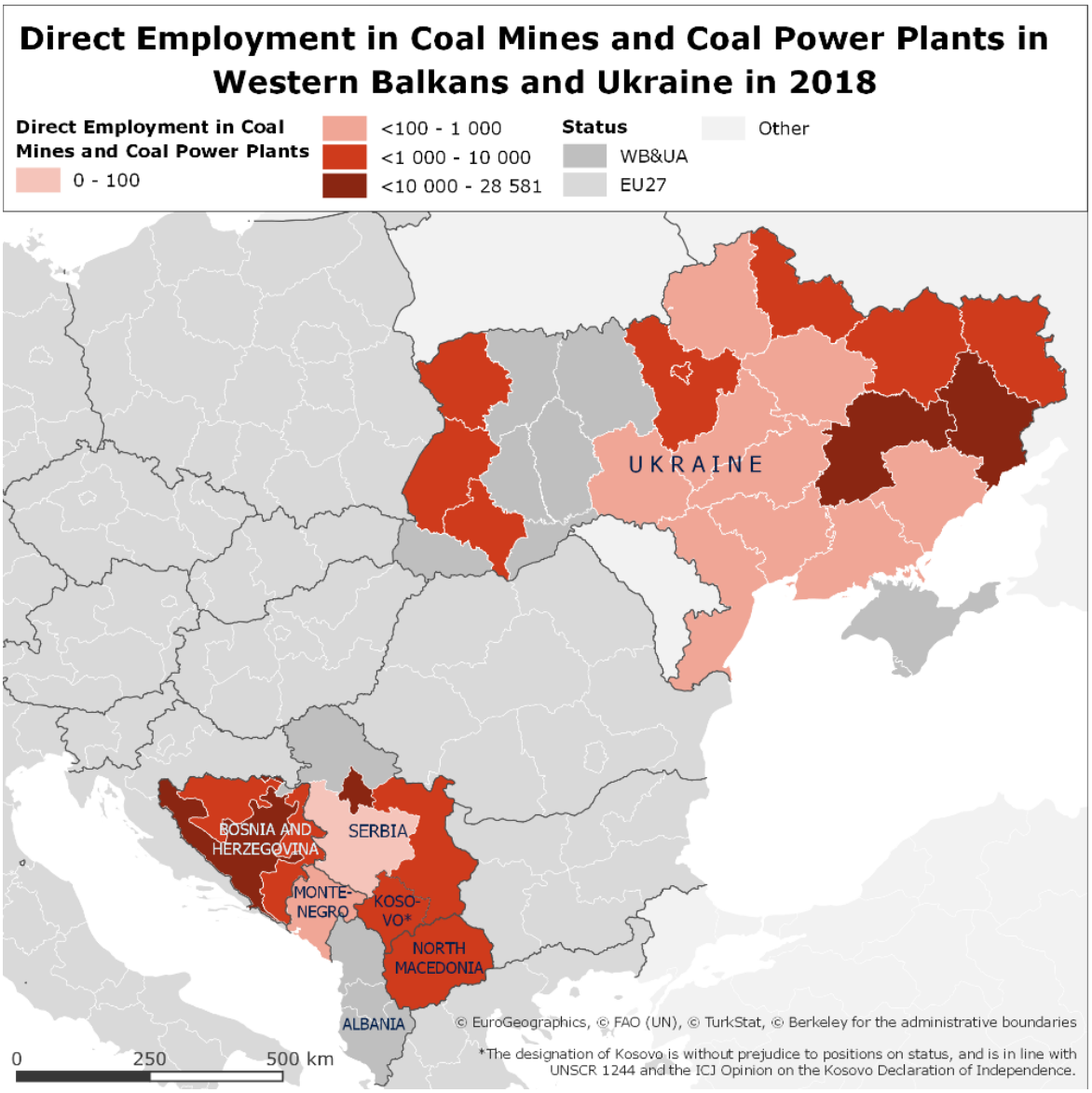
([10]) Alves Dias, P., Kanellopoulos, K., Medarac, H., Kapetaki, Z., Miranda Barbosa, E., Shortall, R., Czako, V., Telsnig, T., Vazquez Hernandez, C., Lacal Arantegui, R., Nijs, W., Gonzalez Aparicio, I., Trombetti, M., Mandras, G., Peteves, E. and Tzimas, E., EU coal regions: opportunities and challenges ahead, EUR 29292 EN, Publications Office of the European Union, Luxembourg, 2018, ISBN 978-92-79-89884-6 (online),978-92-79-89883-9 (print), doi:10.2760/064809 (online),10.2760/668092 (print), JRC112593.

([11]) Kapetaki, Z., Ruiz Castello, P., Armani, R., Bodis, K., Fahl, F., Gonzalez Aparicio, I., Jaeger-Waldau, A., Lebedeva, N., Pinedo Pascua, I., Scarlat, N., Taylor, N., Telsnig, T., Uihlein, A., Vazquez Hernandez, C. and Zangheri, P., Clean energy technologies in coal regions, Kapetaki, Z. editor(s), EUR 29895 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-10356-1, doi:10.2760/384605, JRC117938.

([12]) Alves Dias, P., Conte, A., Kanellopoulos, K., Kapetaki, Z., Mandras, G., Medarac, H., Nijs, W., Ruiz Castello, P., Somers, J. and Tarvydas, D., Recent trends in EU coal, peat and oil shale regions, EUR 30618 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-31019-8, doi:10.2760/975966, JRC123508.

We found 65 coal mines producing 93 Mt of hard coal and lignite in 2018. Ukraine hosts by far the biggest mining industry, with 47 hard coal mines. Lignite is mined in the Western Balkans. Bosnia and Herzegovina has 11 operating mines. Three are found in North Macedonia, two in Serbia and one in Montenegro and Kosovo* Domestic production almost matches demand, except in the case of Ukraine, which imports close to 46% of its demand. From 2016 to 2017 Ukrainian imports grew from 17.2 Mt to 21.3 Mt, and have remained over 21 Mt since then, influenced by the geopolitical situation in eastern regions. The Ukrainian coal power sector consists of 38 power plants, adding up to a total of 26 GW. Serbia counts six plants totalling 4.3 GW, Bosnia and Herzegovina reaches 2 GW with five plants. Kosovo* and North Macedonia have two plants each with total capacity of 1.2 GW and 0.8 GW respectively. There is one 0.2 GW coal power plant in Montenegro. The power sectors analysed show a notable reliance on coal when compared with the EU, where 20% of power was generated from coal in 2018. Kosovo* has the power generation with the highest dependence on coal (95%), followed by Serbia (67%), Bosnia and Herzegovina (65%), North Macedonia (51%), Montenegro (41%) and Ukraine (30%). Albania, with almost total reliance on hydropower supplemented by imports for its electricity supply, does not use coal or peat for domestic power generation.

There are almost **138 000** direct employees in the coal sector in the Western Balkans and Ukraine. Close to 89 500 employees work in coal mining (ranging from 750 jobs in Montenegro to 55 600 jobs in Ukraine) and 48 500 employees work in coal-based power plants (ranging from 170 jobs in Montenegro to 41 000 in Ukraine). In contrast, fewer than 500 jobs can be attributed to the production of fuel peat in Ukraine. The map below shows the regional distribution of this labour force.



Seen as a proportion of the total workforce, these employment levels range from 0.4% in Montenegro to 1.4 % in Kosovo*, with Ukraine (0.5%), North Macedonia (0.5%), Serbia (0.6%) and Bosnia and Herzegovina (1.3%) in between. For purposes of comparison, the EU's largest coal sector, in Poland ([12]), constitutes 0.7% of its national labour force.

Our assessment indicates that there are an additional 131 500 indirect jobs related to the coal activities analysed. These are mostly concentrated in Ukraine (70 500 jobs), Serbia (38 000 jobs) and Bosnia and Herzegovina (13 000 jobs). An additional 5 000 indirect jobs are to be found in Kosovo*, almost 4 000 indirect jobs in North Macedonia and 1 000 indirect jobs in Montenegro. This implies an average compound indirect/direct jobs ratio of 0.95.

Some structural differences must be taken into account when comparing the sectorial findings with those of the EU ([12]). In the territories within the scope of this study, the level of employment in some facilities is not always correlated with their production, what could indicate inefficiencies in the labour market. While coal mines in the EU have an average productivity of 4 730 tonnes per full-time equivalent employee (t/FTE), mines in the Western Balkans and Ukraine have a 755 t/FTE average. Just a limited number of mines in Bosnia and Herzegovina and in Serbia get close to the productivity range seen in the EU. Regarding the power sector, the plant fleet analysed is older than that of the EU. While the EU fleet averages 35 years old, that of the Western Balkans and Ukraine is 44 years old. In terms of productivity, while EU plants average an employment intensity of 0.4 jobs/MW, plants identified in the Western Balkans and Ukraine average 1.67 jobs/MW (1 job/MW for the Western Balkans and 2 jobs/MW for Ukraine), which means an employment intensity up to 4 times higher.

In 2018, close to 23 Mt of solid fossil fuels were used in energy-intensive industries in the Western Balkans and Ukraine, of which the vast majority - 20 Mt (89%) - were used in the production of iron and steel ([13]). Another 2 Mt (9% of the total) were used in the non-metallic minerals sector. The following table shows the distribution of coal use in energy-intensive industries in the Western Balkans and Ukraine.

Solid fossil fuel use 2018 (kt)	**Iron and steel**	**Non-metallic minerals**	**Chemicals**	**Non-ferrous metals**	**Pulp and paper**	**Total energy-intensive industry**
Ukraine	18 301	1 036	5	191		**19 533**
Serbia	958	300	109		22	**1 389**
Bosnia and Herzegovina	620	162	0.3	150	0.2	**932**
Albania		408				**408**
North Macedonia	103	107				**209**
Kosovo*	25					**25**
Montenegro	6					**6**
Total	**20 011**	**2 013**	**114**	**341**	**23**	**22 501**

Source: JRC, based on data from Eurostat

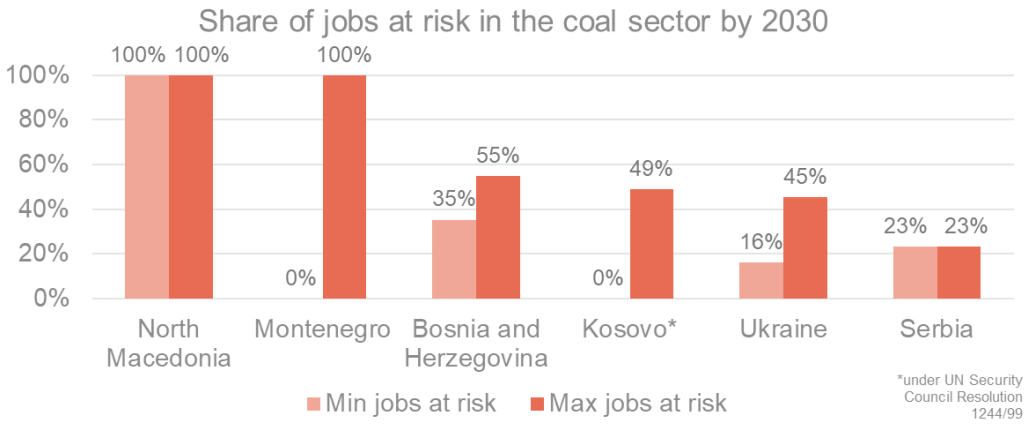
Future perspectives

The Western Balkans and Ukraine have different energy strategies in force. We have considered the scenarios with the highest and lowest levels of decarbonisation and several in between, and assessed their potential employment implications for the coal mining and coal power generation sectors. By 2030, we estimate that between 29 000 and 64 000 jobs are at risk in coal mines and coal power plants in the Western Balkans and Ukraine.

By way of comparison, in the EU ([12]) between 2020 and 2030, total job losses in the coal sector are likely to range from 54 000 to 112 000 jobs. That higher risk is likely to be the result of decarbonisation scenarios which are generally much more ambitious, applied to a significantly larger, though far more productive, sector.

([13]) Eurostat. Complete energy balances [NRG_BAL_C$DEFAULTVIEW], 2021

The maximum potential impact on employment is to be found in the National Energy and Climate Plan (NECP) of North Macedonia ([14]), where all jobs in the coal sector are at risk. The same is true in one of the scenarios for Montenegro. The share of jobs at risk is between 35% and 55% in Bosnia and Herzegovina, up to 49% in Kosovo*, between 16% and 45% in Ukraine and 23% in Serbia. The figure below shows the top and bottom estimates for jobs at risk according to the various scenarios in national energy strategies.



Key conclusions

This report presents a detailed analysis of solid fossil fuel use in the Western Balkans and Ukraine at NUTS 2-equivalent level, building on a series of reports helping to identify coal-related employment at risk. It aims to support policy design to enable a fair and just transition in the targeted sectors.

Each chapter concludes with a detailed table of key findings. To summarise:

- Regarding solid fossil fuels, coal is by far the most used in the Western Balkans and Ukraine, with a total of 138 000 direct jobs (around 89 500 jobs in mining and 48 500 jobs in coal-based power plants).
- The most exposed regions are the Ukrainian regions Donetska oblast and Dnipropetrovska oblast with close to 28 500 and 20 000 jobs respectively related to coal activities. They are followed by Federacija Bosne i Hercegovine in Bosnia and Herzegovina and the Serbian region Beogradski region with close to 12 000 jobs each.
- If the scenarios based on national energy strategies were to be realised in terms of reductions in coal use by 2030, then between 29 000 and 64 000 jobs (a maximum 0.25% of the 2018 total labour force) are at risk in coal mines and power plants across the Western Balkans and Ukraine. Since these strategies do not account for the more recent increased decarbonisation ambition for 2030, these estimates should be seen as conservative.

([14]) All Contracting Parties to the Energy Community Treaty have the obligation to implement the energy acquis in force. North Macedonia delivered the first draft of the National Energy and Climate Plan to the Energy Community in July 2020 (https://www.energy-community.org/implementation/North_Macedonia/reporting.html).

1 Introduction

The European Union is implementing the energy transition with a commitment to reducing greenhouse gases by 55% by 2030 and achieving climate neutrality by 2050. As members of the Energy Community ([15]), the Western Balkans ([16]) and Ukraine (geographical scope presented in Figure 1) agreed to be part of the EU internal energy market and to apply the relevant rules and principles on the basis of a legally binding framework. In other words, the Western Balkans and Ukraine will also have to implement the latest ambitious Fit for 55 package (European Commission 2021), one of whose targets is the reduction of greenhouse gas emissions in the EU ETS ([17]) by 61% by 2030. That being said, Energy Community members are allowed to adapt the acquis and implement possible amendments. This helps them to keep pace with EU developments and continuously align their regulatory frameworks in the energy and related sectors to those of the EU ([18]).

With the exception of Albania, the Western Balkans rely heavily on coal ([19]) in their energy systems. In Albania, a very small amount of imported coal is used in industry. Peat and oil shale are not used in the Western Balkans as energy carriers. Ukraine also relies heavily on coal, alongside a non-systemic use of peat for energy.

Although the energy transition is in its early stages, aging coal power plants and air quality issues (especially in the Western Balkans) are driving the Western Balkans and Ukraine towards coal phase-out and the use of renewables. As can be seen in (Kapetaki et al. 2021), between half and two-thirds of current EU coal power plants could retire by 2030 (60-75 GW), which could affect between 54 000 and 112 000 jobs. A coal phase-out before 2030 is expected in 11 Member States (Denmark, Ireland, Greece, Spain, France, Italy, Hungary, The Netherlands, Portugal, Slovakia and Finland), leaving coal power plants operational in only seven EU Member States (Bulgaria, Czechia, Germany, Croatia, Poland, Romania and Slovenia) ([20]). It should be noted that within the EU, Estonia and Finland have not ruled out the use of peat and oil shale after 2030.

The purpose of this report is to investigate the future of solid fossil fuels in the Western Balkans and Ukraine, and the impact of the energy transition on the number of jobs related to these activities.

The Western Balkans and Ukraine are not EU Member States. However, Montenegro, Serbia, North Macedonia and Albania are official candidates. Accession negotiations and chapters have been opened with Montenegro and Serbia, while Bosnia and Herzegovina and Kosovo* are potential candidates ([21]). Since 2017, Ukraine has had an association agreement with the EU ([22]). This means that the regional structure in the Western Balkans and Ukraine does not necessarily follow the nomenclature of territorial units for statistics (NUTS) as explained in Annex 1.

The report is structured as follows: Chapter 2 reports the current status of coal and peat production and power generation in the Western Balkans and Ukraine. Chapter 3 reviews possible future developments in coal and peat in the Western Balkans and Ukraine. Chapter 4 maps the use of coal in carbon-intensive industries.

Factsheets are provided in Annex 12.

([15]) Energy Community Contracting Parties are Albania, Bosnia and Herzegovina, Kosovo*, North Macedonia, Georgia, Moldova, Montenegro, Serbia and Ukraine.
([16]) The term Western Balkans refers to Montenegro, North Macedonia, Albania, Serbia, Bosnia and Herzegovina and Kosovo*.
([17]) Power sector, energy-intensive industry sectors including oil refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals, as well as aviation and maritime sectors
([18]) Energy Community web page: https://www.energy-community.org/legal/acquis.html
([19]) In this report the term coal is used for hard coal and lignite. In chapter 4 the term coal also includes coking coal.
([20]) Coal regions in transition (https://ec.europa.eu/energy/topics/oil-gas-and-coal/EU-coal-regions/coal-regions-transition_en)
([21]) Eurostat Tutorial: Country codes and protocol order (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Tutorial:Country_codes_and_protocol_order#Codes.2C_names_and_protocol_order_of_European_Union_.28EU.29_Member_States)
([22]) The Council of the EU, EU relations with Ukraine: https://www.consilium.europa.eu/en/policies/eastern-partnership/ukraine/

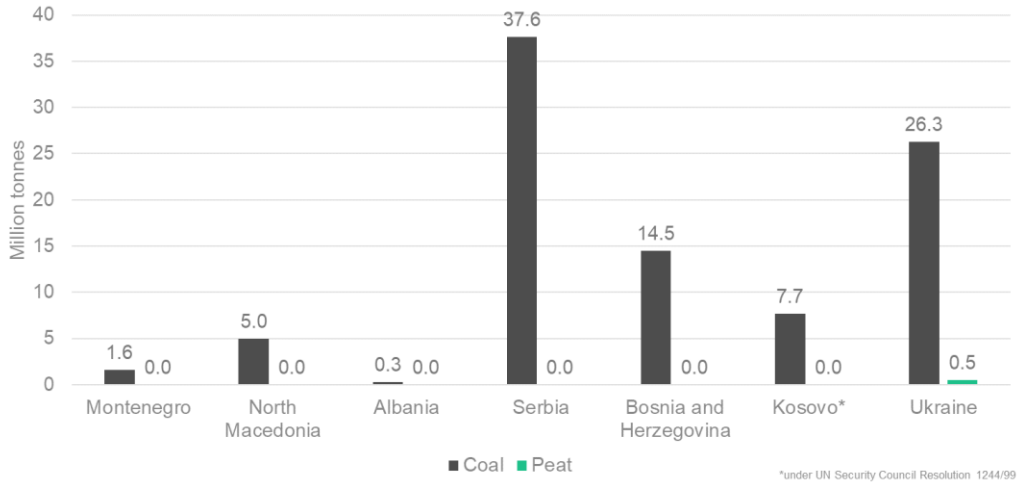
Figure 1. The scope of the report

Source: JRC, 2021

2 Solid fossil fuels in the Western Balkans and Ukraine

Solid fossil fuels are an important primary energy source in the Western Balkans and Ukraine, where coal has been mined since the 19th century, with a significant increase in mining capacities in the second half of the 20th century. As can be seen in Figure 2, coal is by far the most prominent solid fuel in the Western Balkans and Ukraine.

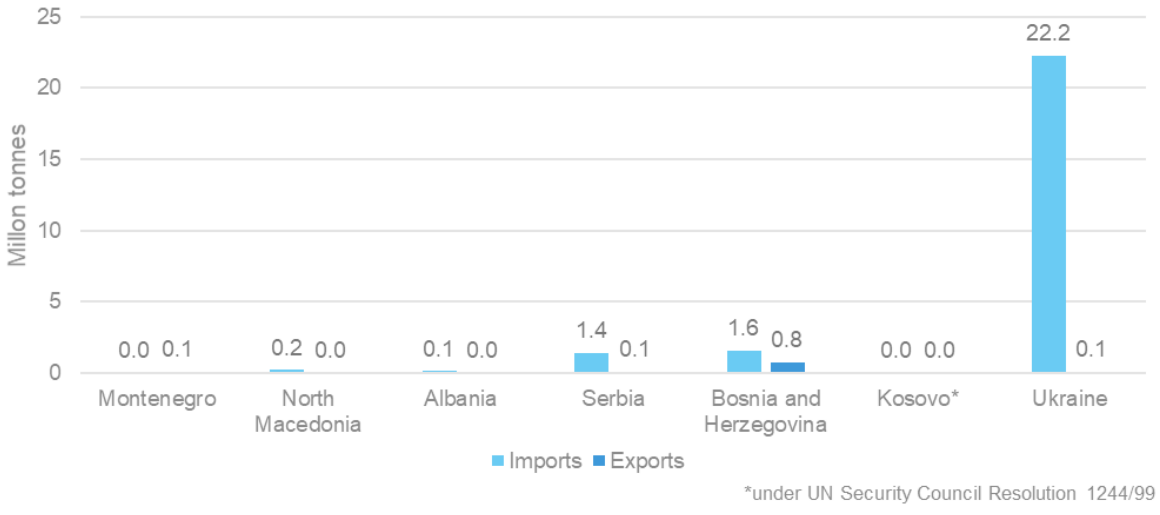
Figure 2. Production of coal and peat in the Western Balkans and Ukraine in 2018



Source: JRC, Eurostat [NRG_CB_SFF], 2021

The Western Balkans and Ukraine produced 93 Mt of coal in 2018. The largest coal producers are Serbia and Ukraine with 38 and 26 Mt produced in 2018, respectively. The rest of the Western Balkans produced less than half of Serbia's output. As shown in Figure 2, the amount of coal produced in Albania (0.3 Mt) is negligible when compared with the rest of the Western Balkans and Ukraine. The Albanian coal sector is described in Annex 2. Peat is only produced in Ukraine but, even there, plays a minor role when compared with coal. Finally, oil shale is not produced in the Western Balkans or in Ukraine.

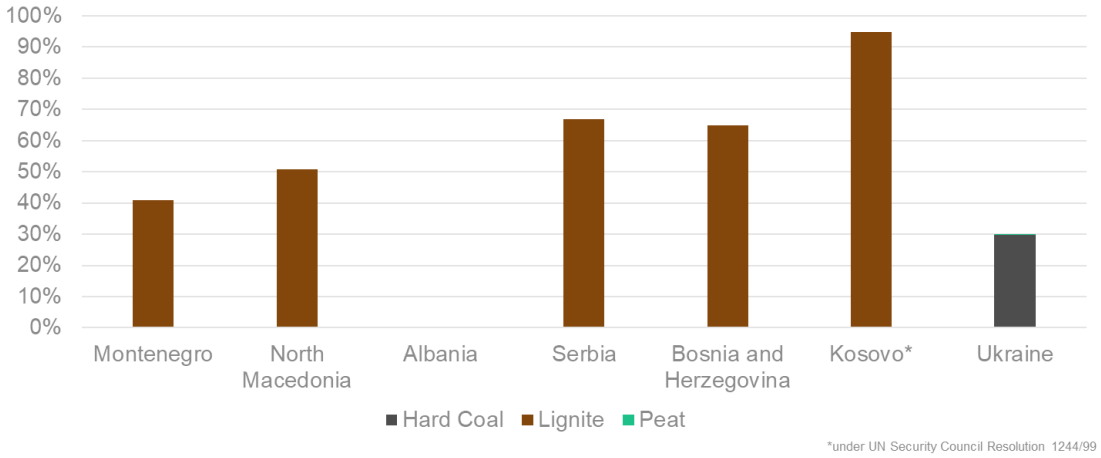
Figure 3. Coal imports and exports, 2018



Source: JRC, Eurostat [NRG_CB_SFF], 2018

As shown in Figure 3, coal imports are only of any real significance in Ukraine. Driven by the coke oven industry and by substantial power use, Ukraine imported 22.2 Mt of coal, on top of 26.3 Mt mined the same year. Almost all the trade involves hard coal. On the other hand, the Western Balkans do not trade significant amounts of coal in relation to the size of their mining industry. Bosnia and Herzegovina and Serbia were the biggest importers after Ukraine, with 1.6 Mt and 1.4 Mt in 2018, respectively, whereas their production in the same year was 14.5 Mt and 37.6 Mt. Coal is almost the only solid fossil fuel used for power generation in the Western Balkans and Ukraine.

Figure 4. Shares of solid fossil fuels over gross electricity generation in Western Balkans and Ukraine in 2018



Source: JRC, Eurostat [NRG_BAL_PEH], 2021

The Western Balkans and Ukraine are highly dependent on coal for power generation (lignite in the Western Balkans, and hard coal in Ukraine). The share of coal in the power generation mix ranges from 30% in Ukraine to 95% in Kosovo* (Figure 4). At the other extreme, with a heavy reliance on hydropower, neighbouring Albania does not generate any power from solid fuels. Regarding peat, although Eurostat records 15 GWh generated in Ukraine, this amount is negligible when compared with coal or other energy carriers.

Due to its role in the energy mix, this report will focus mainly on coal, understood as hard coal and lignite. The small-scale Ukrainian peat sector will be addressed in section 2.2. Shale oil is not used in the Western Balkans and Ukraine and is therefore excluded from this study. Albania also falls outside the scope of this report because it does not use coal for energy. Further information for Albania is provided in Annex 2.

2.1 Coal in the Western Balkans and Ukraine

With 93 Mt of coal produced in 2018, the Western Balkans and Ukraine produced around 20% of the amount produced in the same year by the European Union, where 11 member states produced 442 Mt. In the European Union there are 166 operating coal power plants with a total installed capacity of 112 GW, while in the Western Balkans and Ukraine there are 52 coal-fired power plants with a total installed capacity of 35 GW. This means that the size of the average coal-fired power plant in the European Union and the Western Balkans and Ukraine is almost the same: close to 675 MW (Kapetaki et al. 2021). This section describes the mining sector, power plants and associated direct employment at NUTS 2-equivalent level.

