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Indirect jobs in activities related to coal, peat and oil shale: A RHOMOLO-IO analysis on the EU regions

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Authors:
Mandras, G.
Salotti, S.

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Joint Research Centre

Contact information
Name: Simone Salotti
Address: Edificio Expo, C/Inca Garcilaso 3, 41092 Sevilla (Spain)
Email: simone.salotti@ec.europa.eu
Tel.: +34 954488406

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Indirect jobs in activities related to coal, peat and oil shale: A RHOMOLO-IO analysis on the EU regions

Giovanni Mandras and Simone Salotti

European Commission, Joint Research Centre

Abstract. The European Commission is working in order to ensure a smooth transition to cleaner forms of energy production away from fossil fuels in order to meet the EU objective of reaching climate neutrality by 2050. The Just Transition Mechanism was launched to manage this transition, under the European Green Deal. A key information needed to do that is the number of workers who will be impacted by the ongoing decarbonisation process. This technical report contains the RHOMOLO-IO estimates of the number of jobs indirectly related to the energy production industry of coal, peat, and oil shale. These activities directly employ more than 200,000 workers in the EU, and our results suggest that about 140,000 additional jobs are indirectly related to those. This is a significant number that should be considered by the policy makers dealing with the shift away from energy production with fossil fuels.

JEL Codes: C67, E24.

Keywords: region, growth, Rhomolo, indirect jobs, coal, input-output analysis.

Executive Summary

Coal accounts for about a fifth of total electricity production in the European Union (EU) and provides jobs to thousands of people in mines and power plants across various regions and Member States (MS). The importance of coal has steadily decreased since the 1990s and it will continue to do so in the future according to most existing decarbonisation scenarios compatible with the EU objective of reaching climate neutrality by 2050. The European Commission is working in order to ensure a smooth transition to cleaner forms of energy production.

In 2017, the European Commission launched the initiative for coal regions in transition under the "Clean Energy for all Europeans" package with the aim of supporting the EU regions affected the most by the decline in the coal sector. This initiative led to the announcement in December 2019 of the European Green Deal and to the Just Transition Mechanism (JTM), which must ensure that the transition towards a climate-neutral economy happens in a fair way. The initiative for coal regions in transition was enlarged to oil shale and peat regions in 2020.

Due to the EU climate neutrality objectives, traditional energy sectors that rely on the production and use of fossil fuels will shrink, with concomitant negative impacts on employment. Existing analyses have mostly concentrated on the coal related activities (see Alves Dias et al., 2018). This report updates those estimates and, in line with Kapetaki et al. (2021), it also includes peat and oil shale for energy use.

In 2018, the number of people directly employed in coal mining and related activities was estimated to be around 200,000, mostly located in Poland, Germany, Czech Republic, Romania, and Bulgaria. About 75% of these jobs are in the mining sector, with 90 operative coal mines in 2018. The remaining 25% of the workforce was in the 179 EU coal-fired power plants accounting for a total capacity of 130 GW that is, about 20% of the electricity produced in the EU (in 2020, the numbers had changed already, with 166 power plants for a capacity of 112 GW). In most regions with coal mines, coal is used in the carbon-intensive sectors, with the iron and steel industry accounting for the vast majority of the total coal used.

Estonia is the only EU MS hosting oil shale activities (with nearly 0.4% of the country working population directly employed in those activities), while peat-related activities exist in the following six MS: Finland, Sweden, Estonia, Ireland, Lithuania, and Latvia. More than 6,000 people are directly employed in peat-extraction activities, and more than 5,200 are directly employed in the oil shale industry. Peat is mainly used for heating purposes, and, in 2018, there were more than 200 peat-fired energy plants.

The perspective of activities related to coal, peat and oil shale being shut down in the near future means that the workers involved in these activities will lose their jobs, with potentially dramatic consequences for their well-being and for the economic growth of their regions, depending on how the transition will play out. However, thinking only about the jobs directly involved in these activities could be misleading and could lead to underestimate the economic impact of decarbonisation. There are many workers whose jobs rely on the business generated by coal, peat, and oil shale, and it is plausible to assume that these (indirect) jobs will also be affected by the ongoing structural change of the energy sector.