2.1.1 Operating coal mines

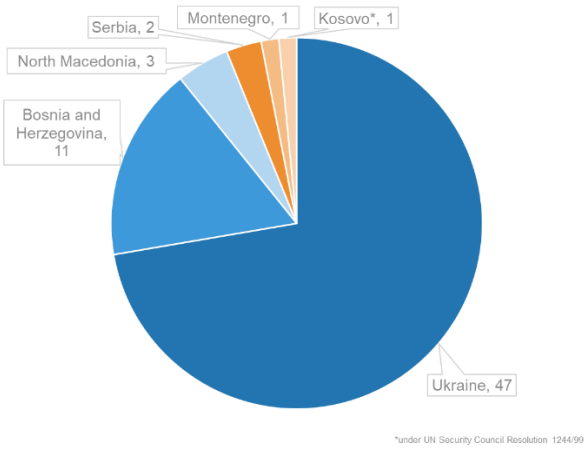
As shown in Figure 5, Ukraine hosts 47 of the 65 coal mines in the Western Balkans and Ukraine: almost 75%. There are 11 mines in Bosnia and Herzegovina and 7 mines in the rest of the Western Balkans.

However, of the 93 Mt of coal produced in 2018, Serbia was the biggest producer at more than 40%, with just under 30% produced in Ukraine. 16% was produced in Bosnia and Herzegovina and the remaining 15% across the rest of the Western Balkans (Figure 6). This coal is mainly used for power and heat generation and partly for the iron and steel industry. Small quantities of coal are also used by other industrial users and households.

In 2018, almost 66 Mt of lignite was produced in the Western Balkans; half of it in Serbia (37.6 Mt). At the same time, 26.3 Mt of hard coal was produced, mainly in Ukraine, out of which 95% was produced in the eastern part of Ukraine and 5% in the west, close to the Polish border (Figure 7).

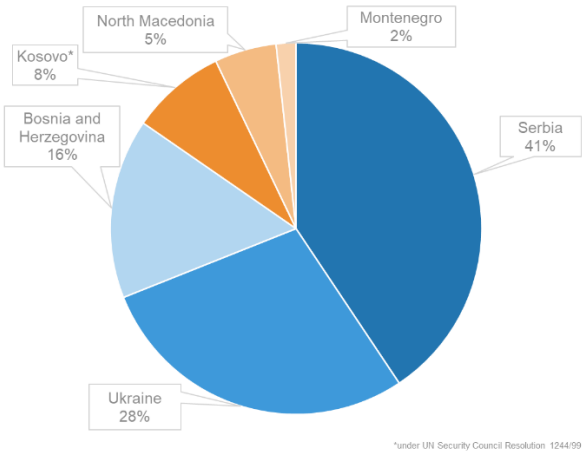
The two largest lignite mines are in Serbia, with coal production of 28.4 and 8.6 Mt, followed by the mine in Kosovo*, producing 7.7 Mt of lignite per year. This is similar to the European Union, where the three largest mines in Germany and Poland produce 30 Mt/year and several additional mines in Poland produce 10 Mt/year (Kapetaki et al. 2021). Each of the three largest mines in Ukraine produces between 2 Mt and 3 Mt of hard coal per year.

Figure 5. Number of coal mines in the Western Balkans and Ukraine



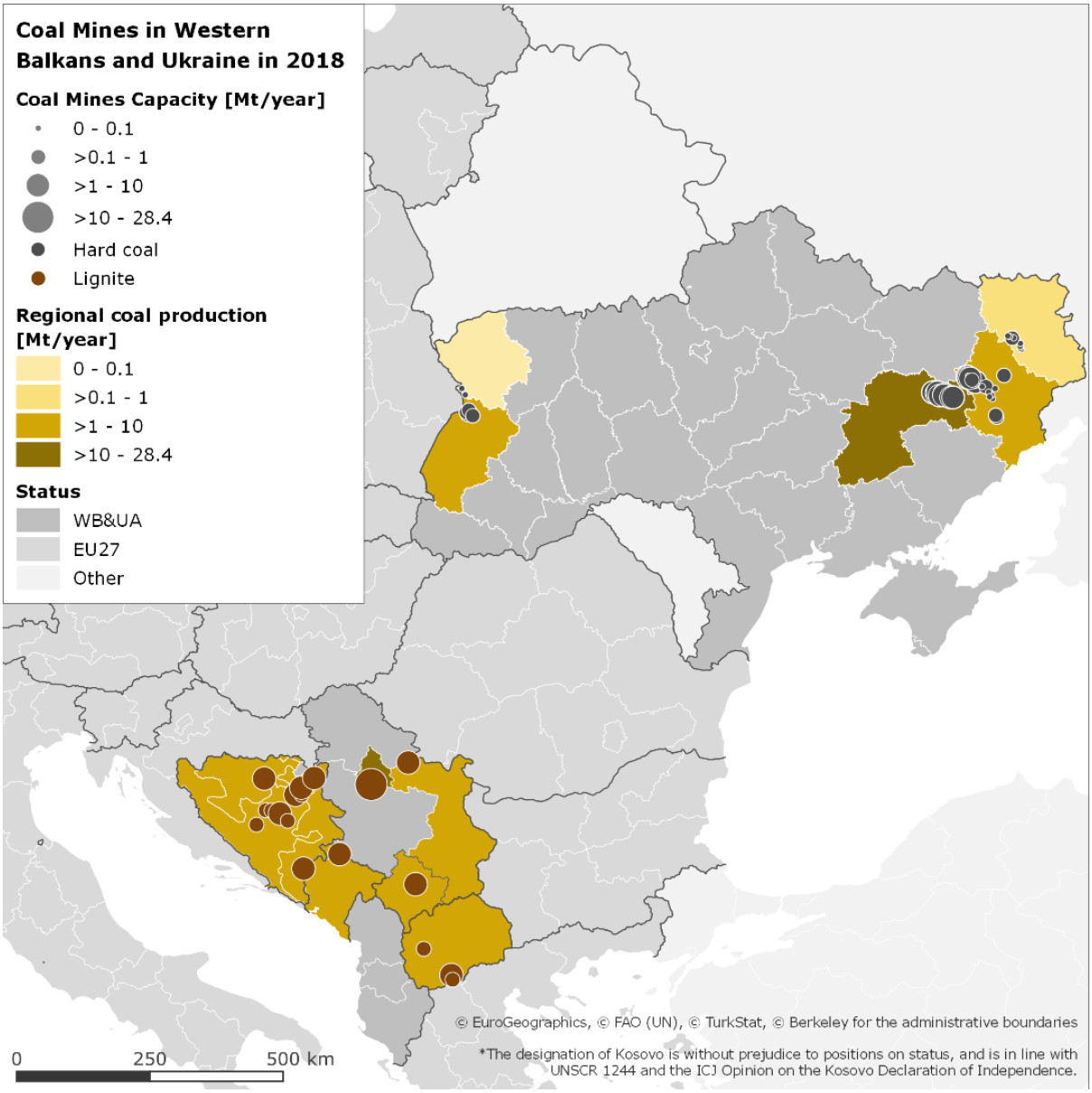
Source: JRC, 2021

Figure 6. Share of coal production in the Western Balkans and Ukraine in 2018



Source: JRC, Eurostat [NRG_CB_SFF], 2021

Figure 7. Coal mining in the in the Western Balkans and Ukraine in 2018



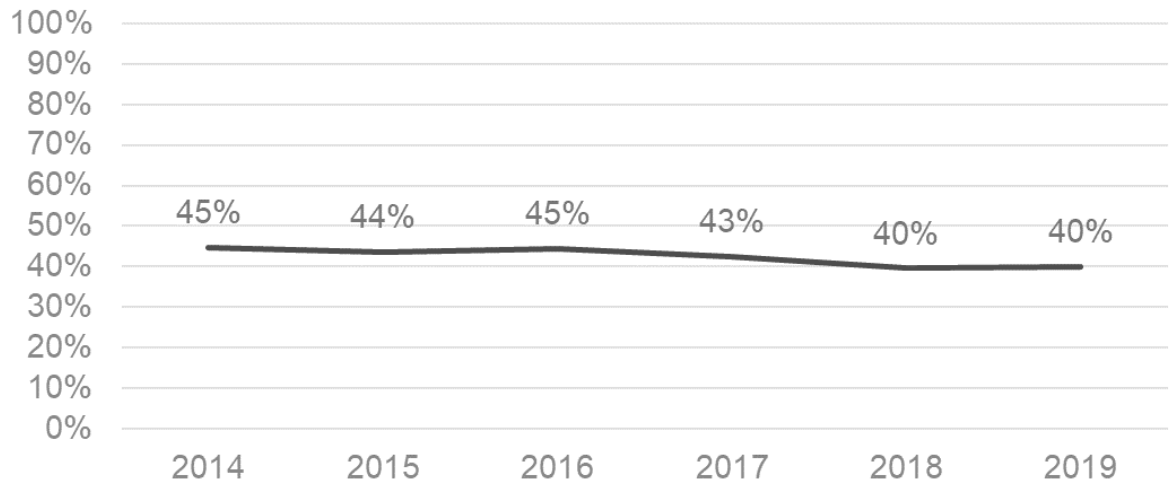
Source: JRC, 2021

In 2018, coal was mined in 12 regions in the Western Balkans and Ukraine. In 2018, the region with the highest aggregated coal production was Serbian region RS11 Beogradski region with 28.4 Mt, followed by Ukrainian region UA12 Dnipropetrovska oblast with 19.1 Mt and Serbian region RS22 Region Južne i Istočne Srbije with 8.6 Mt. A detailed list of regions with coal-mining activities is presented in Annex 3.

2.1.2 Operating coal-fired power plants

The share of electricity from coal-fired power plants in the power generation mix of the Western Balkans and Ukraine was around 45% until 2016, decreasing to 40% from 2018, as shown in Figure 8.

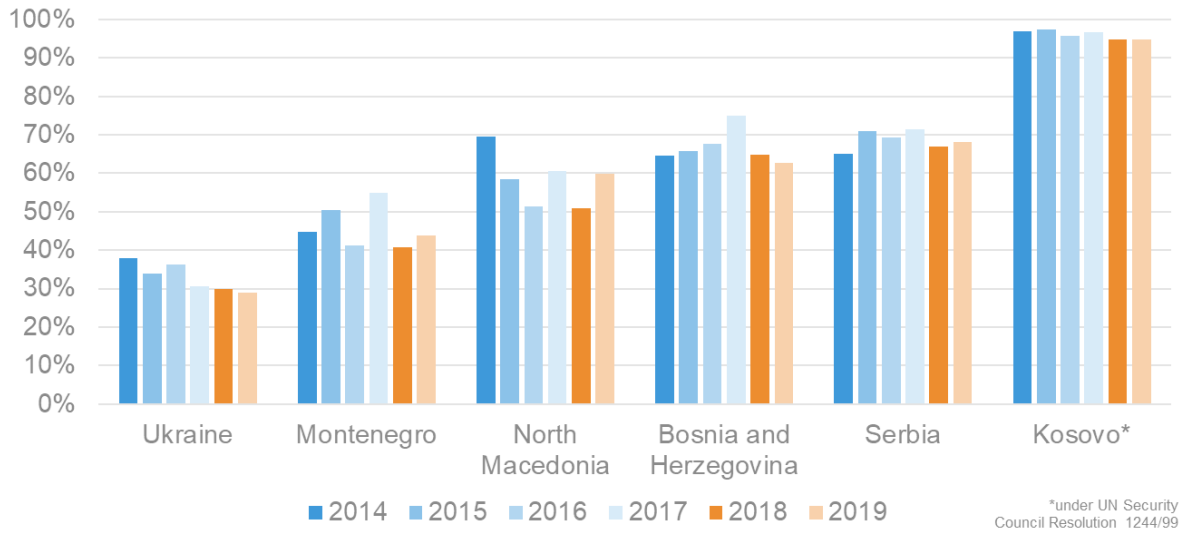
Figure 8. Share of coal in power generation in the Western Balkans and Ukraine from 2014 to 2019 ([23])



Source: JRC, Eurostat [NRG_BAL_PEH], 2021 ([24])

Detailed analysis (Figure 9) shows that Ukraine saw a decrease in the share of coal for power generation from 2014 to 2019 by almost one quarter, from 38% to 29%. North Macedonia also experienced a significant decrease, from 70% in 2014 to 60% in 2019, but it is important to note that in 2018 the share of power generation from coal in North Macedonia dropped to 51%. Although the share also decreased in Kosovo*, the change was marginal, from 97% to 95%. Only Serbia registered an increase in power generation using coal, from 65% in 2014 to 68% in 2019. There was no use of coal for power generation in Albania during the observed period, and it was therefore excluded from this diagram.

Figure 9. Evolution of share of coal in power generation from 2014 to 2019



Source: JRC, Eurostat [NRG_BAL_PEH], 2021

([23]) The data covers Ukraine and all Western Balkans including Albania.

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

Table 1 shows absolute values of coal power generation in 2018 which is also the year for which all the data was provided for bottom-up analysis of coal mines and coal power plants. 10

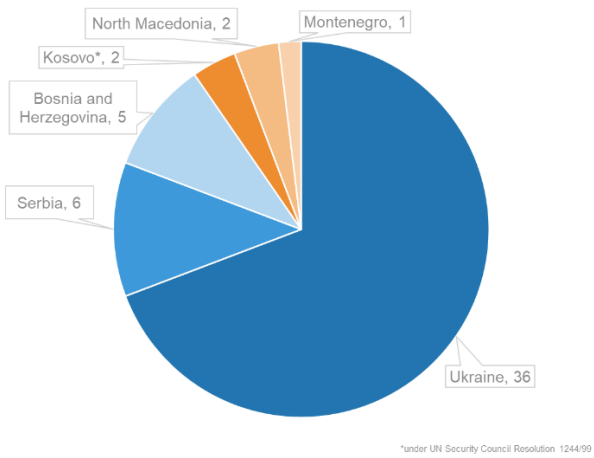
Table 1 Share of coal in power generation in 2018

	Gross electricity generation (GWh)	Electricity generation from coal (GWh)	Share of coal in electricity generation (%)
Montenegro	3 811	1 555	41 %
North Macedonia	5 607	2 848	51 %
Albania	8 553	0	0 %
Serbia	37 426	25 020	67 %
Bosnia and Herzegovina	19 160	12 437	65 %
Kosovo*	5 915	5 601	95 %
Ukraine	159 796	47 709	30 %

Source: Eurostat [NRG_BAL_PEH], 2021.

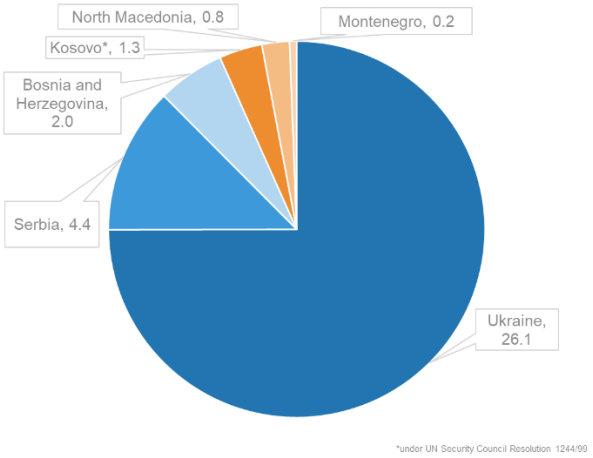
In 2018, there were 52 coal-fired power plants operating in the Western Balkans and Ukraine, with a total installed capacity of almost 35 GW (Figures 10, 11 and 12). 70% of these plants are located in Ukraine and use hard coal (with a total installed capacity of 26 GW). The other 30% (8.7 GW) are lignite-fired power plants in the Western Balkans. There are six power plants in Serbia (4.4 GW) and five in Bosnia and Herzegovina (2 GW), followed by two power plants in Kosovo* (1.3 GW), two in North Macedonia (0.8 GW) and one in Montenegro (0.2 GW). All power plants in the Western Balkans are located close to coal mines, but of a total production of 26 GW in Ukraine, only 11.6 GW is produced by coal power plants in the same regions as coal mines. Others mainly use imported hard coal.

Figure 10. Number of coal power plants in the Western Balkans and Ukraine



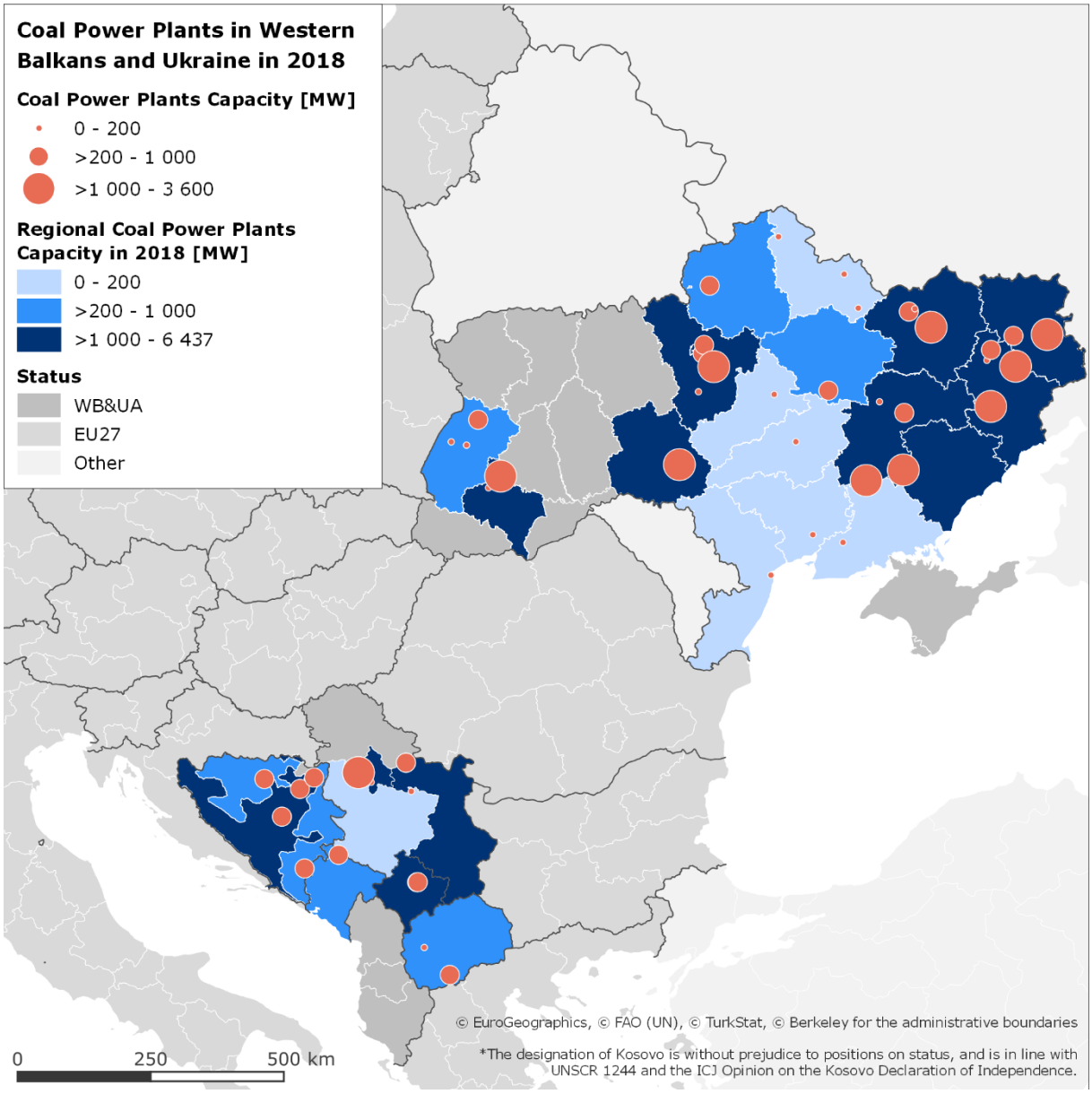
Source: JRC, 2021

Figure 11. Coal power plant capacities in the Western Balkans and Ukraine in 2018 (GW)



Source: JRC, 2021

Figure 12. Coal power plants in the Western Balkans and Ukraine in 2018



Source: JRC, 2021

There are 26 regions equivalent to NUTS 2 regions with coal-fired power plants in the Western Balkans and Ukraine. The region with by far the largest power plant capacity is UA14 Donetska oblast (6.4 GW) in Ukraine, followed by Serbian region RS11 Beogradski region (3.2 GW), Ukrainian region UA12 Dnipropetrovska oblast (3 GW) and another seven Ukrainian regions with a total installed capacity of 15 GW (UA63, UA23, UA26, UA32, UA05, UA44 and UA80).

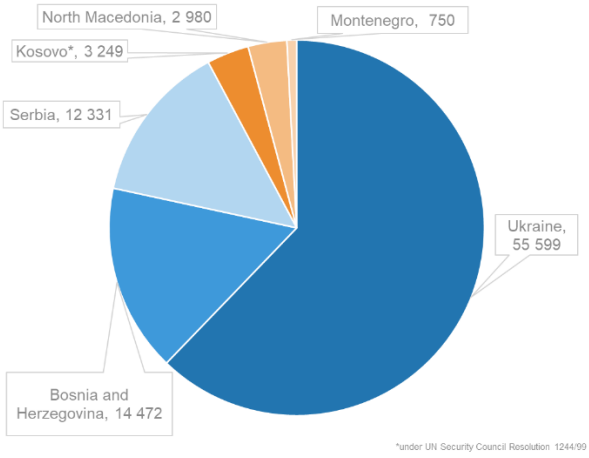
A detailed list of regions with coal power plants is presented in Annex 4.

2.1.3 Direct employment in coal power plants and mines

Direct employment in coal power plants and coal mines has been analysed at regional level. Detailed results are presented in Annex 5. The assessment of employment in the EU coal sector has become a controversial issue ((Ciută and Gallop 2018), (Gray et al. 2018), (Flisowska and Skotnicki 2020)), and there is more uncertainty in the regional scope of this report., as there is no consistent mechanism or approach for reporting the employment indicators. The analysis presented in this section is based on field data provided by experts, relevant national sources, declarations of involved companies and key stakeholders in the sector. Where data gaps persist, to form a whole data set for 2018, assumptions have been made on the basis of the closest data points available, observing the characteristics and dynamics of the sectorial variables described in Section 2.1.5 (such as productivity and plant age).

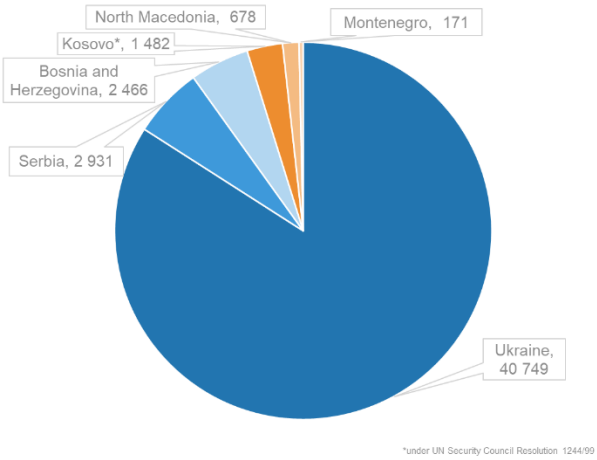
In 2018, the coal sector employed almost 138 000 people in the Western Balkans and Ukraine, of which around 89 500 were employed in coal mining and almost 48 500 in coal-fired power plants. Ukraine employs around two thirds of these workers (more than 96 000 jobs), followed by Bosnia and Herzegovina with almost 17 000, and Serbia with more than 15 000 jobs. Ukraine has the most jobs in both coal mining and coal power plants, followed in each case by Bosnia and Herzegovina and Serbia (Figures 13, 14 and 15).

Figure 13. Number of jobs in coal mines in the Western Balkans and Ukraine



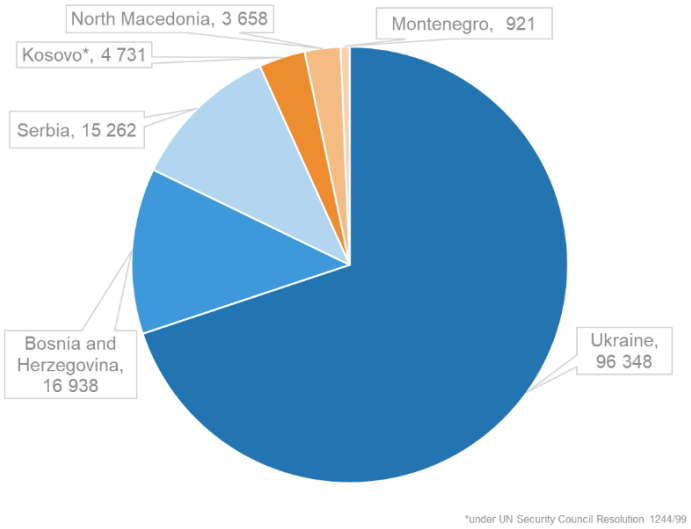
Source: JRC, 2021

Figure 14. Number of jobs in coal power plants in the Western Balkans and Ukraine in 2018



Source: JRC, 2021

Figure 15. Number of overall jobs in coal mines and coal power plants in the Western Balkans and Ukraine



Source: JRC, 2021

A detailed overview of the number of jobs in the coal sector in the Western Balkans and Ukraine is provided in Table 2.