This technical report presents some estimates of the number of jobs indirectly related to the about 215,000 jobs directly involved in the coal, peat, and oil shale industries in the regions of the EU. The estimates are based on the RHOMOLO-IO model and suggest that 140,000 additional EU jobs rely on those industries due to linkages along the intra- and inter-regional supply chains. The analysis also reveals a specific territorial distribution of these jobs across the NUTS 2 regions of the EU.

Indirect jobs in activities related to coal, peat and oil shale: A RHOMOLO-IO analysis on the EU regions

Giovanni Mandras and Simone Salotti
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1 Introduction

Coal accounts for about a fifth of total electricity production in the European Union (EU) and provides jobs to thousands of people in mines and power plants across various regions and Member States (MS). The importance of coal has steadily decreased since the 1990s and it will continue to do so in the future according to most existing decarbonisation scenarios compatible with the EU objective of reaching climate neutrality by 2050. The European Commission is aiming at insuring a smooth transition to cleaner forms of energy production.

In 2017, the European Commission launched the initiative for coal regions in transition under the "Clean Energy for all Europeans" package with the aim of supporting the EU regions affected the most by the decline in the coal sector. Among other things, this initiative led to the announcement in December 2019 of the European Green Deal. Under the latter, the Just Transition Mechanism (JTM) must ensure that the transition towards a climate-neutral economy happens in a fair way. The initiative for coal regions in transition was enlarged to oil shale and peat regions in 2020 and it is now a key building block of the European Green Deal.

An intermediate target towards climate neutrality is the reduction of EU greenhouse gas emissions by at least 55 % by 2030, compared to 1990 levels. Achieving this objective will require a fundamental rebalancing of the existing energy system, moving toward accelerated phase-outs of polluting fossil fuels such as coal, oil shale, and peat, and developing more sustainable economic frameworks. Obviously, this may pose significant challenges for many regions.

Traditional energy sectors that rely on the production and use of fossil fuels will shrink, with concomitant negative impacts on employment. Existing analyses have mostly concentrated on the coal related activities (see Alves Dias et al., 2018). In line with Kapetaki et al. (2021), this technical report also includes peat and oil shale for energy use. Among these fossil fuels, considering their current sector sizes and the

corresponding related employment, coal activities are likely to have the biggest impact in the short to medium term.

As of the beginning of 2021, many EU MS have already announced plans to phase out coal. 11 out of 19 countries using coal and lignite for electricity production have a phase out plan. The lack of a plan for 8 MS means that some work is needed in order to ensure that the EU will be able to meet its commitments under the Paris agreement.

In 2018, the number of workers directly employed in coal mining and related activities was estimated to be around 200,000, mostly located in Poland, Germany, Czech Republic, Romania, and Bulgaria. About 75% of these jobs are in the mining sector, with 90 operative coal mines in 2018. The remaining 25% of the workforce was in the 179 EU coal-fired power plants accounting for a total capacity of 130 GW that is, about 20% of the electricity produced in the EU (in 2020, the numbers had changed already, with 166 power plants for a capacity of 112 GW). In most regions with coal mines, coal is used in the carbon-intensive sectors, with the iron and steel industry accounting for the vast majority of the total coal used.

Peat and oil shale are used to a lesser extent for energy than coal. For instance, the strong link between coal mines and power plants is more diluted in the value chain of fuel peat, since peat is also used for alternative uses (mainly agricultural), and shale is used in small plants which often also use other biomass.

Estonia is the only EU MS hosting oil shale activities (with nearly 0.4% of the country working population directly employed in those activities), while peat-related activities exist in the following six MS: Finland, Sweden, Estonia, Ireland, Lithuania, and Latvia. More than 6,000 people are directly employed in peat-extraction activities, and more than 5,200 are directly employed in the oil shale industry. Peat is mainly used for heating purposes, and, in 2018, there were more than 200 peat-fired energy plants.