Table 2 Direct jobs in coal sector in 2018

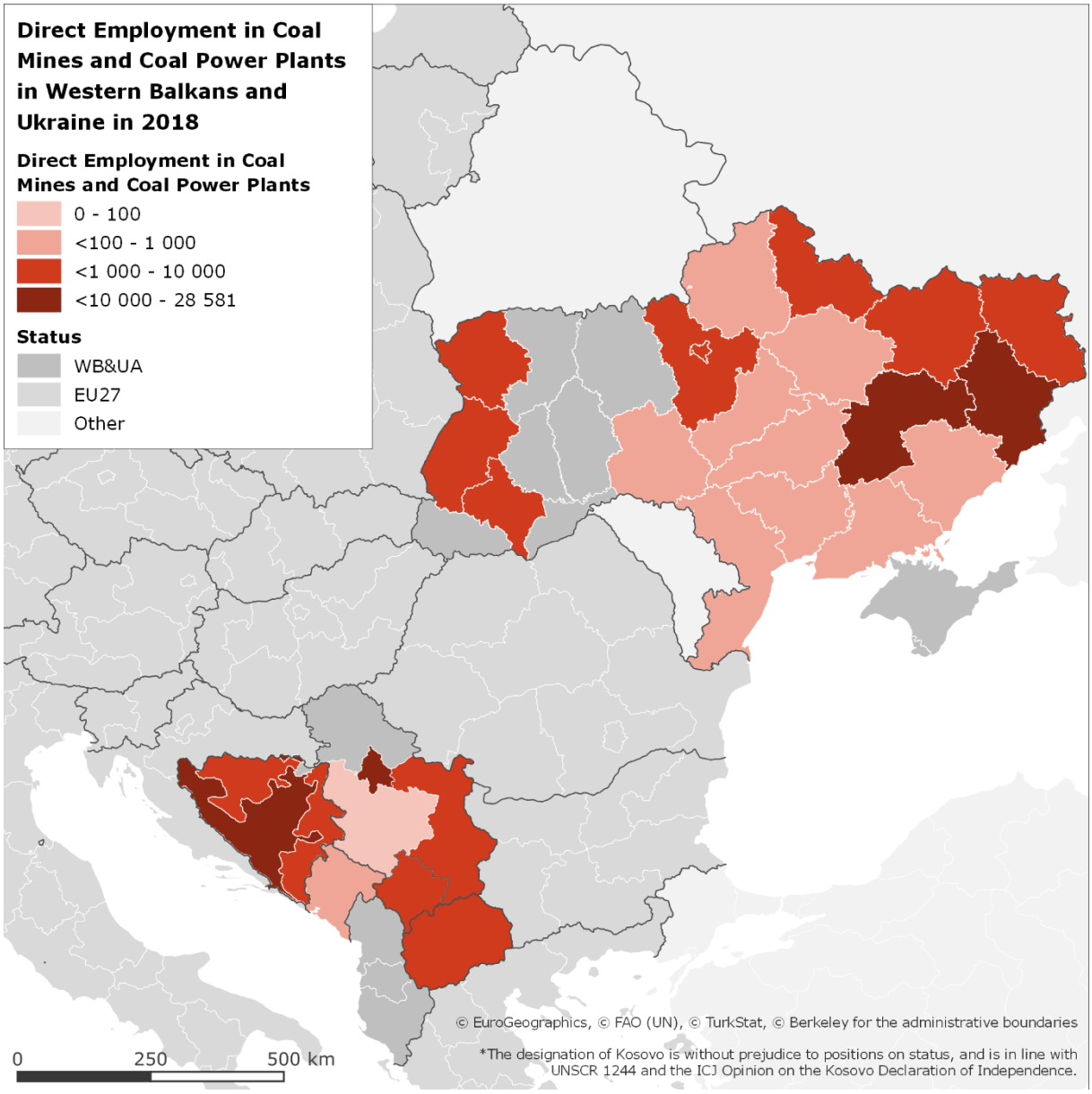
	Mining jobs	Power plant jobs	Overall jobs
Ukraine	55 599 ([1])	40 749 ([1])	96 348
Bosnia and Herzegovina	14 472 ([2])	2 466 ([3])	16 938
Serbia	12 331 ([4])	2 931 ([4])	15 262
Kosovo*	3 249 ([4])	1 482 ([4])	4 731
North Macedonia	2 980 ([5])	678 ([5])	3 658
Montenegro	750 ([4])	171 ([4])	921
TOTAL	**89 381**	**48 477**	**137 858**

([1]) Source: National expert data
([2]) Sources: (Federal Ministry for Energy Mining and Industry 2016; Mine and Thermal Power Plant Gacko 2017, 2019; Mine and Thermal Power Plant Ugljevik 2015, 2016, 2017, 2018, 2019)
([3]) Sources: (Ciută and Gallop 2018; Mine and Thermal Power Plant Gacko 2017, 2019; Mine and Thermal Power Plant Ugljevik 2015, 2016, 2017, 2018, 2019)
([4]) Source:(Ciută and Gallop 2018), in Serbia, distribution among power plants by JRC (
([5]) Sources: (ELEM 2015, 2016, 2017; ESM 2018, 2019), distribution between mines and power plants by JRC

Source: JRC, 2021.

The distribution of the overall number of jobs in the two coal-related sectors – power plants and mining – is given at regional level in Figure 16.

Figure 16. Direct jobs in coal mines and coal power plants in the Western Balkans and Ukraine in 2018



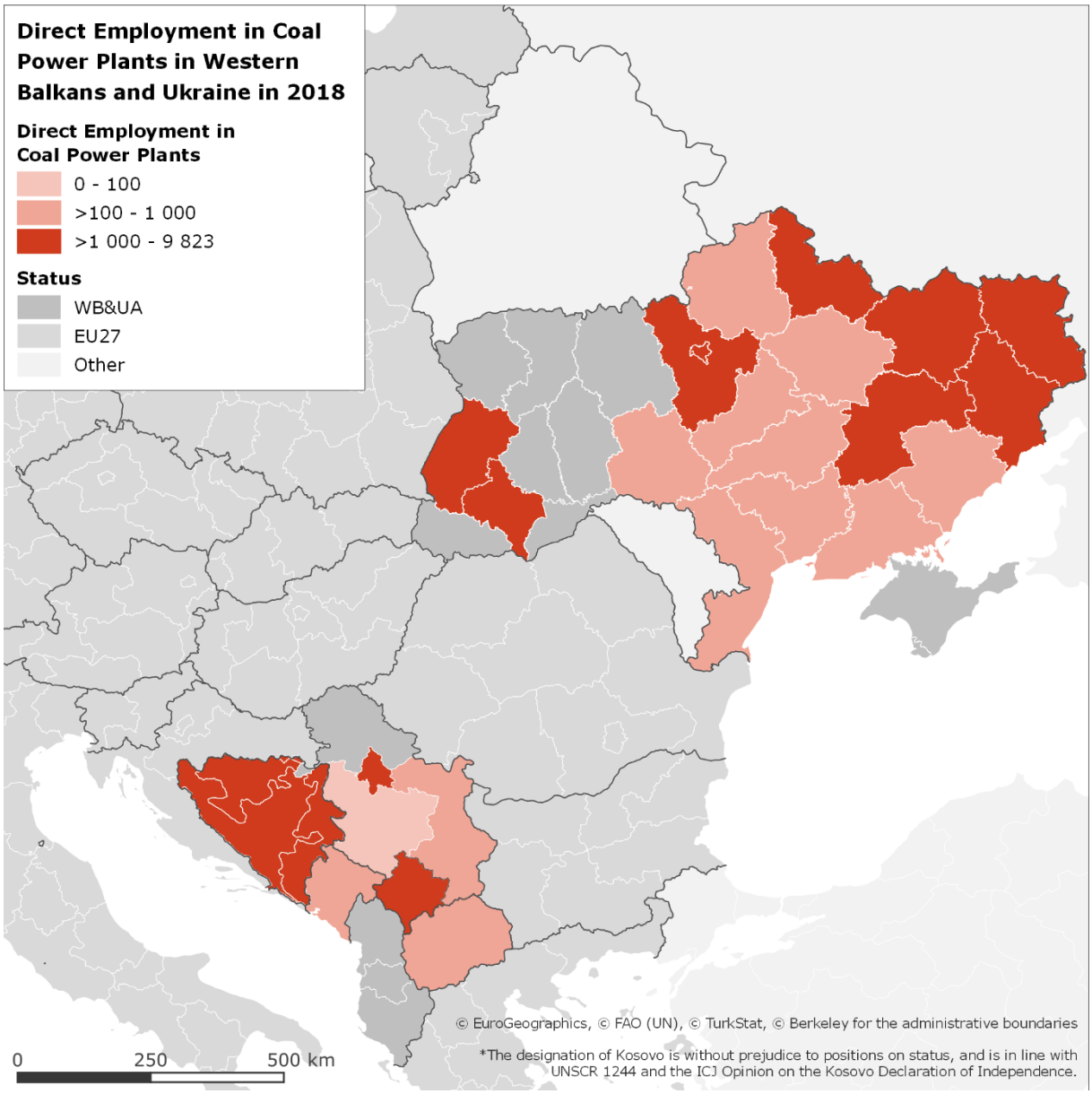
Source: JRC, 2021

There are four regions with more than 10 000 employees in coal-related activities: Ukrainian regions UA14 Donetska oblast (28 600 jobs), UA12 Dnipropetrovska oblast (20 200 jobs), the region BA-FBH Federacija Bosne i Hercegovine (12 300 jobs) in Bosnia and Herzegovina and Serbian region RS11 Beogradski region, with 12 250 employees. In addition, there are four regions in Ukraine with between 7 500 and 10 000 jobs (UA46, UA46, UA32 and UA44) and four regions in the Western Balkans with between 2 900 and 4 700 jobs (XK* in Kosovo*, BA-RS in Bosnia and Herzegovina, MK00 in North Macedonia and RS22 in Serbia).

2.1.3.1 Direct jobs in coal-fired power plants

The sources we considered account for approximately 48 500 employees in coal-fired power plants in the Western Balkans and Ukraine in 2018. At national level, the number of jobs ranges from just above 170 in Montenegro to around 40 750 in Ukraine. Figure 17 presents the estimated number of direct jobs in active coal-fired power plants at regional level.

Figure 17. Direct jobs in coal power plants in the Western Balkans and Ukraine in 2018



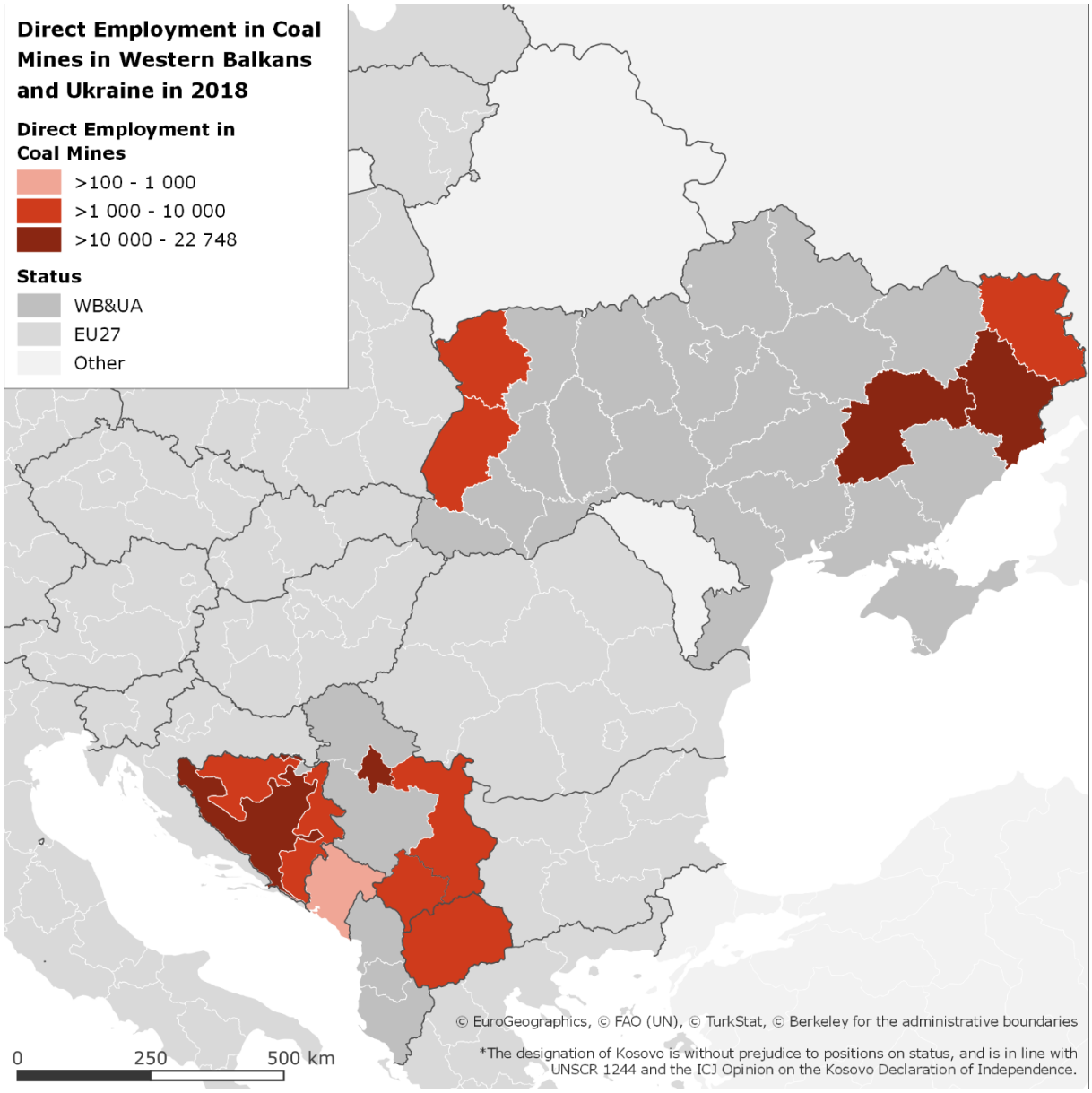
Source: JRC, 2021, (Ciută and Gallop 2018; ELEM 2015, 2016, 2017; ESM 2018, 2019; Mine and Thermal Power Plant Gacko 2017, 2019; Mine and Thermal Power Plant Ugljevik 2017, 2018, 2019, 2015, 2016), National expert data for Ukraine

There are more than 1 000 coal power plant jobs in 13 of the 26 regions with coal power plants. In absolute terms, the largest employers are the Ukrainian regions, UA63 Kharkivska oblast (9 800 jobs), UA32 Kyivska oblast (8 700 jobs), UA14 Donetska oblast (5 800 jobs), UA46 Lvivska oblast (2 800 jobs) and UA80 Kyivska rada (2 100 jobs). The Western Balkan region with the most coal power plant jobs is Serbian region RS11 Beogradski region, with 2 100 employees.

2.1.3.2 Direct jobs in coal mining

In 2018, coal mining provided for almost 89 500 jobs in the Western Balkans and Ukraine. Employment at national level ranged between 750 in Montenegro and 55 600 in Ukraine. As shown in Figure 18, there are four regions with more than 10 000 employees in coal mining activities: UA14 Donetska oblast (22 750 jobs) and UA12 Dnipropetrovska oblast (18 400 jobs) in Ukraine, BA-FBH Federacija Bosne i Hercegovine (11 100 jobs) in Bosnia and Herzegovina and RS11 Beogradski region in Serbia, with 10 200 employees in coal mines. In addition, there are two regions in Ukraine with around 6 500 jobs (UA46 and UA44) and four regions in the Western Balkans with between 2 000 and 3 500 jobs (BA-RS in Bosnia and Herzegovina, XK* in Kosovo*, MK00 in North Macedonia and RS22 in Serbia).

Figure 18. Direct jobs in coal mines in the Western Balkans and Ukraine in 2018



Source: JRC, 2021, (Ciută and Gallop 2018; ELEM 2015, 2016, 2017; ESM 2018, 2019; Federal Ministry for Energy Mining and Industry 2016; Mine and Thermal Power Plant Gacko 2017, 2019; Mine and Thermal Power Plant Ugljevik 2016, 2017, 2018, 2019, 2015), National expert data for Ukraine

2.1.4 Indirect jobs in coal and peat related activities

Information on indirect jobs related to coal and peat is not readily available. However, assuming that levels of employment in an economic sector are closely related to its output, such that the employment / output ratio can be defined for all output levels, then the input-output (IO) modelling approach allows us to calculate employment multipliers to estimate indirect jobs (Hewings 2020).

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 inter-industry linkages along the supply chains (Mandras, Conte, and Salotti 2019).

In this analysis, the IO-output multipliers are related to changes in employment instead of final demand, meaning that indirect jobs can be calculated using direct jobs (see Annex 6 for a brief description of the methodology).

We use the EORA global supply chain database, which consists of a set of multi-region, input-output tables (MRIO) for 190 countries and 26 sectors, interlinked with trade in goods and services (Lenzen et al. 2012, 2013). Trade links between regions, besides extending the supply-chain coverage to all sectors that might be impacted by changes in mining and power plants activities, allow us to assess indirect jobs at INTRA-regional level and to consider spill-over effects at INTER-regional level. However, EORA data are available only at country level so that, after the calculation of the country/level sectoral employment multipliers, we use weights per sector and per fuel to scale the results at sub-national level. On the employment data, we use data disaggregated by economic activity provided by ILOSTAT ([25]).

The number of indirect employees and a comparison between direct jobs in coal-related activities and indirect jobs is provided in Table 3 for the Western Balkans and Ukraine ([26]). The complete results at regional level are reported in Annex 7.

Looking at the ratio between indirect and direct jobs, the coefficients vary noticeably; our results suggests that for every direct job, the associated indirect jobs could be in the range of less than 1 and up to 2.53. In other words, since direct jobs are related to the specific industry and indirect jobs are those that support that sector, this ratio provides a first impression of the regional integration of both, in intra- and in inter-region supply chain. A ratio higher than one means that a region's industry sustains more indirect jobs than direct.

The proportion of direct jobs is higher in Bosnia and Herzegovina and Ukraine, with a ratio of 0.78 and 0.73 respectively, while indirect jobs account for a higher proportion in Serbia (2.47), Montenegro (1.15), North Macedonia (1.07) and Kosovo* (1.05). Overall, the activities along the supply chain provide around 131 500 indirect jobs, with an indirect jobs / direct jobs ratio of 0.95 (direct jobs are close to 138 000).

Figure 19, where the contributions of direct and indirect (intra and inter) jobs in coal-related activities are shown, highlights the importance of considering trade spill-over effects.

Our estimates are in line with the analysis in (Mandras and Salotti 2020). In particular, Serbia shows the largest contribution of inter-regional indirect jobs with a share of 54%, followed by Montenegro (44%) and North Macedonia (37%). Conversely, Ukraine and Bosnia and Herzegovina show the lowest contribution, with an inter-regional indirect jobs share of 7% and 4% respectively, reflecting not only a productive structure less open to trade than the others, but also fewer domestic inter-industry linkages, as the share of direct jobs over total employment (direct plus indirect) is well above 50%.

The scale and distribution of indirect jobs in intra-regional supply chains at sub-national level are shown in Figure 20.

([25]) https://ilostat.ilo.org/data/

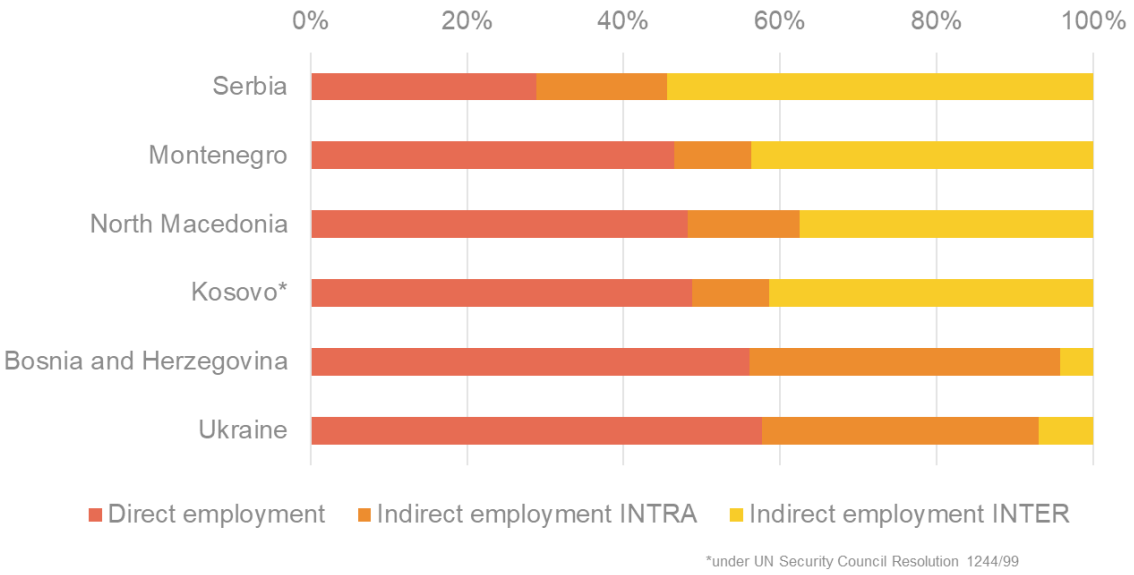
([26]) Note that there are no data available for Kosovo* so that, taking into account similarities between Kosovo* and North Macedonia, we used as a proxy the adjusted employment multipliers of North Macedonia.

Table 3 Number of indirect jobs in coal-related activities at intra- and inter-regional level and indirect jobs / direct jobs ratio in 2018

	Intra-regional	Inter-regional	Total indirect jobs	Indirect jobs/ direct jobs (ratio)
Montenegro	195	866	1 061	1.15
North Macedonia	1 084	2 843	3 927	1.07
Serbia	8 878	28 830	37 708	2.47
Bosnia and Herzegovina	11 988	1 262	13 250	0.78
Kosovo*	946	4 021	4 967	1.05
Ukraine	58 786	11 698	70 484	0.73
TOTAL	81 877	49 522	131 398	0.95

Source: JRC, 2021.

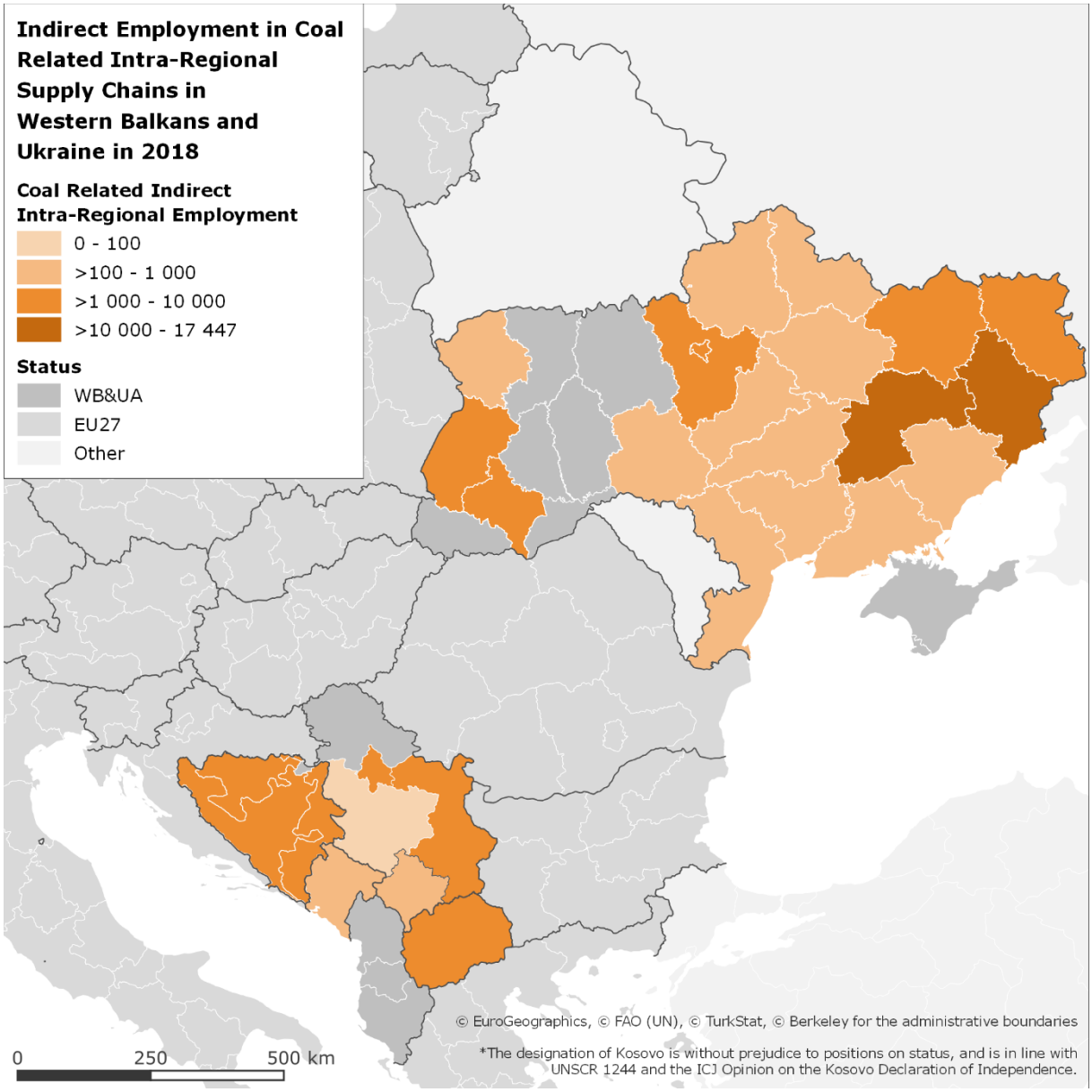
Figure 19. Shares of direct and indirect jobs in the Western Balkans and Ukraine in 2018



Source: JRC, 2021

The five regions with the greatest number of intra-regional indirect jobs belong to Ukraine, Serbia and Bosnia and Herzegovina, and with more than 51 600 indirect jobs, account for 63% of all domestic indirect jobs (Annex 7 and Figure 20). More precisely, UA14 Donetska oblast in Ukraine hosts around 17 400 indirect jobs, followed by UA12 Dnipropetrovska oblast, with more than 12 400 jobs, also in Ukraine. BA-FBH Federacija Bosne i Hercegovine in Bosnia and Herzegovina, RS11 Beogradski region in Serbia and UA63 Kharkivska oblast in Ukraine range between 6 000 and 8 700 indirect jobs in intra-regional supply chains.

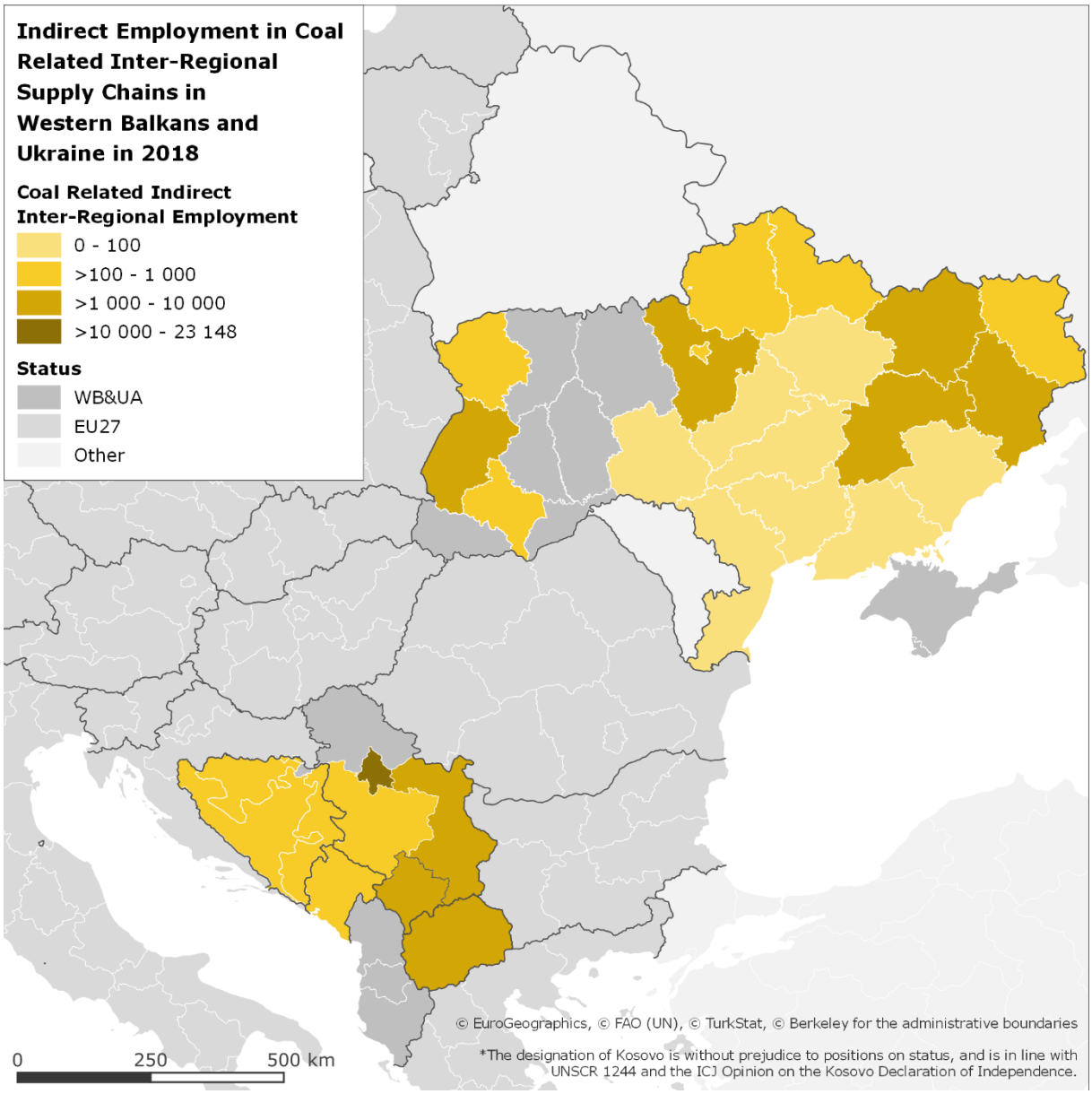
Figure 20. Distribution of indirect jobs in intra-regional supply chains (2018)



Source: JRC, 2021

Interestingly, looking at the distribution of indirect jobs in the inter-regional supply chains (Figure 21), the five regions with the highest inter-regional indirect jobs (Annex 7) account for 79% (around 39 000) of all indirect jobs in the Western Balkans and Ukraine. In particular, RS11 Beogradski region in Serbia has the inter-regional supply chains with the highest number of employees (above 23 100 people), providing alone almost half of the total indirect jobs. Another Serbian region RS22 Region Južne i Istočne Srbije and Kosovar* region XK* Kosovo* follow, with 5 500 and 4 000 jobs respectively, while UA14 Donetska oblast in Ukraine has 3 500 and MK00 Severna Makedonija in North Macedonia 2 800 indirect jobs in the inter-regional supply chains.

Figure 21. Distribution of indirect jobs in inter-regional supply chains (2018)

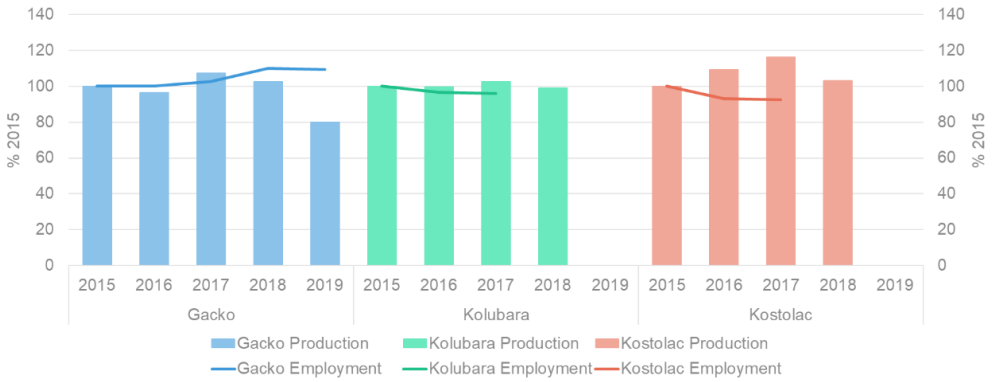


Source: JRC, 2021

2.1.5 Coal Sector benchmark

The coal sector in the Western Balkans and Ukraine presents particular region-specific dynamics. Compared with those previously studied in the European Union (Alves Dias et al., 2018), (Kapetaki et al., 2021), it can be noted (for the Gacko, Kolubara and Kostolac mines in Serbia) that employment levels tend to remain stable regardless of fluctuations in production, and thus a direct correlation cannot be assumed (Figure 22).

Figure 22. Variation in declared production and employment for specific mines. Reference 2015 values

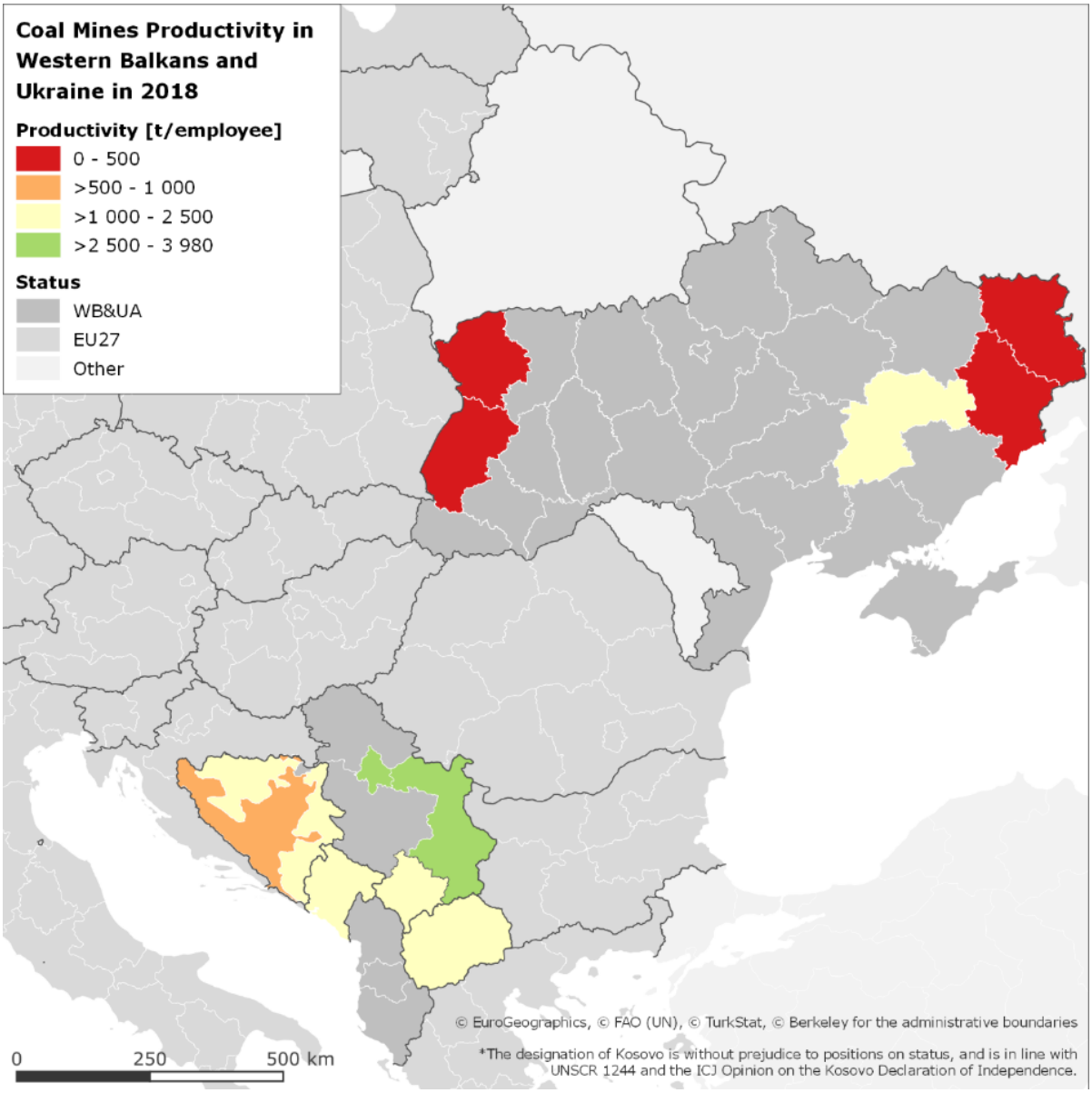


Source: JRC, 2021

In order to analyse the competitiveness of mining regions, the productivity is calculated as the annual production of coal per number of full-time equivalent employees. For the purpose of comparability with European Union mines, productivity ranges in Figure 23 are the same as in (Kapetaki et al. 2021).

With only two regions producing more than 2 500 t/FTE (RS22 Region Južne i Istočne Srbije, 3 980 t/FTE and RS11 Beogradski region, 2 790 t/FTE, both in Serbia), the productivity of mines in the Western Balkans and Ukraine is significantly lower than in the European Union. Figure 23 clearly shows that the mines in the Western Balkans are more productive than the mines in Ukraine. Mine productivity in the Western Balkans mainly ranges between 1 000 and 2 500 t/FTE. Only one region (BA-FBH Federacija Bosne i Hercegovine in Bosnia and Herzegovina) has a productivity below this range (623 t/FTE). The productivity in Ukraine is mainly in the range of 53 to 277 t/FTE, with only one region scoring above this range (UA12 Dnipropetrovska oblast, 1 042 t/FTE).

Figure 23. Productivity of coal mines in the Western Balkans and Ukraine in 2018 ([27])



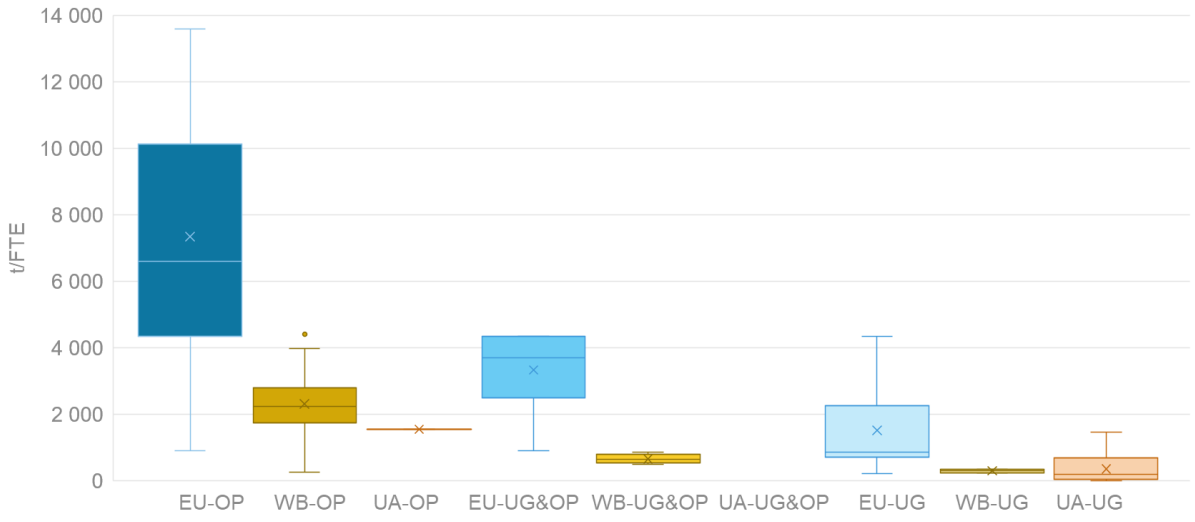
Source: JRC, 2021

Despite inherent variations according to the type of mine, the range of productivity estimated for the Western Balkans and Ukraine shows a structural difference. While EU mines register an average productivity of 4 730 t/FTE, mines in the Western Balkans and Ukraine average overall 755 t/FTE (1 632 t/FTE for the Western Balkans, 389 t/FTE for Ukraine), resulting in an employment intensity six times higher in the Western Balkans and Ukraine. While these differences can in part be explained by the types of mine which predominate, Figure 24 ([28]) shows that the discrepancy also applies in the case of comparable mines.

([27]) The number of jobs used for the calculation includes the number of jobs in mining and administration.

([28]) The diagram shows productivity distributions in quartiles, with the box showing the main range of productivities and lines outliers (25% above and 25% below the main range. The symbol "X" shows the median productivity.

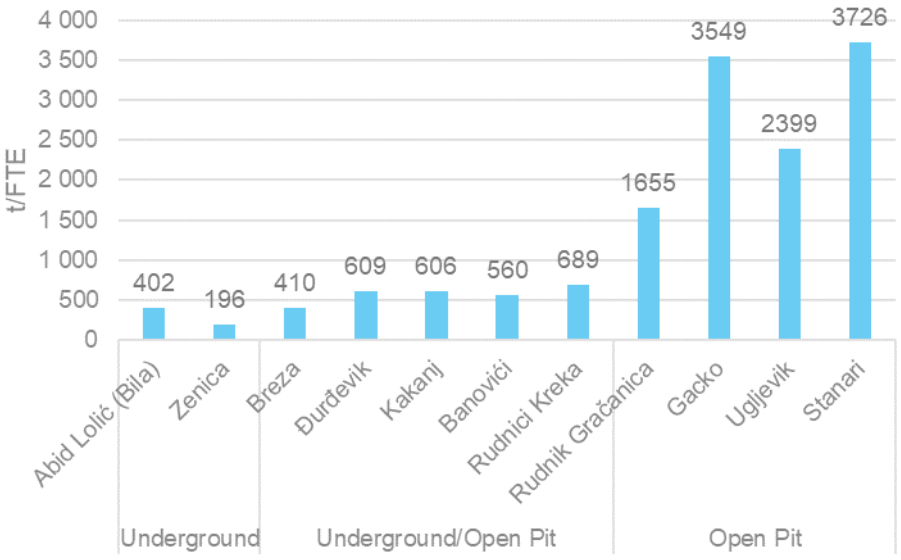
Figure 24. Productivity distribution for underground (UG), open Pit (OP) and mixed (UG&OP) mines in the EU, Western Balkans (WB) and Ukraine (UA) mines



Source: JRC, 2021

There is no consistent evidence to explain these differences across the Western Balkans and Ukraine, but for Bosnia and Herzegovina, the evolution of its productivity is analysed in detail in (BA Energy Strategy 2017). Starting from an average 418 t/FTE in 2005 in the region Federacija Bosne i Hercegovine (BA-FBH), productivity is registered to have reached 527 t/FTE by 2015. There is, however, a significant difference between the value for the region BA-FBH Federacija Bosne i Hercegovine and that of the region BA-RS Republika Srpska, where productivity reached values of 2707 t/FTE, within the lower range of EU productivity. These extremes reveal the remarkably low productivity found in the regions with the oldest exploitations. As shown in Figure 25, the more productive mines can reach 9 times the productivity of the less efficient ones. The main factors driving this spread in productivity are 'volumes, operating technology, logistics costs, degree of "outsourcing", type of mine and geological characteristics, skills and equipment of miners' (BA Energy Strategy 2017).

Figure 25. Productivity values for specific mines in Bosnia and Herzegovina, 2015.

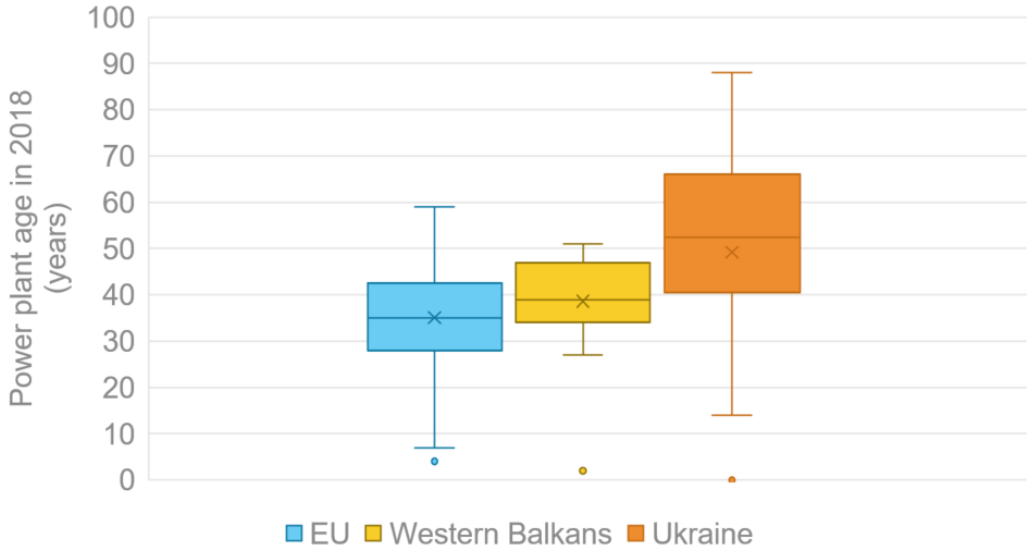


Source: (BA Energy Strategy 2017)

The main drivers behind productivity in Ukrainian coal mines range from geological (from very low to low coal seams) to organisational, with low performance in state-owned mines and aging equipment across installations (Petlovanyi et al. 2018).

Regarding power plants, the Western Balkans and Ukraine have, generally speaking, older plants than the European Union, as depicted in Figure 26. The EU fleet averages 35 years old, while the Western Balkans and Ukraine is on average 39 and 49 years old, with remarkably wider distribution for Ukraine. For plants over 50 years old, revamping of units is very likely to have taken place.

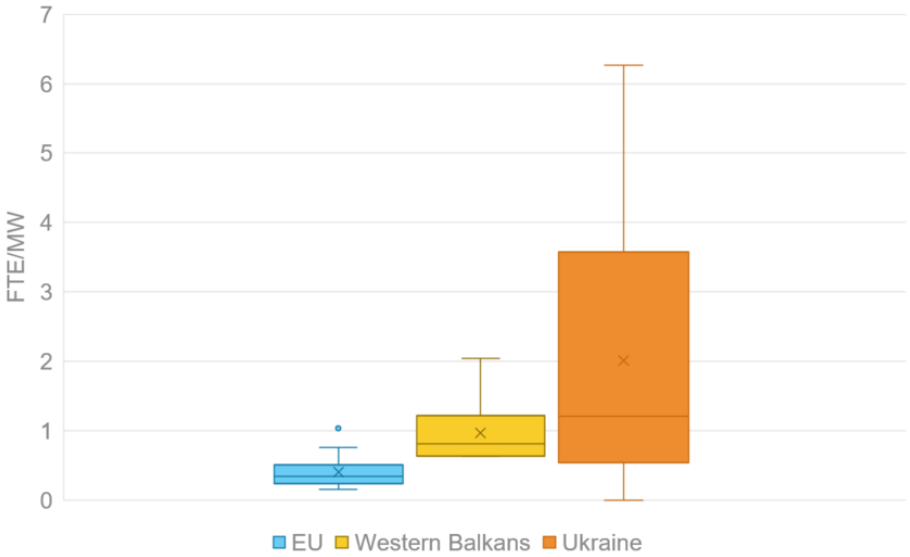
Figure 26. Comparative age distribution of power plants.



Source: JRC, 2021

However, the plant age gap does not explain the differences in employment intensity distributions shown in Figure 27. While the European Union averages an employment intensity for power plants of 0.4 FTE/MW, the equivalent average (where data has been identified) in the Western Balkans and Ukraine reaches 1.67 FTE/MW (1 FTE/MW for the Western Balkans and 2 FTE/MW for Ukraine when discarding outliers), implying an employment intensity up to 4 times higher. Such a difference does not correspond with, and is not driven by, technological differences or the age distribution of the plants, and may therefore be due to differentiated economic structures and other similar considerations.

Figure 27. Comparative power plants employment intensity.



Source: JRC, 2021

Given the importance of ensuring a fair transition for coal regions, the assessment of coal-related employment has attracted controversy (Ciută and Gallop 2018). The analysis presented in this report is based on documentary evidence, but the discrepancies highlighted above should be taken into account when trying to understand its implications.

2.2 Peat in Ukraine

Peat does not play an essential role in any of the energy systems analysed. Among the solid fuel producers in the scope of this study, only Ukraine produces peat. In 2018, while mining 26 Mt of coal, Ukraine produced 0.6 Mt of peat. Of that amount, it is estimated that 0.49 Mt was used for energy purposes. Although significant reserves of 199.8 Mt were recorded in 2018, actual production provided only 0.18% of Ukraine's total energy consumption ([29]).

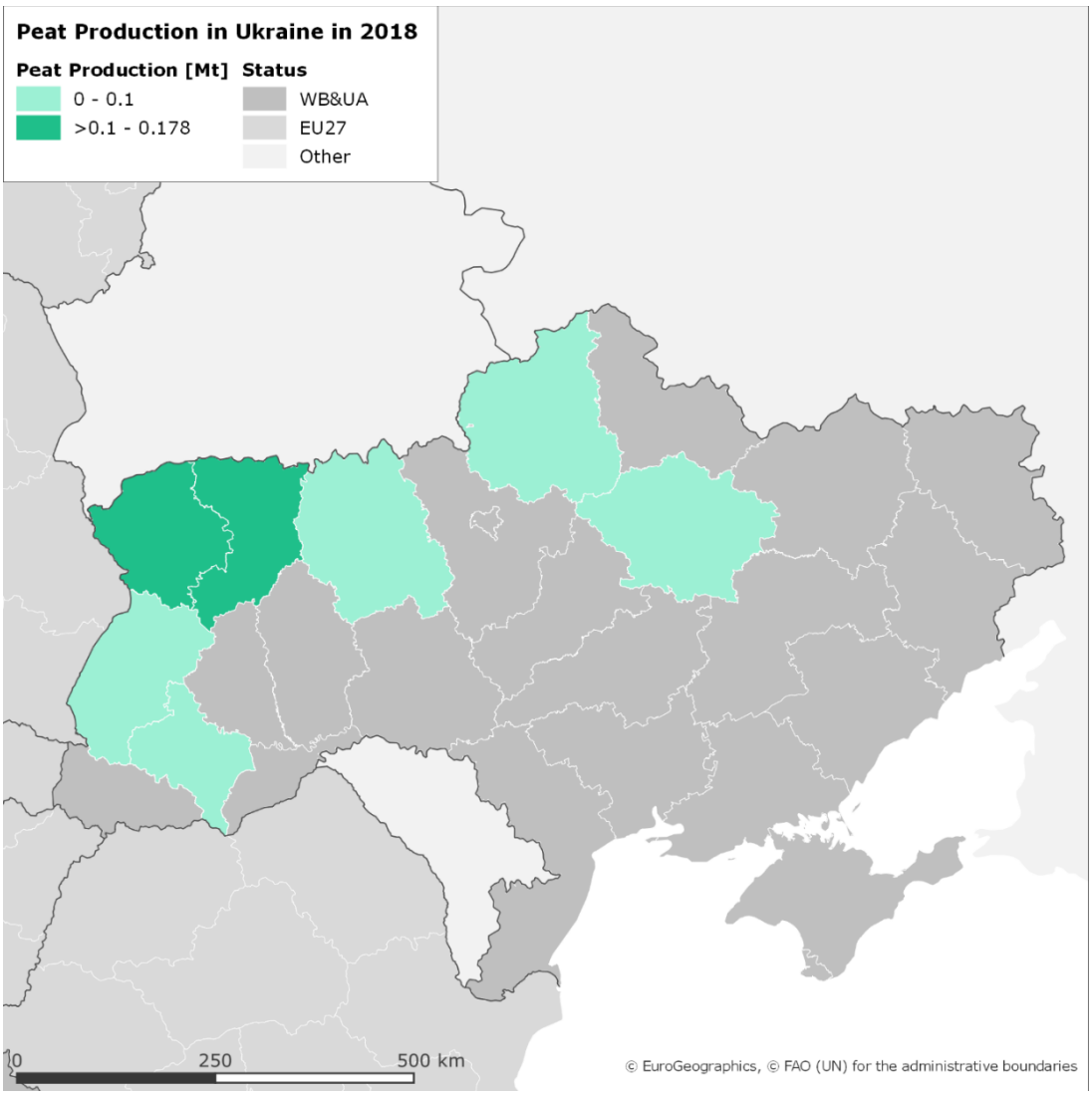
As shown in Figure 28, peat extraction mostly takes place in regions UA07 Volynska oblast and UA56 Rivnenska oblast, and is not all intended for energy purposes. With 0.021 Mt and 0.018 Mt of peat imports and exports, trade is not a key element for peat either.

In Ukraine, peat is mostly used in co-firing district heating networks and transformed into pellets for distributed heating applications. The majority of plants fuelled with peat are located in the region UA61 Ternopilska oblast.

Regarding employment, if accounting only for peat extraction for energy purposes, around 475 FTE can be assigned to peat extraction activity. The majority of employment is located in the region UA74, Chernihivska oblast, and job numbers are far lower in the other peat-producing regions, as can be seen in Figure 29.

We have identified no power plants exclusively linked to the use of peat, and close to 20 FTE at heating plants located in the region UA61 Ternopilska oblast.

Figure 28. Peat production for energy uses in Ukraine in 2018



Source: JRC, 2021

([29]) http://www.ukrstat.gov.ua/. 51,17 Mtoe Ukrainian total energy consumption in 2018, 1 t of peat = 0.203 toe

Following the method described in section 2.1.4, the estimated indirect jobs and the ratio between indirect and direct jobs in peat and shale oil-related activities are shown in Table 4. As described in the coal section, the indirect/direct employment ratio provides an indication of the integration of the region both in the intra-regional and inter-regional supply chains. A ratio lower than one means that a region's industry sustains fewer indirect jobs than direct, evidencing a less strongly integrated economic activity.

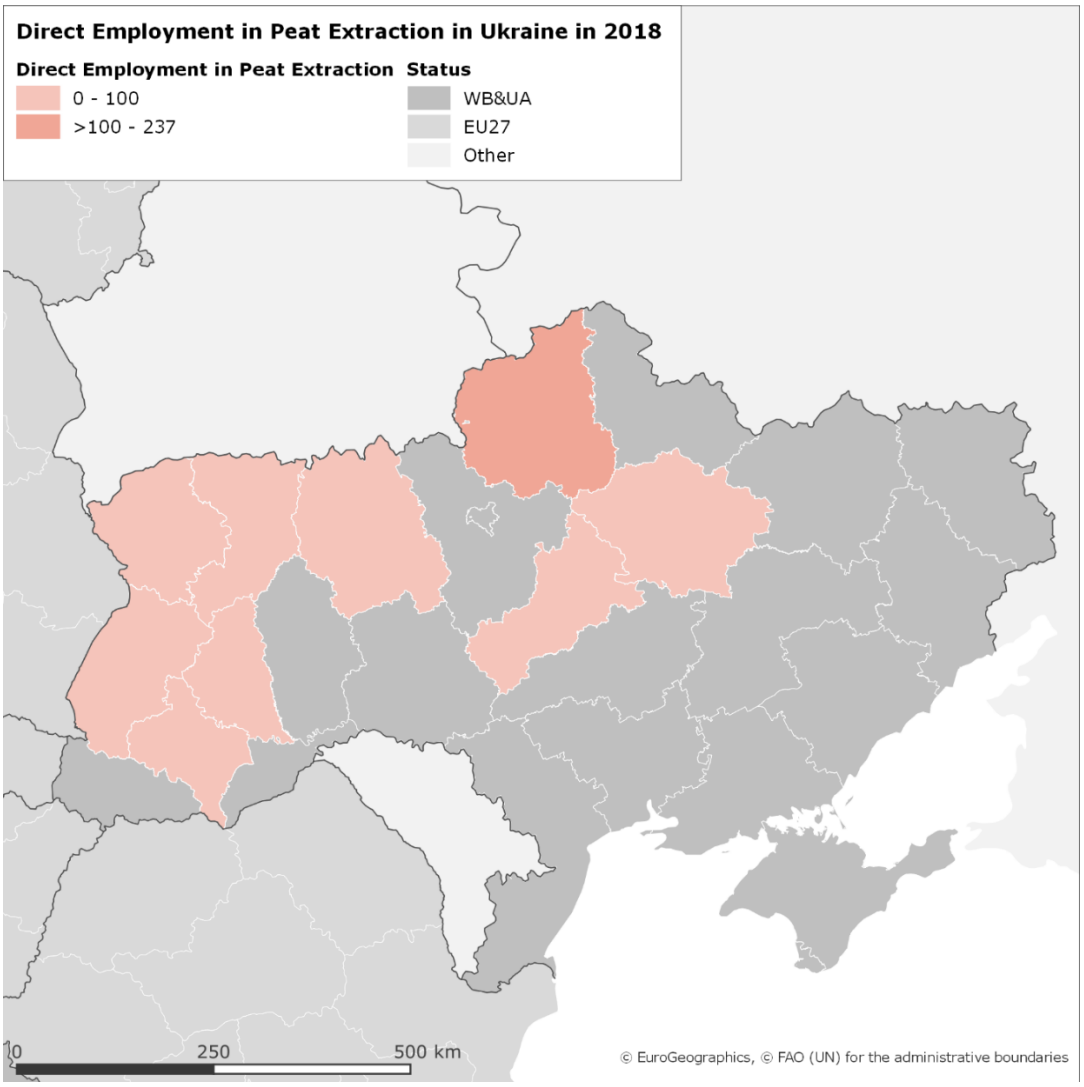
Table 4 Number of indirect jobs in peat-related activities at intra- and inter-regional level and indirect jobs/direct jobs ratio in 2018

	Intra-regional	Inter-regional	Total indirect jobs	Indirect jobs/ direct jobs (ratio)
Ukraine	302	60	362	0.73

Source: JRC, 2021.

Figure 29 shows the regional distribution of fuel peat-related employment. Note that some production centres declared as operative have registered employment for 2018, without registered production. This results in a non-proportional mapping when compared with the fuel production shown in Figure 28

Figure 29. Direct jobs in peat extraction sites in Ukraine in 2018



Source: JRC, 2021

2.3 Key points

- Coal is the most prominent solid fossil fuel in Ukraine and the Western Balkans. Hard coal is produced in Ukraine and lignite in the Western Balkans.
- The Western Balkans and Ukraine produced 93 Mt of coal in 2018 in 12 NUTS 2-equivalent regions.
- The largest coal producers in 2018 were Serbia and Ukraine (38 Mt and 26 Mt, respectively). Ukraine is the largest coal importer (22 Mt in 2018).
- The 3 regions producing the most coal are Serbian RS11 Beogradski region (28 Mt), Ukrainian UA12 Dnipropetrovska oblast (19 Mt) and RS22 Region Južne i Istočne Srbije (9 Mt) also in Serbia.
- Of 65 mines in the Western Balkans and Ukraine, 47 are in Ukraine, 11 in Bosnia and Herzegovina, 3 in North Macedonia, 2 in Serbia and 1 each in Montenegro and Kosovo*.
- The Western Balkans and Ukraine are highly dependent on coal in the power mix, ranging from 30% in Ukraine to 95% in Kosovo*.
- From 2014 to 2019, the average share of coal in the power generation mix in the Western Balkans and Ukraine decreased from 45% to 40% (almost entirely due to changes in Ukraine).
- There are 36 coal power plants in Ukraine (26 GW), 6 in Serbia (4.4 GW), 5 in Bosnia and Herzegovina (2 GW), 2 in Kosovo* (1.3 GW) and North Macedonia (0.8 GW) and 1 in Montenegro (0.2 GW).
- The top 3 regions by coal power plant capacity are UA14 Donetska oblast (6.4 GW) in Ukraine, RS11 Beogradski region (3.2 GW) in Serbia and UA12 Dnipropetrovska oblast (3 GW) in Ukraine.
- There were around 48 500 employees in coal power plants in the Western Balkans and Ukraine in 2018. Coal power plants employed 40 750 people in Ukraine, 2 900 in Serbia, 2 500 in Bosnia and Herzegovina, 1 500 in Kosovo*, 700 in North Macedonia and 170 in Montenegro.
- The top 3 regions by coal power plant employment were all in Ukraine: UA63 Kharkivska oblast (9 800 jobs), UA32 Kyivska oblast (8 700 jobs) and UA14 Donetska oblast (5 800 jobs).
- There were around 89 500 employees in coal mines in the Western Balkans and Ukraine in 2018. Coal mines employed 55 600 people in Ukraine, 14 500 in Bosnia and Herzegovina, 12 300 in Serbia, 3 250 in Kosovo*, 3 000 in North Macedonia and 750 in Montenegro.
- The top 3 regions by coal mining employment were UA14 Donetska oblast (22 750 jobs) and UA12 Dnipropetrovska oblast (18 400 jobs), both in Ukraine and BA-FBH Federacija Bosne i Hercegovine (11 100 jobs) in Bosnia and Herzegovina.
- Direct coal-related jobs numbered 96 400 in Ukraine, 16 900 in Bosnia and Herzegovina, 15 300 in Serbia, 4 700 in Kosovo*, 3 700 in North Macedonia and 920 in Montenegro.
- The top 3 regions by overall direct coal employment were UA14 Donetska oblast (28 600 jobs) and UA12 Dnipropetrovska oblast (20 200 jobs), both in Ukraine and BA-FBH Federacija Bosne i Hercegovine (12 250 jobs) in Bosnia and Herzegovina.
- Indirect coal-related jobs numbered 70 500 in Ukraine, 37 700 in Serbia, 13 200 in Bosnia and Herzegovina, 5 000 in Kosovo*, 4 000 in North Macedonia and 1 100 in Montenegro. The top 3 regions by indirect coal-related jobs were RS11 Beogradski region (30 300 jobs) in Serbia and Ukrainian regions UA14 Donetska oblast (20 900 jobs) and UA12 Dnipropetrovska oblast (14 800 jobs).
- The productivity of mines in the Western Balkans and Ukraine is significantly lower than in the EU: on average 755 t/FTE (1 632 t/FTE in the Western Balkans and 389 t/FTE in Ukraine) compared to 4 730 t/FTE in the EU.
- Employment intensity in coal power plants in the Western Balkans and Ukraine is much higher than in the EU: 1.67 FTE/MW (1 FTE/MW in the Western Balkans and 2 FTW/MW in Ukraine) compared to 0.4 FTE/MW in the EU.
- Peat is used for energy (mainly heating) only in Ukraine: 0.5 Mt out of a total 0.6 Mt produced in 2018.
- The peat sector in Ukraine employs 475 employees, mainly in UA74 Chernihivska oblast

3 Possible future developments of coal activities

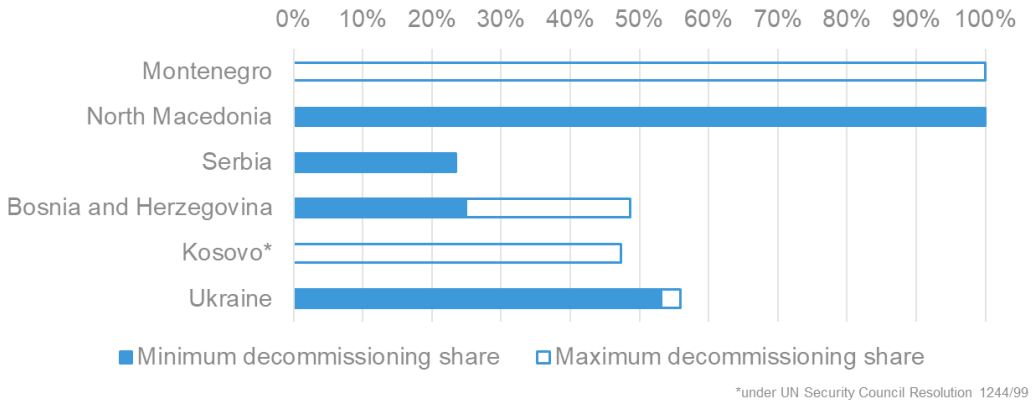
Possible future developments are assessed only for coal, based on national energy strategies, in particular:

- Montenegro: *Strategija razvoja energetike Crne Gore do 2030. godine* (ME Energy Strategy 2014)
- North Macedonia: *National Energy and Climate Plan of The Republic of North Macedonia* (MK NECP 2020)
- Serbia: *Strategija razvoja energetike Republike Srbije do 2025. godine s projekcijama do 2030.* godine (RS Energy Strategy 2015)
- Bosnia and Herzegovina: *Okvirna energetska strategija Bosne i Hercegovine do 2035. godine* (BA Energy Strategy 2017)
- Kosovo*: *Energy Strategy of The Republic of Kosovo 2017-2026* (XK Energy Strategy 2017)
- Ukraine: *Energy Strategy of Ukraine for the Period up to 2035 'Security, Energy Efficiency, Competitiveness'* (UA Energy Strategy 2017)

Peat is not further included in this section, given its marginal or non-existent role in all energy systems and its omission from the strategies analysed.

The purpose of this section is explorative, aiming to assess the current employment risk in the coal sector on the basis of the most recent energy strategies under analysis, all dating from the period 2014-2020. The results presented in Figure 30 are subject to change due to factors such as altered climate ambitions, market circumstances and commodity prices.

Figure 30. Coal power plant decommissioning shares by 2030



Source: JRC, 2021, (BA Energy Strategy 2017; ME Energy Strategy 2014; MK NECP 2020; RS Energy Strategy 2015; UA Energy Strategy 2017; XK Energy Strategy 2017)

Figure 30 shows that only **North Macedonia** plans to phase out coal by 2030 as seen in all scenarios provided in the National Energy and Climate Plan of the Republic of North Macedonia (MK NECP 2020) ([30]).

Serbia plans to decommission all coal power plants below 300 MW by 2024 because they are on average more than 45 years old, with an efficiency below 30% (RS Energy Strategy 2015), but this would only account for six of a total of 14 coal-fired units in Serbia. No additional alternative scenarios were presented in the Serbian energy strategy and for this reason there are no additional coal-fired power plant closures expected in Serbia.

Bosnia and Herzegovina has defined planned decommissioning years for all coal-fired power plants in four different scenarios (Entities Working Group Scenario, Indicative Plan, Cost-optimised Indicative Plan and Mild RES Plan with Energy Efficiency) (BA Energy Strategy 2017). The range provided in our analysis for minimum and maximum decommissioning shares is based on expected coal-fired power plant closures until 2030 in these scenarios.

Kosovo* has three scenarios for existing power plants Kosovo A, Kosovo B and possible new power plant Kosova e Re. Kosovo B power plant is refurbished in all three scenarios and Kosovo A power plant is decommissioned

([30]) National Energy and Climate Plan of the Republic of North Macedonia: Draft NECP (https://www.energy-community.org/dam/jcr:bbb63b32-6446-4df8-adc6-c90613daf309/Draft_NECP_NM_%202020.pdf) Secretariat's Recommendation (https://www.energy-community.org/dam/jcr:ad73687c-12d3-48ff-a48f-faed18760ce5/ECS_RE01_MK_NECP_112020.pdf)

in two and refurbished in the third scenario (XK Energy Strategy 2017). The range provided in our analysis for 2030 is based on these three scenarios and ranges from 0% decommissioning if Kosovo A is refurbished to 47% if it is closed.

According to **Montenegro's** energy strategy, the closure of power plant Pljevlja is planned for the end of 2030 (ME Energy Strategy 2014). On 1 January 2018, Directive 2001/80/EC took effect in the Energy Community. This directive requires operators of large combustion plants to reduce the emissions of air pollutants significantly. Under the opt-out mechanism, the power plant Pljevlja was allowed to operate an additional 20 000 hours, after which the plant could operate if it complied with the stricter emission standards of the Industrial Emissions Directive. The power plant Pljevlja exceeded this 20 000 h limit (Balkan Green Energy News 2021a) on 20 April 2021 and the Energy Community Secretariat launched an infringement procedure against Montenegro (Energy Community 2021) ([31]). On 1 July 2021, it was announced that Montenegro had joined the Powering Past Coal Alliance (PPCA) and planned coal phase-out by 2035 at the latest (Balkan Green Energy News 2021b). The exact date for coal phase-out would be defined in the Montenegrin NECP. During the preparation of this analysis there was no information on the formal position of the Energy Community Secretariat and the impact of this news on the infringement procedure. On 20 September 2021 Montenegrin Ministry of Capital Investments announced that 54 million EUR planned for reconstruction of power plant Pljevlja could be transferred to renewable energy projects ([32]). This is why for Montenegro the capacity that could be decommissioned by 2030 has been presented as a range from 0% if power plant Pljevlja stays operational to 100% in the case of closure.

The Ukrainian energy strategy (UA Energy Strategy 2017) projects that the primary supply of coal will be reduced by 52% by 2030 compared to 2015. Since no indication is given of how this should be achieved, the JRC has identified two possible scenarios to address the reduction of coal-fired power generation: 1) prioritise decommissioning of the coal-fired power plants that use imported coal and 2) age-based decommissioning of all coal-fired power plants. As a result, the range of capacities that should be decommissioned before 2030 is between 53% and 56% of currently installed coal-fired power plants.

In the final analysis, the above-mentioned scenarios with the lowest values of jobs at risk were defined as LOW job risk foresight, while the scenarios with the highest values of jobs at risk were defined as HIGH job risk foresight (Table 5).

Table 5 LOW and HIGH employment risk foresight assumptions

	LOW job risk foresight	**HIGH job risk foresight**
Montenegro	The government of Montenegro delays coal phase-out until 2035.	Montenegro closes power plant Pljevlja I before 2030.
North Macedonia	Full coal phase-out by 2027.	Full coal phase-out by 2027.
Serbia	Decommissioning of all coal power plants below 300 MW until 2024.	Decommissioning of all coal power plants below 300 MW until 2024.
Bosnia and Herzegovina	Power plants Tuzla 3 and 4 and Kakanj 5 and 6 decommission before 2030.	Power plants Tuzla 3, 4 and 5, Kakanj 5 and 6 and Gacko decommission before 2030.
Kosovo*	Power plant Kosovo A refurbished and still operational in 2030.	Power plant Kosovo A decommissioned in 2023.
Ukraine	Priority of decommissioning of coal power plants using imported coal.	Age-based decommissioning of all coal power plants independently to the source of coal.

Source: JRC, 2021. (BA Energy Strategy 2017; ME Energy Strategy 2014; MK NECP 2020; RS Energy Strategy 2015; UA Energy Strategy 2017; XK Energy Strategy 2017), (Energy Community 2021), (Balkan Green Energy News 2021b)

([31]) Case ECS-15/21: Montenegro / environment (https://www.energy-community.org/legal/cases/2021/case1521MN.html)
([32]) Ministry announcement: https://www.gov.me/clanak/saopstenje-mki-povodom-najava-o-ekoloskoj-rekonstrukciji-te-pljevlja

3.1 Potential new coal power plants and mines in the Western Balkans and Ukraine

There are several potential new coal-fired power plant projects listed in national strategies dating from the period 2014-2017 (Table 6), but at the moment most of these projects are not progressing as planned. Some of them are abandoned or equipment suppliers have stepped out (Bankwatch 2019), (Energetika-net 2021), (ContourGlobal 2020), some face issues with investors (Montenegro Government 2010), (Capital 2021), some lack governmental or local support (Serbian Ministry of Mining and Energy 2021), (Akta 2017), and some are currently on hold for other reasons (EPBIH 2021), (GEM 2021), (Modrić 2021), (Ekapija 2020).

All new coal-mining projects mentioned in national strategies are directly related to new coal power plant projects, for which they would be producing lignite. The low probability that any of the planned new coal power plants will actually be constructed has direct consequences for the construction of any new coal mines.

Table 6 Potential new coal power plants in the Western Balkans according to national strategies

	Project name	Capacity (MW)	Target year
Montenegro	TE Pljevlja II	225	2020
	TE Maoče	500	after 2030
Serbia	TENT B3	750	2020-2030
	TE Kolubara B	2 x 375	2020-2030
	TE Kostolac B3	350	2020-2030
	TE Novi Kovin	2 x 350	2020-2030
	TE Štavalj	300	2020-2030
Bosnia and Herzegovina	Tuzla 7	450	2020-2035
	Kakanj 8	350	2024
	Banovići	350	2020-2030
	Kongora	2 x 275	2026
	Zenica	385	2020
	Ugljevik 3	600	2019-2025
	Gacko 2	350	2024
Kosovo*	Kosova e Re	450	2023

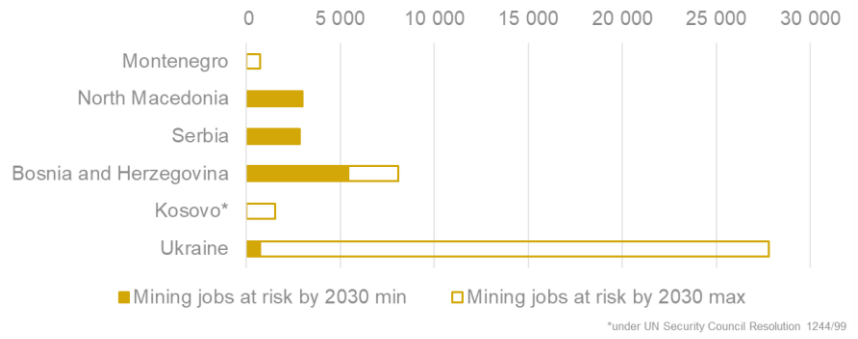
Source: JRC, 2021., (BA Energy Strategy 2017; ME Energy Strategy 2014; RS Energy Strategy 2015; XK Energy Strategy 2017)

3.2 Impacts on employment in coal mines

Coal mines in the Western Balkans are strongly connected to nearby coal power plants (Annex 8). For this reason, the future of coal mines is directly related to these power plants. For Ukraine, no data is available on the source of coal for each coal-fired power plant ([33]). Analysis of the impact of the energy strategy on employment in coal mines in Ukraine was therefore performed on the basis of power plant closures at regional level.

Following the scenario assumptions in the introduction of section 3, between 750 and nearly 28 000 jobs could be at risk in Ukrainian coal mines by 2030, depending on the scale of decarbonisation and pathways pursued in the scenarios under examination. Bosnia and Herzegovina is the next highest with between 5 400 and 8 100 jobs at risk, followed by North Macedonia and Serbia with just below 3 000 each, Kosovo* with up to 1 500 and finally Montenegro with up to 750 jobs at risk in coal mines (Figure 31). The big range of jobs at risk in Ukraine is a consequence of the lack of detail regarding implementation of the phase-out strategy. Depending on whether total amounts of coal are reached by cutting down on local production or imports, or driven by the aging of power plants and their corresponding supplies, the outcome can greatly differ, especially regarding employment in local coal mines.

Figure 31. Jobs at risk in coal mines by 2030



Source: JRC, 2021

The wide range of potential outcomes shown for Ukraine reflects a combination of its decarbonisation ambition and its significant share of imported coal. The reduction of coal use set by the strategy almost exactly matches the current level of imports. Therefore, in a conservative scenario, if reduction were achieved by reducing imports, there would be very little impact on the current level of mining jobs.

Regional analysis (Figure 32) shows that the regions with the highest number of mining jobs at risk are UA14 Donetska oblast (11 400 jobs) and UA12 Dnipropetrovska oblast (9 200 jobs), both in Ukraine and BA-FBH Federacija Bosne i Hercegovine (6 600 jobs) in Bosnia and Herzegovina, followed by two Ukrainian regions with more than 3 200 (UA46 and UA44), six regions from the Western Balkans between 650 and 3 000 (MK00 in North Macedona, RS11 in Serbia, XK* in Kosovo*, BA-RS in Bosnia and Herzegovina, ME00 in Montenegro and RS22, also in Serbia) and one Ukrainian region with almost 600 jobs at risk (UA07). Detailed regional analysis of jobs at risk in coal mines is provided in Annex 9.

Figure 32. Regional jobs at risk in coal mines by 2030

Source: JRC, 2021

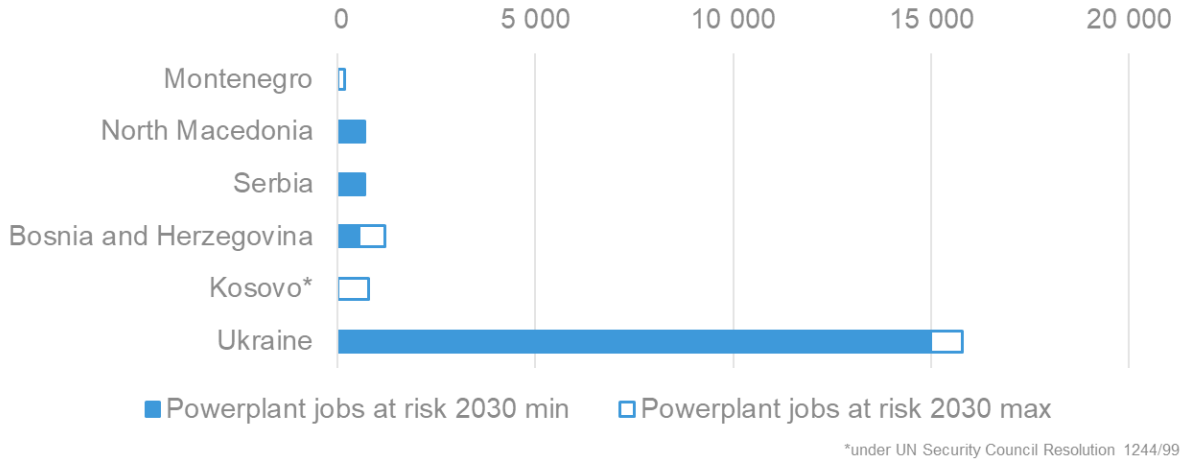
([33]) National expert data and UA Energy Strategy

3.3 Impacts on employment in coal power plants

This report analyses the number of jobs at risk related to the retirement of power plants as if these power plants were standalone businesses. This is why the number of jobs at risk in power plants is directly related to the number of employees. Most of these power plants are, however, a part of bigger national utility companies which are all going through the energy transition and need to invest in new energy sources. But since the future development of these companies is not always clear, the potential re-employment of some of this skilful and experienced workforce to other energy plants, existing or new, in the same companies has not been analysed.

At national level (Figure 33), around 15 000 jobs in Ukrainian power plants are at risk by 2030 for both foresight scenarios. In all of the Western Balkans, 3 500 jobs are at risk in power plants in the worst case scenario.

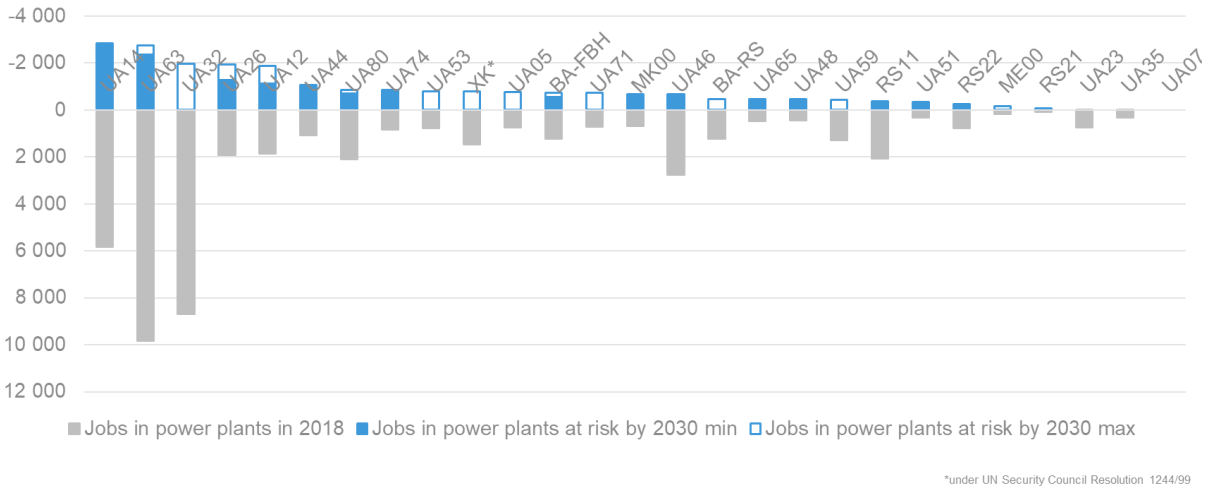
Figure 33. Jobs at risk in coal power plants by 2030



Source: JRC, 2021

The top nine regions in terms of jobs at risk, and 12 out of the top 15 regions, are in Ukraine, led by UA14 Donetska oblast and UA63 Kharkivska oblast with around 2 800 jobs at risk, followed by another three regions with around 1 900 jobs each (UA32, UA26 and UA12) and one region with 1 100 jobs at risk (UA44) (Figure 34). Detailed regional analysis of jobs at risk in coal power plants is provided in Annex 10.

Figure 34. Regional jobs at risk in coal power plants by 2030

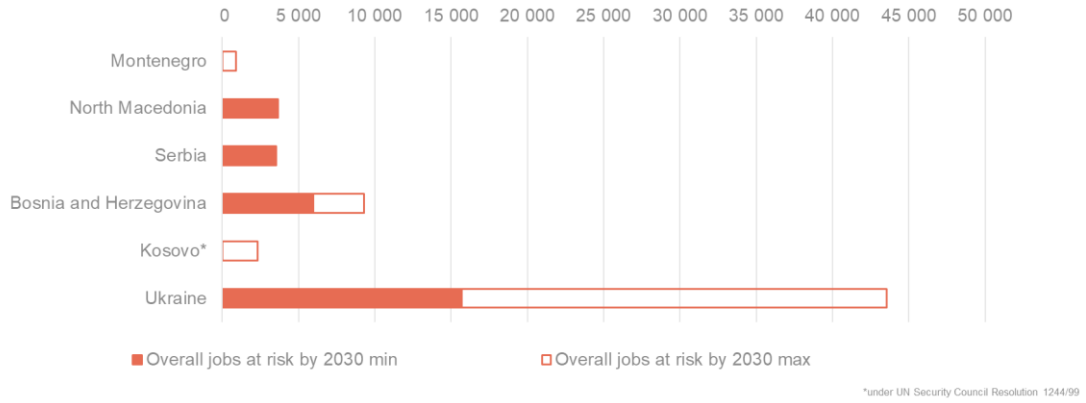


Source: JRC, 2021

3.4 Impacts on overall direct employment in the coal sector

In the coal sector overall, there are between 15 700 and 43 600 jobs at risk in Ukraine, followed by between 6 000 and 9 300 jobs at risk in Bosnia and Herzegovina, around 3 600 each in North Macedonia and Serbia, up to 2 300 in Kosovo* and up to just over 900 jobs at risk in Montenegro (Figure 35). The big range given for Ukraine reflects the alternatives in the scenarios studied, where power plants could be closed first because of age (with a direct impact on employment in coal mines in the same regions) or because they are importers of coal (thus preserving jobs in coal mines, even if some of the surviving power plants are older).

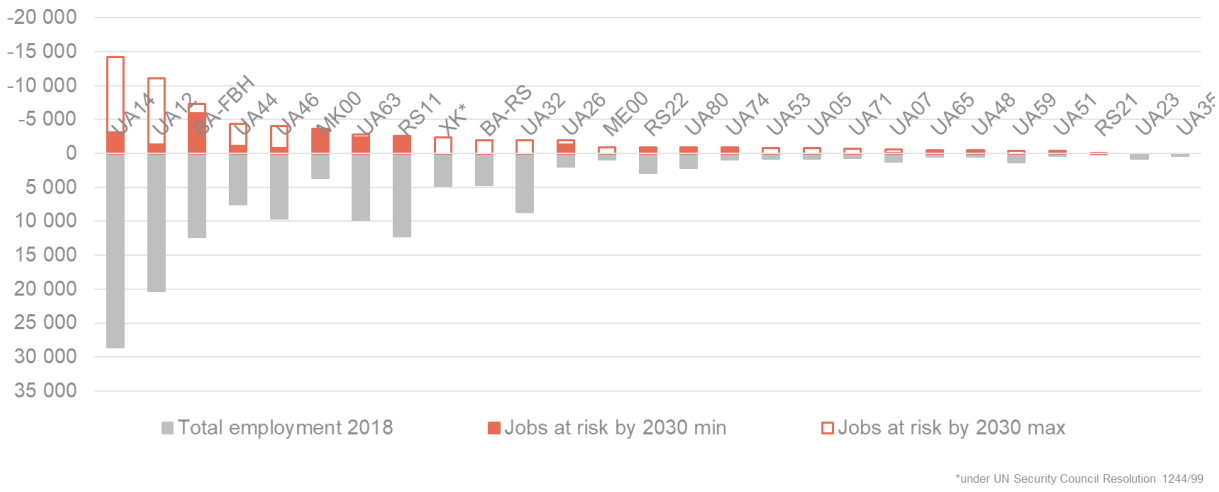
Figure 35. Jobs at risk in coal sector by 2030



Source: JRC, 2021

The regional analysis of overall jobs at risk in Figure 36 shows that Ukrainian regions UA14 Donetska oblast and UA12 Dnipropetrovska oblast still lead with 14 200 and 11 000 jobs at risk respectively, followed by BA-FBH Federacija Bosne i Hecegovine in Bosnia and Herzegovina with 7 300 jobs at risk. In the top 15 regions by jobs at risk, there are now eight regions in Ukraine and seven regions in the Western Balkans.

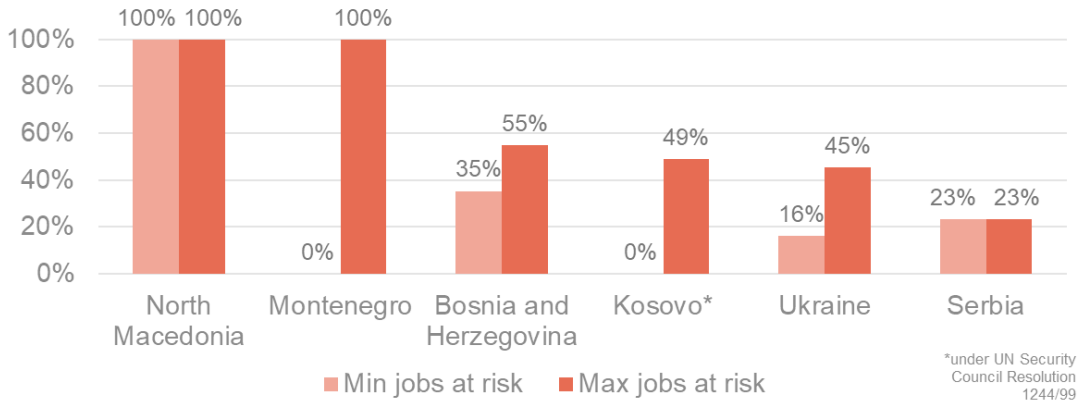
Figure 36. Regional jobs at risk in coal sector by 2030



Source: JRC, 2021

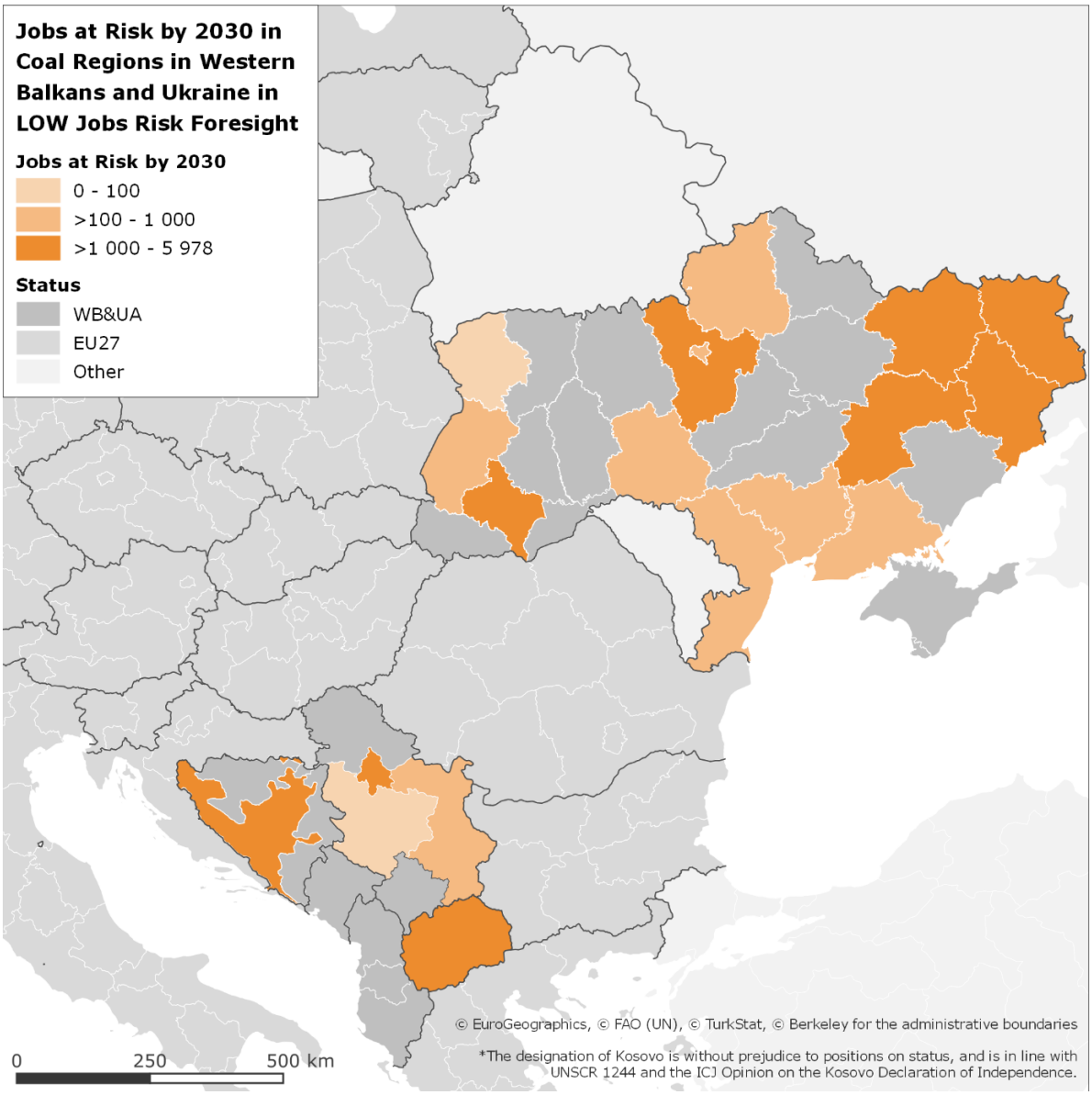
Looking at jobs at risk as a proportion of total coal sector employment, it is evident that all coal jobs are at risk in North Macedonia, and also in one of the possible scenarios for Montenegro. The share of jobs at risk is between 35% and 55% in Bosnia and Herzegovina, up to 49% in Kosovo*, between 16% and 45% in Ukraine and 23% in Serbia (Figure 37).

Figure 37. Shares of jobs at risk in coal sector by 2030



Source: JRC, 2021

Figure 38. Coal-related direct jobs at risk by 2030 in the Western Balkans and Ukraine in LOW job risk foresight

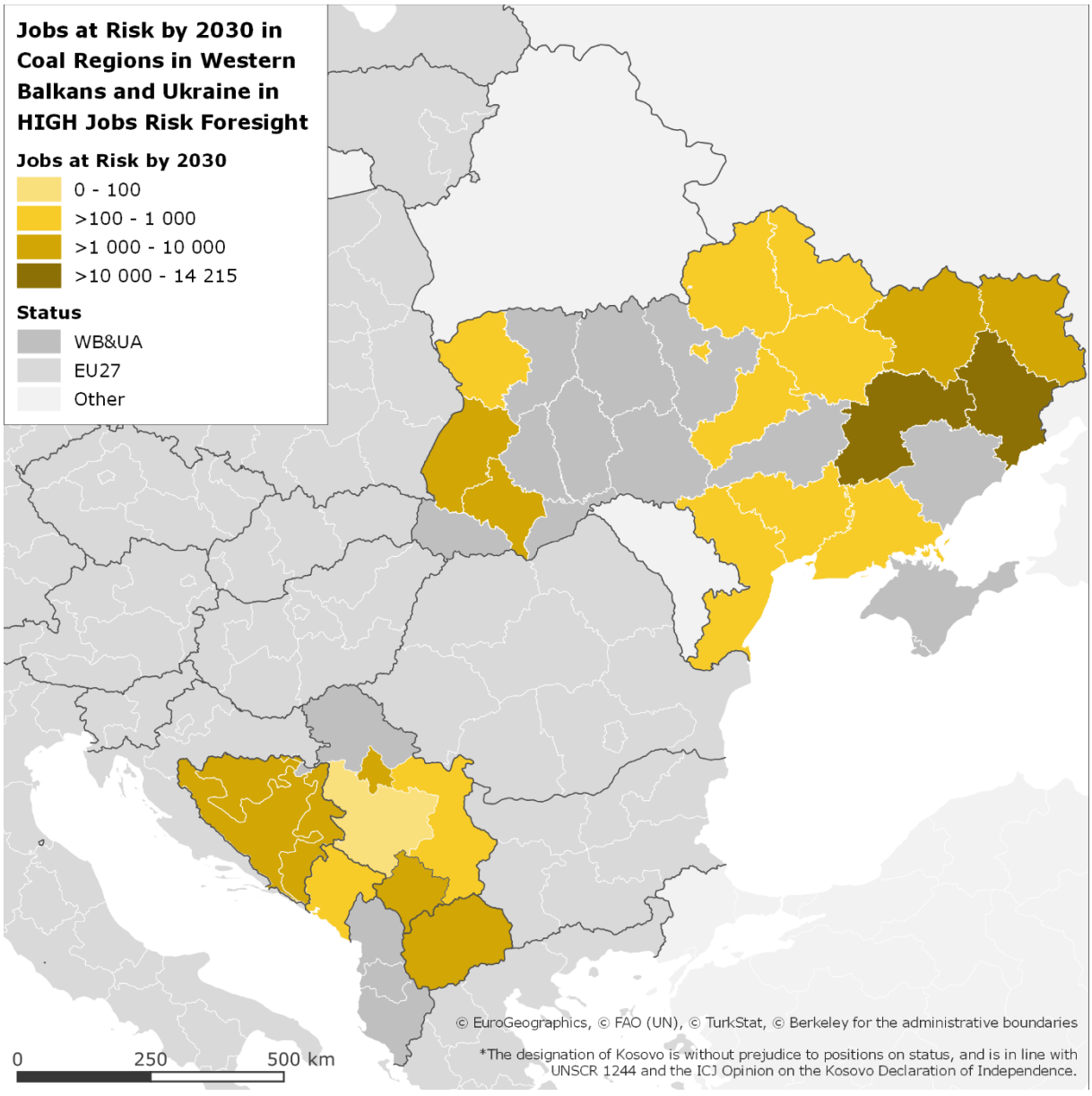


Source: JRC, 2021

In a LOW job risk foresight (Figure 38), as described in chapter 3, it can be seen that the regions with more than 1 000 jobs at risk are in the east of Ukraine (where there is the highest number of coal mines), around Kiev, in South-West Ukraine, in central Bosnia and Herzegovina, in North Macedonia and around Belgrade in Serbia.

HIGH job risk foresight (Figure 39), as described in chapter 3, reveals a slightly different picture, with mining regions in eastern and western parts of Ukraine most clearly impacted. In the Western Balkans, the highest impact can be seen in Bosnia and Herzegovina in its entirety, North Macedonia, Kosovo* and around Belgrade in Serbia.

Figure 39. Coal-related direct jobs at risk by 2030 in the Western Balkans and Ukraine in HIGH job risk foresight



Source: JRC, 2021

3.5 Key points

- Projects for new coal power plants mentioned in national energy strategies in the period 2014-2017 are either abandoned or on hold, and it can be assumed that none of them will be built by 2030. Building new power plants would seriously derail decarbonisation plans and the energy transition objectives of the region. New mining projects are closely related to new power plants, and it can therefore be assumed that no new mining projects will be opened during the coming decade.
- Montenegro planned the closure of Pljevlja power plant before 2030 (national energy strategy). In 2018 it was granted an additional 20 000 operating hours under the opt-out mechanism (Directive 2001/80/EC). This was exceeded in 2020 and the Energy Community Secretariat launched an infringement procedure against Montenegro on 20/04/2021 for which a Court decision is pending. The government of Montenegro announced coal phase-out by 2035. In September 2021 The Ministry of Capital Investments announced possible transfer of funds for refurbishing power plant Pljevlja into renewable energy projects.
- North Macedonia has declared a coal phase-out by 2027 (National Energy and Climate Plan).
- Serbia plans to close all coal-fired power plant units with a capacity below 300 MW by 2024 (national energy strategy) but this would only account for six out of of 14 coal-fired units in Serbia .
- Bosnia and Herzegovina defined decommissioning years for all coal power plants under four different scenarios (national energy strategy). Power plants Tuzla 3 and 4 and Kakanj 5 and 6 decommission always before 2030, power plants Tuzla 5 and Gacko only in some of scenarios.
- Kosovo* defined three different scenarios in their national energy strategy where the power plant Kosovo A is either closed or still operational and a possible new plant Kosova e Re could be built.
- Ukraine projected a reduction in primary supply of coal of 52% by 2030 compared to 2015, but did not define implementation details (national energy strategy).
- Jobs at risk in coal mining number between 750 and 28 000 in Ukraine, between 5 400 and 8 100 in Bosnia and Herzegovina, about 3 000 each in North Macedonia and Serbia, up to 1 500 in Kosovo* and up to 750 in Montenegro.
- The top 3 regions by jobs at risk in coal mining are Ukrainian regions UA14 Donetska oblast (11 400 jobs), UA12 Dnipropetrovska oblast (9 200 jobs) and BA-FBH Federacija Bosne i Hercegovine (6 600 jobs) in Bosnia and Herzegovina.
- Jobs at risk in coal power plants total between 15 000 and 15 800 in Ukraine, between 550 and 1 200 in Bosnia and Herzegovina, up to 780 in Kosovo*, just below 700 each in Serbia and North Macedonia and up to 170 in Montenegro.
- The top 3 regions by jobs at risk in coal power plants are Ukrainian regions UA14 Donetska oblast (2 850 jobs), UA63 Kharkivska oblast (2 750 jobs) and UA32 Kyivska oblast (1 950 jobs).
- Direct jobs at risk in the coal sector overall total between 15 700 and 43 600 in Ukraine, between 6 000 and 9 300 in Bosnia and Herzegovina, around 3 600 each in North Macedonia and Serbia, up to 2 300 in Kosovo* and up to around 900 in Montenegro.
- The top 3 regions for jobs at risk in the coal sector overall are Ukrainian regions UA14 Donetska oblast (14 200 jobs), UA12 Dnipropetrovska oblast (11 000 jobs) and BA-FBH Federacija Bosne i Hecegovine (7 300 jobs) in Bosnia and Herzegovina.

4 Mapping of carbon-intensive industries

Besides its use in the energy sector, coal is also used as a feedstock and fuel in carbon-intensive industries (CII). CIIs typically produce steel, cement, chemicals, paper and other primary industrial products. This section identifies the areas with the highest demand for coal in industry.

4.1 Overall coal consumption in carbon-intensive industry

In 2018, some 23 Mt of solid fossil fuels were used in energy-intensive industry in the Western Balkans and Ukraine, of which the vast majority - 20 Mt (89%) - were used in the production of iron and steel, as depicted in Table 7. Another 2 Mt (9% of the total) were used in the non-metallic minerals sector ([34]). Minor amounts of solid fossil fuels were used in other energy-intensive industries. This analysis focusses on solid fossil fuel use in the iron and steel and non-metallic minerals industries, since these represent 98% of the total use in industry.

Table 7 Solid fossil fuel use in energy-intensive industry, 2018

Solid fossil fuel use 2018, thousand tonnes	Iron and steel	Non-metallic minerals	Non-ferrous metals	Chemicals	Pulp and paper	Total energy-intensive industry
Ukraine	**18 301**	**1 036**	191	5		19 533
Serbia	**958**	**300**		109	22	1 389
Bosnia and Herzegovina	**620**	**162**	150	0.3	0.2	932
Albania		**408**				408
North Macedonia	**103**	**107**				209
Kosovo*	**25**					25
Montenegro	**6**					6
Total	**20 011**	**2 013**	341	114	23	22 501

Source: JRC, based on NRG_BAL_C from Eurostat

Ukraine's solid fossil fuel use in industry is of an order of magnitude larger than that of the Western Balkans and accounts for 87% of the total consumption covered by this analysis. This is unsurprising given the relative size of Ukraine and of its industrial output. Serbia's industry consumed the second largest amount of solid fossil fuels, at 1.4 Mt, followed by Bosnia and Herzegovina, Albania and North Macedonia. Kosovo* and Montenegro used negligible amounts of solid fossil fuels in industry.

4.1.1 Iron and steel

As the vast majority of industrial fossil fuel consumption is in the iron and steel sector, this section briefly explains this industry's manufacturing process and use of fossil fuels.

There are two main routes to make crude steel: it can be produced from the virgin raw material, iron ore, in the so-called primary route, or from recycled steel scrap, in the secondary route. These two routes have vastly different processes, energy consumptions and coal usage rates.

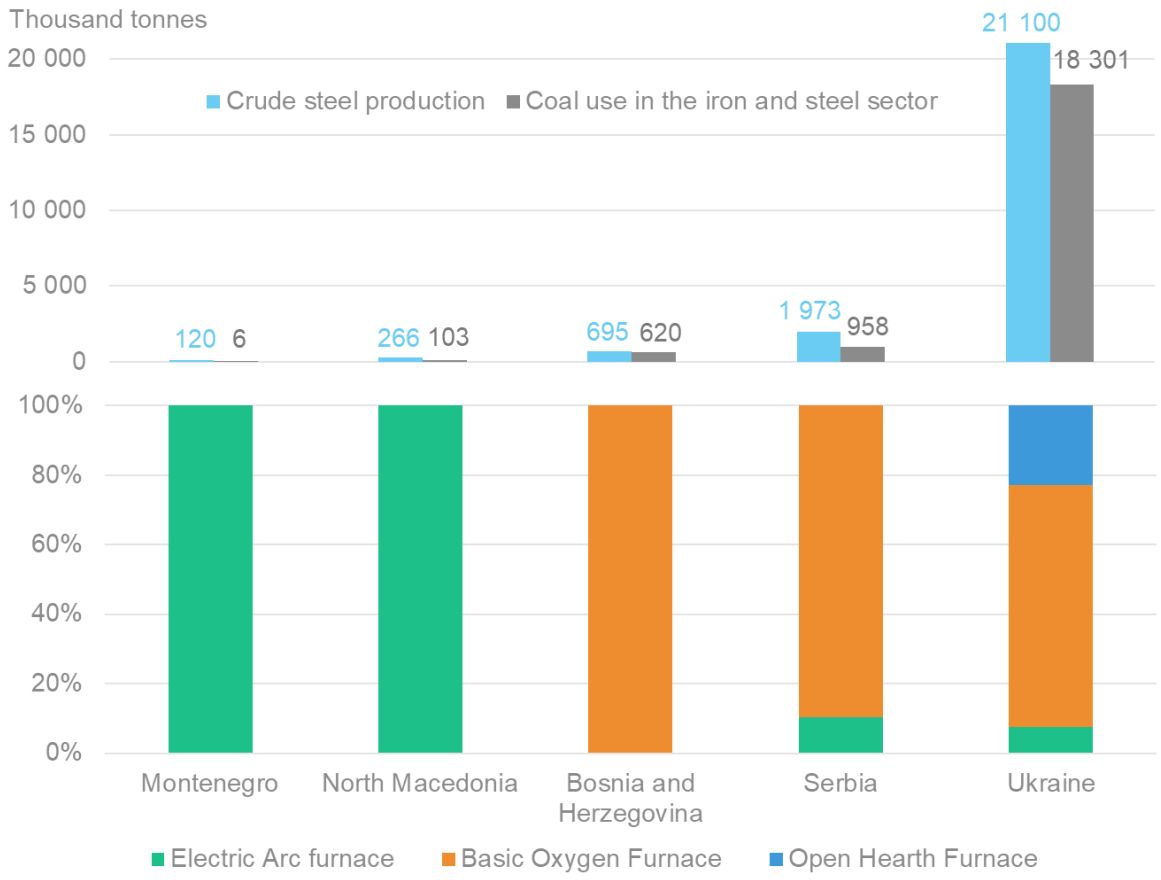
In the primary route, iron oxides are reduced to liquid iron in a blast furnace, using coke as both a fuel source and as a reducing agent. Coke is thus an essential feedstock in the ironmaking process, and cannot be wholly replaced by other fuels due to its specific properties. However, steel production in Ukraine uses open-hearth furnaces, an older, less efficient steelmaking process, for a quarter of its primary steel production. Ukraine and Russia are the only two remaining countries worldwide that still use open-hearth furnaces, which are heated by burning gas, and therefore do not need coal as an essential process input.

In the secondary steelmaking route, recycled steel scrap is smelted in an electric arc furnace to make steel. Electricity is the main energy source in this process and small amounts of solid carbon sources are needed as slag foaming agents, however larger quantities of solid fossil fuels can also be used as an energy input to the process (Echterhof 2021).

([34]) In Eurostat, the non-metallic minerals industry comprises the production of cement, lime, glass and ceramics.

Figure 40 shows the production of crude steel at national level in 2018 and split by production process. Three countries, Bosnia and Herzegovina, Serbia and Ukraine produced crude steel via the blast furnace route, while North Macedonia and Montenegro produced only small amounts of steel, exclusively via the electric arc furnace route. According to the World Steel Association (WSA 2019), Albania and Kosovo* did not produce any crude steel.

Figure 40. 2018 coal use in the iron and steel sector and production of crude steel, total and by process



JRC, based on data from the World Steel Association

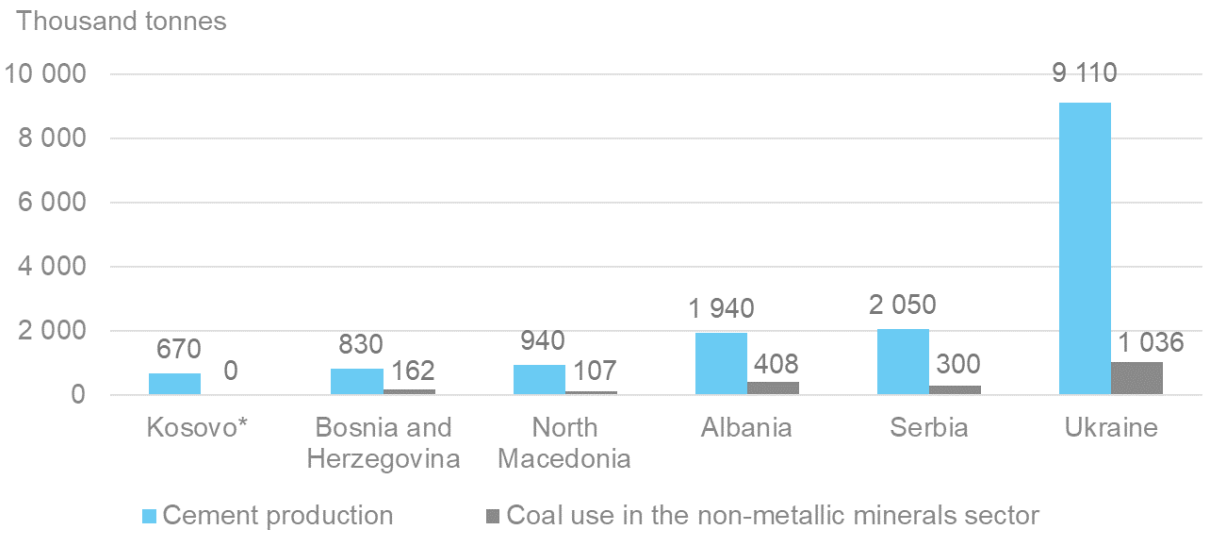
4.1.2 Non-metallic minerals

The industry activity "non-metallic minerals" in Eurostat comprises the production of cement, lime, glass and ceramics, and consumed around 2 Mt of solid fossil fuels in the Western Balkans and Ukraine. For this analysis, all solid fossil fuel use in this category is attributed to the cement sector, due to limitations on available data for industrial plants in the Western Balkans and Ukraine. The use of coal in the glass and ceramics industry is very limited, as noted in (Alves Dias, P., Conte, A., Kanellopoulos, K., Kapetaki, Z., Mandras, G., Medarac, H., Nijs, W., Ruiz Castello, P., Somers, J. and Tarvydas 2021). This simplified methodology does not attribute any coal use to the production of lime.

Producing cement clinker, the necessary intermediate product to make cement, is a very energy-intensive process. Coal can be used as a fuel to provide thermal energy, however different types of fuels (natural gas, oil, waste fuels, biomass) are also used and the fuel mix can vary widely, depending on costs and availability.

Figure 41 shows the production of cement at national level in 2018. Ukraine is the largest producer of cement by a considerable margin (9 Mt), and uses 1 Mt of coal in the process. On the other hand, Kosovo* does not use any coal for its cement production, relying mostly on gas oil and petroleum coke.

Figure 41. Cement production and coal use in 2018



JRC, based on data from Cemnet and Eurostat

4.2 Coal consumption by industry in coal regions

The solid fossil fuel consumption per industry was obtained from the Eurostat energy balances ([NRG_BAL_C]) and allocated to industrial facilities in the Western Balkans and Ukraine. The steel plants are extracted from the Plantfacts database (Steel Institute VDEh 2019) and the cement plants from the Global Cement Report online database (Cemnet 2021). Both databases indicate the capacity of each plant but not the production level in a given year. The total coal use of the steel and cement sector is distributed according to the production capacity of each plant.

4.2.1 Iron and steel

As shown in Figure 40, only Bosnia and Herzegovina, Serbia and Ukraine produce crude steel via the blast furnace route. Of these countries, only Bosnia and Herzegovina and Ukraine also refine coking coal to coke in coke ovens domestically, while Serbia imports the totality of the coke it uses. Bosnia and Herzegovina on the other hand is a net exporter of coke, as can be seen in Table 8. Of the 945 000 tonnes of coke that it produced in 2018, only 45% was used in the domestic steel industry, while the rest was exported. It is worth noting that no coking coal is mined in Bosnia and Herzegovina, according to Eurostat. All 1.5 Mt of coking coal used in Bosnia and Herzegovina in 2018 were imported, of which 90% (1.3 Mt) were fed into coke ovens to produce coke. The picture is similar in Ukraine, where 2.6 times as much coking coal is imported compared to the amount mined in 2018 (11.8 Mt import to 4.6 Mt indigenous production).

Table 8 Coking coal and coke use in the Ukraine, Bosnia-Herzegovina and Serbia

2018, thousand tonnes	Indigenous coking coal production	Coking coal input in coke ovens	Coke input in blast furnaces	Net import of coke
Ukraine	4 606	15 531	8 872	814
Bosnia and Herzegovina	0	1 319	429	-527
Serbia	0	0	792	774

JRC, based on data from Eurostat

Accounting for both the coking coal used in coke ovens and the subsequent use of coke in blast furnaces would double-count the amount of coal used in industry[35]. To avoid double-counting, a single figure for coal consumption in the industry is calculated and allocated to the integrated steel mills according to their capacity.

([35]) Eurostat- Coal production and consumption statistics: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Coal_production_and_consumption_statistics#Deliveries_of_coal_to_coking_plants_and_coke_oven_coke_production

Using this approach, the coke that Bosnia and Herzegovina exports is not allocated to the steel industry, while the coke that Serbia imports, even though not produced domestically, counts towards its steel sector.

Montenegro, North Macedonia and Kosovo* do not have any integrated primary steel plants. Montenegro and North Macedonia produce steel in electric arc furnace plants, and further process it into semi-finished products in downstream mills. Kosovo* does not produce any crude steel, but uses a small amount of coal to process steel in a galvanising plant.

Allocating the solid fossil fuel use by steel plant, the estimated coal use per region in the iron and steel industries of the Western Balkans and Ukraine is shown in Table 9 below.

Table 9 Solid fossil fuel use in the iron and steel industry, by region in 2018

	Region	Solid fossil fuel use in steel industry (thousand tonnes, 2018)
Ukraine	UA14 Donetska oblast	7 218
	UA12 Dnipropetrovska oblast	7 045
	UA44 Luhanska oblast	2 283
	UA23 Zaporizka oblast	1 755
Serbia	RS22 Region Južne i Istočne Srbije	958
Bosnia and Herzegovina	BA-FBH Federacija Bosne i Hercegovine	620
North Macedonia	MK00 Severna Makedonija	103
Kosovo*	XK* Kosovo*	25
Montenegro	ME00 Crna Gora	6

Source: JRC, based on data from Steel Institute VDEh and Eurostat

4.2.2 Cement

Using data from the Global Cement Report online database (Cemnet 2021), cement plants were identified throughout the Western Balkans and Ukraine except for Montenegro. Furthermore, according to Eurostat, Kosovo* did not use any solid fossil fuels in its cement sector in 2018. Consequently, Montenegro and Kosovo* do not feature in the analysis of the cement industry. The amount of coal used in the non-metallic minerals sector according to the Eurostat energy balances is allocated to each plant based on its cement making capacity, and shown in Table 10.

Table 10 Solid fossil fuel use in the cement industry, by region in 2018

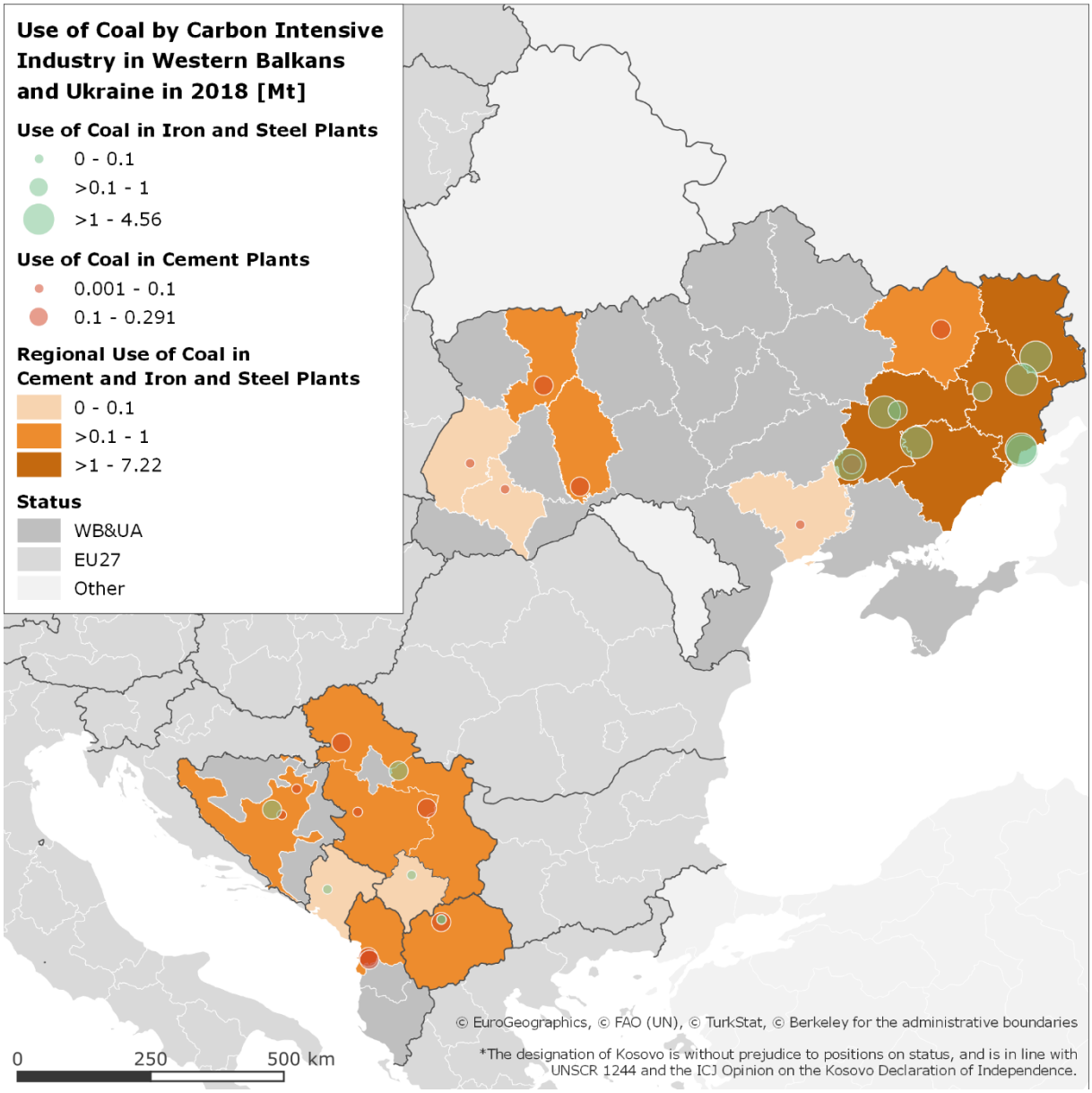
Country	Region	Solid fossil fuel use (thousand tonnes, 2018)
Ukraine	UA63 Kharkivska oblast	291
	UA68 Khmelnytska oblast	223
	UA56 Rivnenska oblast	144
	UA12 Dnipropetrovska oblast	108
	UA46 Lvivska oblast	94
	UA48 Mykolaivska oblast	90
	UA26 Ivano-Frankivska oblast	86
Albania	AL01 Veri	408
Serbia	RS21 Region Šumadije i Zapadne Srbije	175
	RS12 Region Vojvodine	125
Bosnia and Herzegovina	BA-FBH Federacija Bosne i Hercegovine	162
North Macedonia	MK00 Severna Makedonija	107

Source: JRC, based on data from Cemnet and Eurostat

4.2.3 Total coal consumption by industry

The coal use of each cement and steel plant is mapped in Figure 42, with the corresponding aggregated coal use by region. It shows that the use of coal in Ukraine is concentrated in eastern regions due to the presence of the steel industry, notably close to the Sea of Azov and the border with Russia. In Western Ukraine, two regions show a moderate coal demand due to the presence of two cement plants. Industrial coal use is spread across the Western Balkans, mostly in regions of Serbia and North Macedonia, as well as in two western regions in Bosnia and Herzegovina and Albania.

Figure 42 Coal use by carbon intensive industry, 2018



Source: JRC, 2021

4.3 Key points

- In 2018, some 23 Mt of solid fossil fuels were used in carbon-intensive industry in the Western Balkans and Ukraine. The iron and steel and non-metallic minerals sectors are responsible for 98% of that coal demand.
- The iron and steel sector alone accounts for 89% of all coal consumption, mainly due to the production of metallurgical coke from coking coal in coke ovens, and the subsequent use of coke as a reductant and fuel in blast furnaces.
- Ukraine's solid fossil fuel use in industry is of an order of magnitude larger than that of the Western Balkans and accounts for 87% of the total coal consumption covered by this analysis.
- Ukraine, Serbia and Bosnia and Herzegovina and Montenegro produce steel via the primary (blast furnace) route, for which coal, in the form of coke, is an indispensable input.
- Only Bosnia and Herzegovina and Ukraine refine coking coal to coke domestically, while Serbia imports the totality of the coke it uses. Bosnia and Herzegovina exports 55% of the coke it produces.
- Ukraine uses some 18 Mt of coal in its iron and steel industry, and 1 Mt of coal in its non-metallic minerals (cement) industry. Coal demand in Ukraine is concentrated in the eastern part of the country due to the presence of the steel industry.
- Coal is currently one of several fuel alternatives that can be used to produce cement, including also biomass and waste. In the Western Balkans and Ukraine, coal (along with natural gas, oil and petroleum coke) is the main fuel used in the cement industry.

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List of abbreviations and definitions

CII	Carbon Intensive Industries
ETS	Emissions Trading System
FTE	Full Time Equivalent (Employment)
ICJ	International Court of Justice
IO	Input Output
JRC	Joint Research Centre
MRIO	Multi-Region, Input-Output
NECP	National Energy and Climate Plan
NUTS	Nomenclature of Territorial Units for Statistics, from the French version Nomenclature des Unités Territoriales Statistiques)
OP	Open Pit
PPCA	Powering Past Coal Alliance
UG	Under Ground
UG&OP	Under Ground and Open Pit
UNSCR	United Nations Security Council Resolution
WB	Western Balkans
WSA	World Steel Association

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Annexes

Annex 1 Regions in the Western Balkans and Ukraine

Since the Western Balkans and Ukraine are not EU Member States, they may not always follow the NUTS regional structure. For this reason, regional analysis which would be similar to NUTS 2 level analysis performed in previous report for EU, will be done in the following way:

- Montenegro has only one NUTS 2 region:
  - ME00 Crna Gora (Црна Гора) ([36]);
- North Macedonia has only one NUTS 2 region:
  - MK00 Severna Makedonija (Северна Македонија) ([37]);
- Albania has three NUTS 2 regions ([38]):
  - AL01 Veri;
  - AL02 Qender;
  - AL03 Jug;
- Serbia has four NUTS 2 regions ([39]):
  - RS11 Beogradski region (Београдски регион);
  - RS12 Region Vojvodine (Регион Војводине);
  - RS21 Region Šumadije i Zapadne Srbije (Регион Шумадије и Западне Србије);
  - RS22 Region Južne i Istočne Srbije (Регион Јужне и Источне Србије);
- Bosnia and Herzegovina by the Constitution consists of two separate entities and one special district ([40]):
  - Federacija Bosne i Hercegovine- in this report the code will be BA-FBH;
  - Republika Srpska- in this report the code will be BA-RS;
  - Brčko Distrikt- in this report the code will be BA-BD;
- Kosovo* will due to size be considered as a whole.
  - In this report the code will be XK*.
- Ukraine has 27 regions ([41]):
  - UA01 Avtonomna Respublika Krym (Автономна Республіка Крим)
  - UA05 Vinnytska oblast (Вінницька область)
  - UA07 Volynska oblast (Волинська область)
  - UA12 Dnipropetrovska oblast (Дніпропетровська область)
  - UA14 Donetska oblast (Донецька область)
  - UA18 Zhytomyrska oblast (Житомирська область)
  - UA21 Zakarpatska oblast (Закарпатська область)
  - UA23 Zaporizka oblast (Запорізька область)

([36]) Eurostat NUTS2 classification for Montenegro: https://ec.europa.eu/eurostat/documents/345175/7451602/2021-NUTS-2-map-ME.pdf
([37]) Eurostat NUTS2 classification for North Macedonia: https://ec.europa.eu/eurostat/documents/345175/7451602/2021-NUTS-2-map-MK.pdf
([38]) Eurostat NUTS2 classification for Albania: https://ec.europa.eu/eurostat/documents/345175/7451602/2021-NUTS-2-map-AL.pdf
([39]) Eurostat NUTS2 classification for Serbia: https://ec.europa.eu/eurostat/documents/345175/7451602/2021-NUTS-2-map-RS.pdf
([40]) The Constitution of Bosnia and Herzegovina: http://www.ustavnisud.ba/public/down/USTAV_BOSNE_I_HERCEGOVINE_bos.pdf
([41]) United Nations Office for the Coordination of Humanitarian Affairs in Ukraine: Ukraine - Subnational Administrative Divisions https://data.humdata.org/dataset/ukraine-administrative-boundaries-as-of-q2-2017?fbclid=IwAR3_SwXixG779h8UwiQlhwVerDSPmbIV1IAjmBzaRu93TMJ32uozEskeW7E

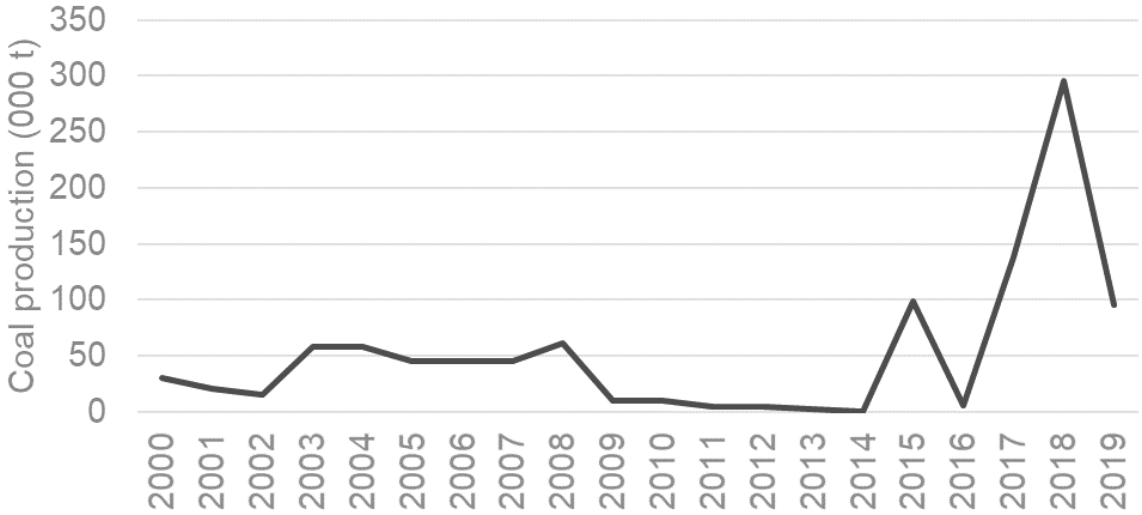
- UA26 Ivano-Frankivska oblast (Івано-Франківська область)
- UA32 Kyivska oblast (Київська область)
- UA35 Kirovohradska oblast (Кіровоградська область)
- UA44 Luhanska oblast (Луганська область)
- UA46 Lvivska oblast (Львівська область)
- UA48 Mykolaivska oblast (Миколаївська область)
- UA51 Odeska oblast (Одеська область)
- UA53 Poltavska oblast (Полтавська область)
- UA56 Rivnenska oblast (Рівненська область)
- UA59 Sumska oblast (Сумська область)
- UA61 Ternopilska oblast (Тернопільська область)
- UA63 Kharkivska oblast (Харківська область)
- UA65 Khersonska oblast (Херсонська область)
- UA68 Khmelnytska oblast (Хмельницька область)
- UA71 Cherkaska oblast (Черкаська область)
- UA73 Chernivetska oblast (Чернівецька область)
- UA74 Chernihivska oblast (Чернігівська область)
- UA80 Kyivska rada (Київська рада)
- UA85 Sevastopilska rada (Севастопільська рада)

Annex 2 Discussion about Albanian coal sector

According to Eurostat ([NRG_CB_SFF]), in 2018 Albania produced 300 kt of bituminous coal. This is between 0.8% and 18.5% of the level of coal production in the rest of the Western Balkans and Ukraine. Further analysis (Figure 43) shows that the production of coal peaked in 2018, with the last twenty years showing an average production near 60 kt, while along 2009 - 2014 the production was below 10 kt.

Regarding energy production, there is no registered use of solid fuels in Albania for gross electricity production (Eurostat [NRG_BAL_PEH]).

Figure 43. Production of coal in Albania in the period 2000-2019



Source: JRC, Eurostat [NRG_CB_SFF], 2021

According to the report on activity in the mining sector for 2020 (Industrisë, Ministria Energjisë Dhe Natyrore 2020), there were seven companies with registered coal extraction in 2020. The coal produced by these companies was mainly used as fuel in the cement industry. Although the amounts of extracted coal are registered in the annual report, there is no information available about the number of miners working in these mines.

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Annex 3 Coal mining regions in the Western Balkans and Ukraine

	Region code	Region name	Type of coal	Production 2018 (Mt)	Productivity 2018 (tonnes/ employee)	No. of active mines in 2018
Montenegro	ME00	Crna Gora	Lignite	1.6	2 128	1
North Macedonia	MK00	Severna Makedonija	Lignite	5.0	1 677	3
Serbia	RS11	Beogradski region	Lignite	28.4	2 790	1
	RS22	Region Južne i Istočne Srbije	Lignite	8.6	3 980	1
Bosnia and Herzegovina	BA-FBH	Federacija Bosne i Hercegovine	Lignite	6.9	623	8
	BA-RS	Republika Srpska	Lignite	7.3	2 139	3
Kosovo*	XK*	Kosovo*	Lignite	7.7	2 358	1
Ukraine	UA07	Volynska oblast	Hard coal	0.1	62	2
	UA12	Dnipropetrovska oblast	Hard coal	19.1	1 042	10
	UA14	Donetska oblast	Hard coal	6.3	277	20
	UA44	Luhanska oblast	Hard coal	0.3	53	8
	UA46	Lvivska oblast	Hard coal	1.4	208	7

Source: JRC, 2021

Montenegro: (Ciută and Gallop 2018; Eurostat 2021)

North Macedonia: (Ciută and Gallop 2018; ELEM 2015, 2016, 2017; ESM 2018, 2019)

Serbia: (Ciută and Gallop 2018; EPS 2015, 2016, 2017, 2018)

Bosnia and Herzegovina: (BA Energy Strategy 2017; Ciută and Gallop 2018; EFT Stanari 2020; Federal Ministry for Energy Mining and Industry 2016; Mine and Thermal Power Plant Gacko 2017, 2019; Mine and Thermal Power Plant Ugljevik 2019, 2020, 2015, 2016, 2017, 2018)

Kosovo*: (Ciută and Gallop 2018; Eurostat 2021)

Ukraine: National expert data

Annex 4 Regions with coal power plants in the Western Balkans and Ukraine

	Code	Region name	Type	Capacity (MW)
Montenegro	ME00	Crna Gora	Lignite	210
North Macedonia	MK00	Severna Makedonija	Lignite	824
Serbia	RS11	Beogradski region	Lignite	3 244
	RS21	Region Šumadije i Zapadne Srbije	Lignite	125
	RS22	Region Južne i Istočne Srbije	Lignite	1 007
Bosnia and Herzegovina	BA-FBH	Federacija Bosne i Hercegovine	Lignite	1 153
	BA-RS	Republika Srpska	Lignite	855
Kosovo*	XK*	Kosovo*	Lignite	1 288
Ukraine	UA05	Vinnytska oblast	Hard Coal	1 800
	UA12	Dnipropetrovska oblast	Hard Coal	3 051
	UA14	Donetska oblast	Hard Coal	6 437
	UA23	Zaporizka oblast	Hard Coal	2 850
	UA26	Ivano-Frankivska oblast	Hard Coal	2 566
	UA32	Kyivska oblast	Hard Coal	1 945
	UA35	Kirovohradska oblast	Hard Coal	15
	UA44	Luhanska oblast	Hard Coal	1 480
	UA46	Lvivska oblast	Hard Coal	594
	UA48	Mykolaivska oblast	Hard Coal	40
	UA51	Odeska oblast	Hard Coal	68
	UA53	Poltavska oblast	Hard Coal	255
	UA59	Sumska oblast	Hard Coal	168
	UA63	Kharkivska oblast	Hard Coal	2 952
	UA65	Khersonska oblast	Hard Coal	80
	UA71	Cherkaska oblast	Hard Coal	200
	UA74	Chernihivska oblast	Hard Coal	210
	UA80	Kyivska rada	Hard Coal	1 360

Source: JRC, 2021

Western Balkans: (JRC-PPDB-OPEN 2019)

Ukraine: National expert data

Annex 5 Distribution of 2018 direct jobs in coal activities per region

	Code	Region name	Mining jobs	Power plant jobs	Overall jobs
Montenegro	ME00	Crna Gora	750	171	921
North Macedonia	MK00	Severna Makedonija	2 980	678	3 658
Serbia	RS11	Beogradski region	10 169	2 081	12 250
	RS21	Region Šumadije i Zapadne Srbije	0	80	80
	RS22	Region Južne i Istočne Srbije	2 162	770	2 932
Bosnia and Herzegovina	BA-FBH	Federacija Bosne i Hercegovine	11 063	1 236	12 299
	BA-RS	Republika Srpska	3 409	1 230	4 639
Kosovo*	XK*	Kosovo*	3 249	1 482	4 731
Ukraine	UA05	Vinnytska oblast	0	751	751
	UA07	Volynska oblast	1 180	0	1 180
	UA12	Dnipropetrovska oblast	18 371	1 863	20 234
	UA14	Donetska oblast	22 748	5 833	28 581
	UA23	Zaporizka oblast	0	732	732
	UA26	Ivano-Frankivska oblast	0	1 922	1 922
	UA32	Kyivska oblast	0	8 688	8 688
	UA35	Kirovohradska oblast	0	321	321
	UA44	Luhanska oblast	6 474	1 068	7 542
	UA46	Lvivska oblast	6 826	2 770	9 596
	UA48	Mykolaivska oblast	0	443	443
	UA51	Odeska oblast	0	328	328
	UA53	Poltavska oblast	0	779	779
	UA59	Sumska oblast	0	1 303	1 303
	UA63	Kharkivska oblast	0	9 823	9 823
	UA65	Khersonska oblast	0	464	464
	UA71	Cherkaska oblast	0	718	718
	UA74	Chernihivska oblast	0	849	849
	UA80	Kyivska rada	0	2 094	2 094

Annex 6 Methodology behind the estimation of indirect employment

The Input Output (IO) table can be defined as a set of sector-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 and supplies of factors in the economy (Miller and 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 objective 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 transmissions mechanism 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 final demand of one sector entails expansionary (or the opposite) effects on the output of intermediate sectors which, correspondingly, increase their 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 need to convert jobs to 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.

Annex 7 Number of coal indirect jobs

	Code	Region name	Intra-regional jobs	Inter-regional jobs	Overall indirect jobs	Ind. jobs/ direct jobs (ratio)
Montenegro	ME00	Crna Gora	195	866	1 061	1.15
North Macedonia	MK00	Severna Makedonija	1 084	2 843	3 927	1.07
Serbia	RS11	Beogradski region	7 128	23 148	30 276	2.47
	RS21	Region Šumadije i Zapadne Srbije	46	149	196	2.44
	RS22	Region Južne i Istočne Srbije	1 704	5 532	7 236	2.46
Bosnia and Herzegovina	BA-FBH	Federacija Bosne i Hercegovine	8 699	916	9 616	0.78
	BA-RS	Republika Srpska	3 288	346	3 634	0.78
Kosovo*	XK*	Kosovo*	946	4 021	4 967	1.05
Ukraine	UA05	Vinnytska oblast	448	89	537	0.72
	UA07	Volynska oblast	713	142	855	0.72
	UA12	Dnipropetrovska oblast	12 351	2 458	14 809	0.73
	UA14	Donetska oblast	17 447	3 472	20 919	0.73
	UA23	Zaporizka oblast	448	89	537	0.73
	UA26	Ivano-Frankivska oblast	1 170	233	1 403	0.73
	UA32	Kyivska oblast	5 301	1 055	6 356	0.73
	UA35	Kirovohradska oblast	199	40	239	0.74
	UA44	Luhanska oblast	4 586	913	5 499	0.73
	UA46	Lvivska oblast	5 869	1 168	7 037	0.73
	UA48	Mykolaivska oblast	274	54	328	0.74
	UA51	Odeska oblast	199	40	239	0.73
	UA53	Poltavska oblast	473	94	567	0.73
	UA59	Sumska oblast	796	158	954	0.73
	UA63	Kharkivska oblast	5 998	1 194	7 192	0.73
	UA65	Khersonska oblast	274	54	328	0.71
	UA71	Cherkaska oblast	448	89	537	0.75
	UA74	Chernihivska oblast	523	104	627	0.74
	UA80	Kyivska rada	1 269	253	1 522	0.73

Annex 8 Connections between coal mines and coal power plants in the Western Balkans

	Mine (% coal for power plant)	Power plant	Comment
Montenegro	Pljevlja (95%)	Pljevlja	(ME Energy Strategy 2014)
North Macedonia	Suvodol and Brod Gneotino	Bitola	Mines and power plant are a part of the same company (ESM 2021)
	Oslomej	Oslomej	Mines and power plant are a part of the same company (ESM 2021)
Serbia	Kolubara	Nikola Tesla A and B, Kolubara, Morava	Connection between the mines and power plants is explained on EPS web pages (EPS 2021)
	Kostolac	Kostolac A and B	Connection between the mines and power plants is explained on EPS web pages (EPS 2021)
Bosnia and Herzegovina	Kreka (63%), Đurđevik (85%), Banovići (70%)	Tuzla	(BA Energy Strategy 2017)
	Breza (96%), Kakanj (99%), Abid Lolić (77%), Gračanica (79%), Zenica (<39%)	Kakanj	Zenica mine sells 61% of coal to Arcelor Mittal iron and steel facility. (BA Energy Strategy 2017)
	Gacko (99%)	Gacko	Mine and power plant are a part of the same company (BA Energy Strategy 2017; RiTE Gacko 2021)
	Ugljevik (97%)	Ugljevik	Mine and power plant are a part of the same company (BA Energy Strategy 2017; RiTE Ugljevik 2021)
	Stanari (98%)	Stanari	Mine and power plant are a part of the same company (BA Energy Strategy 2017; EFT Stanari 2021)
Kosovo*	Kosovo (Sibovc)	Kosovo A and B	Mine and power plants are a part of the same company (KEK 2021)

Annex 9 Potential impact of closure of coal mines on jobs at regional level by 2030

	Code	Region name	Potential coal production decrease [Mt]		Jobs at risk	
			Min	Max	Min	Max
Montenegro	ME00	Crna Gora	0	1.6	0	750
North Macedonia	MK00	Severna Makedonija	5	5	2 980	2 980
Serbia	RS11	Beogradski region	6.06	6.06	2 173	2 173
	RS22	Region Južne i Istočne Srbije	2.64	2.64	666	666
Bosnia and Herzegovina	BA-FBH	Federacija Bosne i Hercegovine	3.2	4.21	5 435	6 599
	BA-RS	Republika Srpska	0	2.59	0	1 488
Kosovo*	XK*	Kosovo*	0	3.63	0	1 539
Ukraine	UA07	Volynska oblast	0.006	0.03	15	589
	UA12	Dnipropetrovska oblast	1.6	9.56	241	9 181
	UA14	Donetska oblast	0.52	3.15	298	11 366
	UA44	Luhanska oblast	0.02	0.17	85	3 236
	UA46	Lvivska oblast	0.12	0.71	90	3 410

Annex 10 Potential impact of power plants decommissioning on jobs at regional level by 2030

	Code	Region name	Capacity that could retire [MW]		Jobs at risk	
			Min	Max	Min	Max
Montenegro	ME00	Crna Gora	0	210	0	171
North Macedonia	MK00	Severna Makedonija	824	824	678	678
Serbia	RS11	Beogradski region	595	595	381	381
	RS21	Region Šumadije i Zapadne Srbije	125	125	80	80
	RS22	Region Južne i Istočne Srbije	310	310	237	237
Bosnia and Herzegovina	BA-FBH	Federacija Bosne i Hercegovine	500	700	543	720
	BA-RS	Republika Srpska	0	276	0	471
Kosovo*	XK*	Kosovo*	0	610	0	777
Ukraine	UA05	Vinnytska oblast	0	1 800	0	751
	UA12	Dnipropetrovska oblast	972	3 051	1 117	1 863
	UA14	Donetska oblast	2 687	2 687	2 849	2 849
	UA23	Zaporizka oblast	0	0	0	0
	UA26	Ivano-Frankivska oblast	2 366	2 566	1 264	1 922
	UA32	Kyivska oblast	0	1 945	0	1 952
	UA35	Kirovohradska oblast	0	0	0	0
	UA44	Luhanska oblast	1 480	1 480	1 068	1 068
	UA46	Lvivska oblast	510	510	670	670
	UA48	Mykolaivska oblast	40	40	443	443
	UA51	Odeska oblast	68	68	328	328
	UA53	Poltavska oblast	0	255	0	779
	UA59	Sumska oblast	0	115	0	412
	UA63	Kharkivska oblast	2 270	2 420	2 360	2 731
	UA65	Khersonska oblast	80	80	464	464
	UA71	Cherkaska oblast	0	200	0	718
	UA74	Chernihivska oblast	210	210	849	849
	UA80	Kyivska rada	160	160	686	863

Annex 11 Relevant data on the Ukrainian peat sector (2018) ([42])

Sector	Region	Code	Production [kt]	Direct employment [FTE]	Indirect employment domestic [FTE]	Indirect employment trade [FTE]	Total employment [FTE]
MINING	Volyn	UA07	178	94	57	11	163
	Zhytomyr	UA18	16	9	6	1	16
	Ivanofrankivsk	UA26	6	3	2	0	5
	Lviv	UA46	26	13	8	2	23
	Poltava	UA53	1	1	1	0	1
	Rivne	UA56	168	89	54	11	154
	Cherkasy	UA71	0	28	17	3	49
	Chernihiv	UA74	53	237	145	29	411
ENERGY PRODUCTION	Ternopil	UA61	N.A.	20	12	2	35

Annex 12 Factsheets ([43], [44])

([42]) National expert data

([43]) All data in factsheets refer to 2018.

([44]) Sources:
Montenegro: (Ciută and Gallop 2018; Eurostat 2021), (JRC-PPDB-OPEN 2019)
Serbia: (Ciută and Gallop 2018; EPS 2015, 2016, 2017, 2018), (JRC-PPDB-OPEN 2019)
North Macedonia: (Ciută and Gallop 2018; ELEM 2015, 2016, 2017; ESM 2018, 2019), (JRC-PPDB-OPEN 2019)
Kosovo*: (Ciută and Gallop 2018; Eurostat 2021), (JRC-PPDB-OPEN 2019)
Ukraine: National expert data

Montenegro

Coal mines	Coal power plants	Estimated jobs
Number of mines: 1 Production: 1.6 Mt	Number of power plants: 1 Capacity: 210 MW	Mining jobs: 750 Power plant jobs: 171 Total jobs: 921

Coal mines

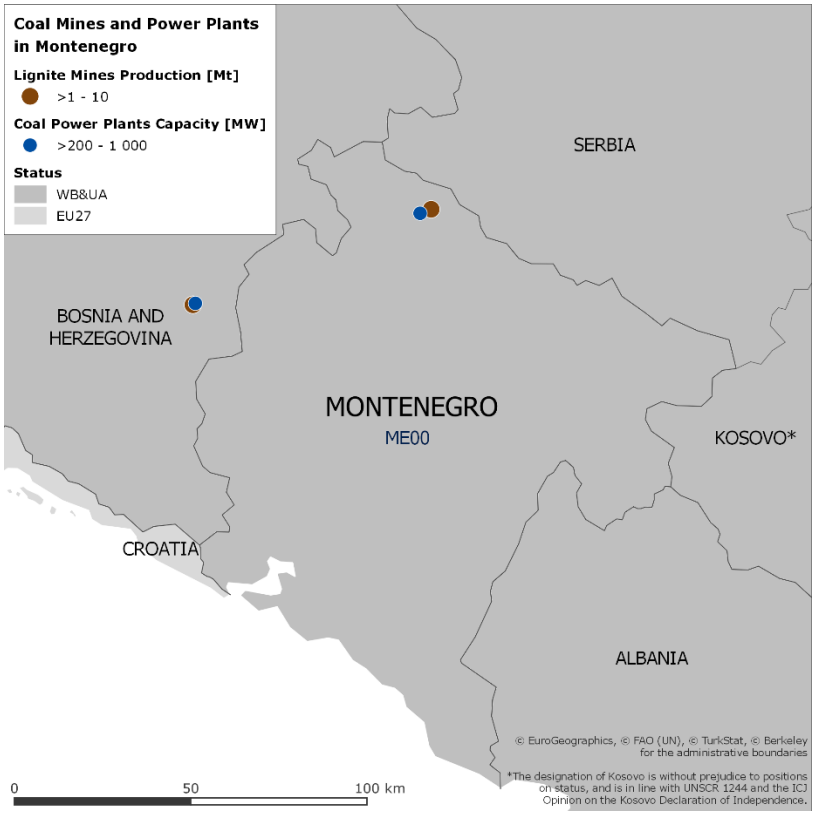
Code	Region	Coal type	Production [Mt]	Average productivity [t/FTE]	No. of mines
ME00	Crna Gora	Lignite	1.6	2 128	1

Coal power plants

Code	Region	Capacity [MW]
ME00	Crna Gora	210

Estimates of employment in coal-related activities

Code	Region	Jobs in coal mines	Jobs in coal power plants	Total coal-related jobs
ME00	Crna Gora	750	171	921



North Macedonia

Coal mines	Coal power plants	Estimated jobs
Number of mines: 3 Production: 5 Mt	Number of power plants: 2 Capacity: 824 MW	Mining jobs: 2 980 Power plant jobs: 678 Total jobs: 3 658

Coal mines

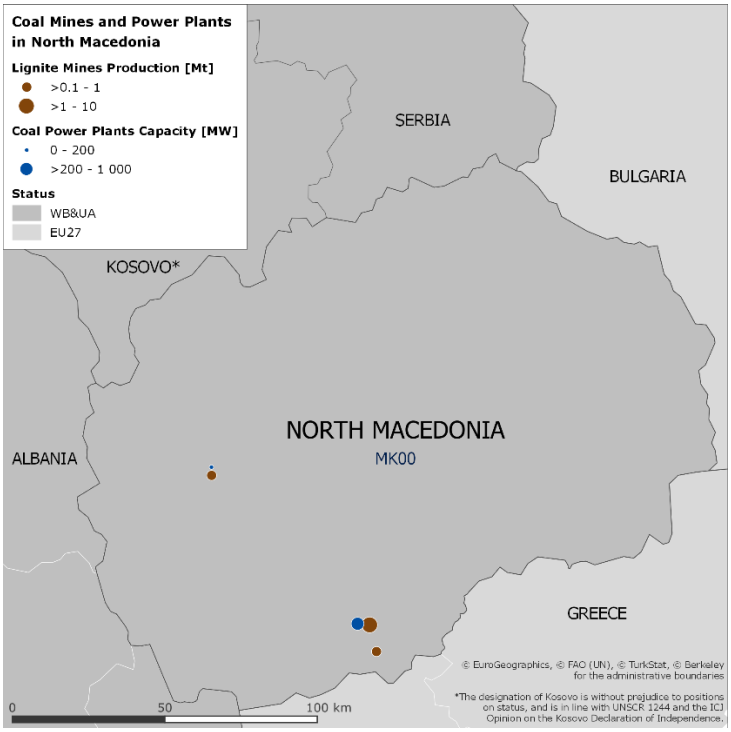
Code	Region	Coal type	Production [Mt]	Average productivity [t/FTE]	No. of mines
MK00	Severna Makedonija	Lignite	5	1 677	3

Coal power plants

Code	Region	Capacity [MW]
MK00	Severna Makedonija	824

Estimates of employment in coal-related activities

Code	Region	Jobs in coal mines	Jobs in coal power plants	Total coal-related jobs
MK00	Severna Makedonija	2 980	678	3 658



Serbia

Coal mines	Coal power plants	Estimated jobs
Number of mines: 2 Production: 36.98 Mt	Number of power plants: 6 Capacity: 4 376 MW	Mining jobs: 12 331 Power plant jobs: 2 931 Total jobs: 15 262

Coal mines

Code	Region	Coal type	Production [Mt]	Average productivity [t/FTE]	No. of mines
RS11	Beogradski region	Lignite	28.37	2 790	1
RS22	Region Južne i Istočne Srbije	Lignite	8.6	3 980	1

Coal power plants

Code	Region	Capacity [MW]
RS11	Beogradski region	3 244
RS21	Region Šumadije i Zapadne Srbije	125
RS22	Region Južne i Istočne Srbije	1 007

Estimates of employment in coal-related activities

Code	Region	Jobs in coal mines	Jobs in coal power plants	Total coal-related jobs
RS11	Beogradski region	10 169	2 081	12 250
RS21	Region Šumadije i Zapadne Srbije	0	80	80
RS22	Region Južne i Istočne Srbije	2 162	770	2 932


Coal Mines and Power Plants in Serbia
Lignite Mines Production [Mt]
>0.1 - 1
>1 - 10
>10 - 28.4
Coal Power Plants Capacity [MW]
0 - 200
>200 - 1 000
>1 000 - 3 600
Status
WB&UA
EU27
HUNGARY
RS12
ROMANIA
CROATIA
RS11
SERBIA
RS21
RS22
BULGARIA
BOSNIA AND HERZEGOVINA
MONTENEGRO
KOSOVO*
ALBANIA
NORTH MACEDONIA
0
50
100 km
© EuroGeographics, © FAO (UN), © TurkStat, © Berkeley for the administrative boundaries
*The designation of Kosovo is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Bosnia and Herzegovina

Coal mines	Coal power plants	Estimated jobs
Number of mines: 11 Production: 14.19 Mt	Number of power plants: 5 Capacity: 2 008	Mining jobs: 14 472 Power plant jobs: 2 466 Total jobs: 16 938

Coal mines

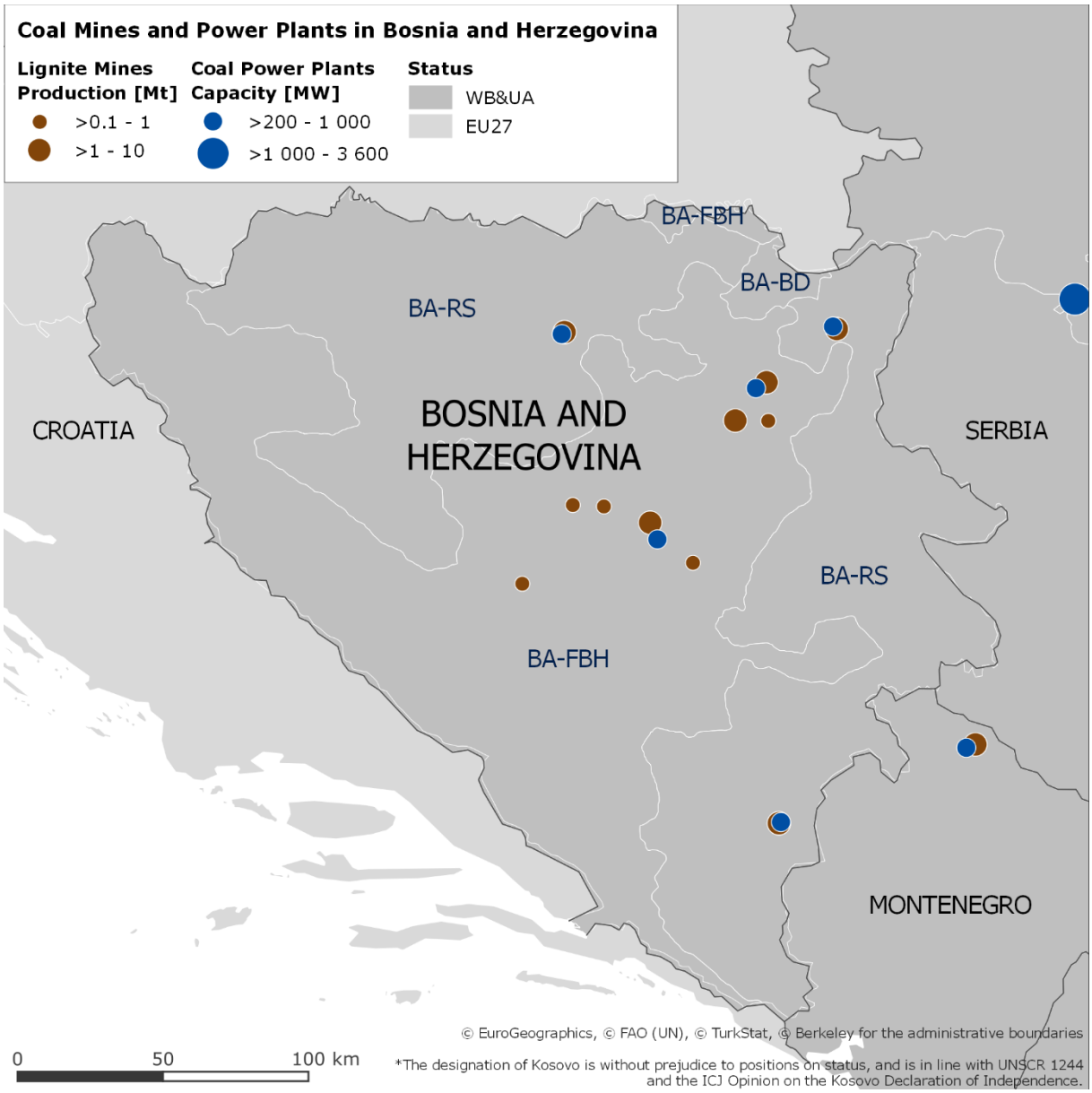
Code	Region	Coal type	Production [Mt]	Average productivity [t/FTE]	No. of mines
BA-FBH	Federacija Bosne i Hercegovine	Lignite	6.9	623	8
BA-RS	Republika Srpska	Lignite	7.29	2139	3

Coal power plants

Code	Region	Capacity [MW]
BA-FBH	Federacija Bosne i Hercegovine	1153
BA-RS	Republika Srpska	855

Estimates of employment in coal-related activities

Code	Region	Jobs in coal mines	Jobs in coal power plants	Total coal-related jobs
BA-FBH	Federacija Bosne i Hercegovine	11 063	1 236	12 299
BA-RS	Republika Srpska	3 409	1 230	4 639


Coal Mines and Power Plants in Bosnia and Herzegovina
Lignite Mines Production [Mt]
>0.1 - 1
>1 - 10
Coal Power Plants Capacity [MW]
>200 - 1 000
>1 000 - 3 600
Status
WB&UA
EU27
BA-FBH
BA-BD
BA-RS
BOSNIA AND HERZEGOVINA
CROATIA
SERBIA
BA-RS
BA-FBH
MONTENEGRO
0
50
100 km
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*The designation of Kosovo is without prejudice to positions on status, and is in line with UNSCR 1244 and the ICJ Opinion on the Kosovo Declaration of Independence.

Kosovo*

Coal mines	Coal power plants	Estimated jobs
Number of mines: 1 Production: 7.66 Mt	Number of power plants: 1 Capacity: 1 288 MW	Mining jobs: 3 249 Power plant jobs: 1 482 Total jobs: 4 731

Coal mines

Code	Region	Coal type	Production [Mt]	Average productivity [t/FTE]	No. of mines
XK*	Kosovo*	Lignite	7.66	2 358	1

Coal power plants

Code	Region	Capacity [MW]
XK*	Kosovo*	1 288

Estimates of employment in coal-related activities

Code	Region	Jobs in coal mines	Jobs in coal power plants	Total coal-related jobs
XK*	Kosovo*	3 249	1 482	4 731

Ukraine

Coal mines	Coal power plants	Estimated jobs
Number of mines: 47 Production: 27.29 Mt	Number of power plants: 38 Capacity: 26 070 MW	Mining jobs: 55 599 Power plant jobs: 40 749 Total jobs: 96 348

Coal mines

Code	Region	Coal type	Production [Mt]	Average productivity [t/FTE]	No. of mines
UA07	Volynska oblast	Hard Coal	0.07	62	2
UA12	Dnipropetrovska oblast	Hard Coal	19.14	1042	10
UA14	Donetska oblast	Hard Coal	6.3	277	20
UA44	Luhanska oblast	Hard Coal	0.34	53	8
UA46	Lvivska oblast	Hard Coal	1.42	208	7

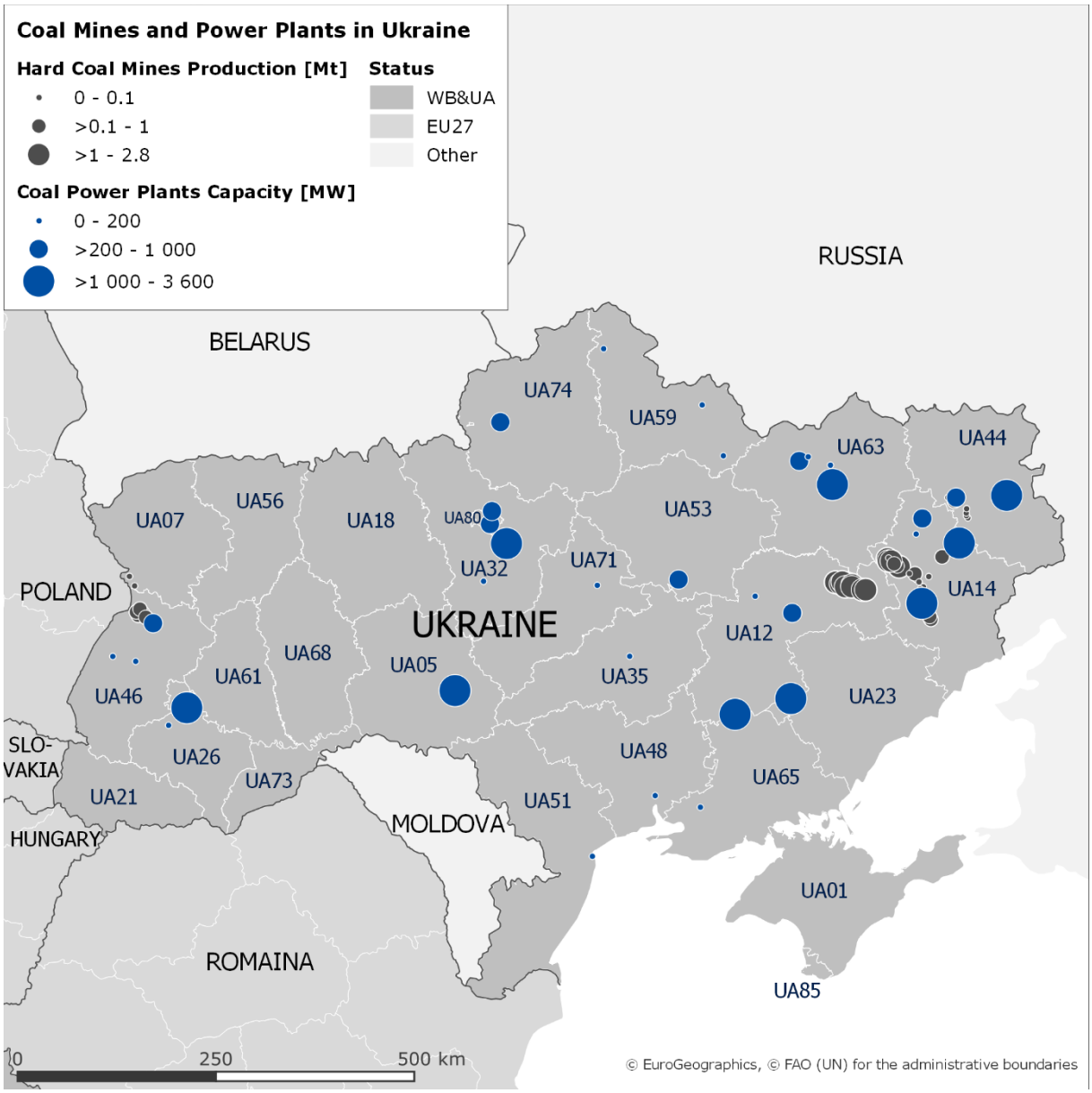
Coal power plants

Code	Region	Capacity [MW]
UA05	Vinnytska oblast	1 800
UA12	Dnipropetrovska oblast	3 051
UA14	Donetska oblast	6 437
UA23	Zaporizka oblast	2 850
UA26	Ivano-Frankivska oblast	2 566
UA32	Kyivska oblast	1 945
UA35	Kirovohradska oblast	15
UA44	Luhanska oblast	1 480
UA46	Lvivska oblast	594
UA48	Mykolaivska oblast	40
UA51	Odeska oblast	68
UA53	Poltavska oblast	255

UA59	Sumska oblast	168
UA63	Kharkivska oblast	2 952
UA65	Khersonska oblast	80
UA71	Cherkaska oblast	200
UA74	Chernihivska oblast	210
UA80	Kyivska rada	1 360

Estimates of employment in coal-related activities

Code	Region	Jobs in coal mines	Jobs in coal power plants	Total coal-related jobs
UA05	Vinnytska oblast	0	751	751
UA07	Volynska oblast	1 180	0	1 180
UA12	Dnipropetrovska oblast	18 371	1 863	20 234
UA14	Donetska oblast	22 748	5 833	28 581
UA23	Zaporizka oblast	0	732	732
UA26	Ivano-Frankivska oblast	0	1 922	1 922
UA32	Kyivska oblast	0	8 688	8 688
UA35	Kirovohradska oblast	0	321	321
UA44	Luhanska oblast	6 474	1 068	7 542
UA46	Lvivska oblast	6 826	2 770	9 596
UA48	Mykolaivska oblast	0	443	443
UA51	Odeska oblast	0	328	328
UA53	Poltavska oblast	0	779	779
UA59	Sumska oblast	0	1 303	1 303
UA63	Kharkivska oblast	0	9 823	9 823
UA65	Khersonska oblast	0	464	464
UA71	Cherkaska oblast	0	718	718
UA74	Chernihivska oblast	0	849	849
UA80	Kyivska rada	0	2 094	2 094


Coal Mines and Power Plants in Ukraine
Hard Coal Mines Production [Mt]
0 - 0.1
>0.1 - 1
>1 - 2.8
Status
WB&UA
EU27
Other
Coal Power Plants Capacity [MW]
0 - 200
>200 - 1 000
>1 000 - 3 600
RUSSIA
BELARUS
UA74
UA59
UA63
UA44
UA56
UA07
UA18
UA80
UA53
UA32
UA71
POLAND
UA14
UKRAINE
UA12
UA68
UA05
UA61
UA35
UA46
UA23
SLO-
VAKIA
UA26
UA48
UA73
UA65
UA21
UA51
MOLDOVA
HUNGARY
UA01
ROMAINA
UA85
0
250
500 km
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