The perspective of activities related to coal, peat and oil shale being shut down in the near future means that the workers involved in these activities will lose their jobs, with potentially dramatic consequences for their well-being as well as for the economic growth of their regions, depending on how the transition will play out. However, thinking only about the jobs directly involved in these activities could be misleading and could lead to underestimate the economic impact of decarbonisation. There are many workers whose jobs rely on the business generated by coal, peat, and oil shale, and it is plausible to assume that these (indirect) jobs will also be affected by the ongoing structural change of the energy sector.

Since official data on the number of jobs indirectly related to coal activities do not exist, estimates can help to gauge the importance of this additional dimension when managing

the necessary transition towards decarbonisation. The present study reports the estimated number of indirect jobs obtained using the RHOMOLO-IO modelling framework (Mandras et al., 2019) which covers all the NUTS-2 regions of the EU27 and, for the purpose of this analysis, 14 economic sectors (the disaggregation of the coal-related sectors has been made using direct jobs data provided by DG ENER).

The remainder of the report is organised as follows. In Section 2, we briefly illustrate the model and how it is used for the present analysis. Section 3 explains the data used for the estimates and contains the results on the indirect jobs in coal-related activities. Section 4 concentrates on the indirect jobs in the peat and oil shale-related activities. Section 5 concludes.

2 The RHOMOLO-IO model

The RHOMOLO-IO model is based on a set of Input-Output (IO) tables containing data on sectorally disaggregated regional economic accounts for the whole EU. It is a snapshot of flows of products and services in the economy for a single year (in this case, 2013: see Thissen et al., 2019, for a description of the dataset used in this analysis, which also constitutes the main dataset used for the RHOMOLO model, see Lecca et al., 2018). IO tables were originally created to identify and disaggregate all the monetary flows between industries (inter-industry expenditure flows), between consumers and industries, and between industries and suppliers of factors in the economy (Leontief, 1941 and 1986; Miller and Blair, 2009).

Under a number of assumptions, IO tables can be used in economic modelling exercises to study the potential output effects of exogenous changes in final demand. The IO modelling approach is commonly used to assess the economic benefits/losses induced by a given project or investment and it is a powerful tool to evaluate the impacts generated along the supply chains of the various sectors of the economy.

A key output from IO analysis is the calculation of the so-called multipliers used to study the knock-on effects throughout the economy of a change in final demand. IO multipliers are indicative of how an increase (decrease) in final demand of one sector (which is the direct effect of the shock) entails expansionary (contractionary) effects on the output of intermediate sectors that, correspondingly, increase their demand for their own intermediates inputs. 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 can be related to changes in employment. In other words indirect job loss/increase can be calculated using direct jobs, which is what is done in the present analysis.

The two key assumptions in IO modelling are the following: (a) the supply-side of the economy fully responds to changes in demand, and (b) the production technology for all sectors is represented by fixed coefficients. The latter means that an increase (decrease) in the production of any sector's output implies a proportional increase (decrease) in that sector's input requirements.

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.

In order to represent formally the RHOMOLO-IO model, let us start by characterising sectoral output as follows:

$$x_i = \sum_{j=1}^{n} z_{ij} + y_i \qquad (1)$$

x_i is output of sector i; z_{ij} stands for transactions from sector i to sector j; y_i stands for sales from sector i to final demand users. Equation (1) simply means that output is given by the sum of intermediate sales and final demand. We could re-write equation (1) as follows:

$$x_i = \sum_{n=1}^{n} a_{in} x_n + y_i \qquad (2)$$

$\sum_{n=1}^{n} a_{in} x_n$ stands for intermediate sales (equivalently to $\sum_{j=1}^{n} z_{ij}$) expressed as output multiplying the technical coefficients a_{in}. The latter express the quantity of input i used to produce output x and is defined as the ratio between intermediate transactions divided by output: $a_{in} = {}^{z_{in}}/_{x_n}$. The fact that these coefficients are fixed means that constant returns to scale are assumed, and it is a way to represent the available production technology in the economy.

In matrix notation, we can re-write equation (2) as follows:

$$Y = [I - A]X, \qquad (3)$$

where X is the vector of outputs, Y is the vector of final demands, A is the matrix of technical coefficients (also called IO coefficients), and I is the identity matrix (with ones on the main diagonal and zeros elsewhere). For a given Y, this is a set of n linear equations in the n unknowns $x_1, x_2, \dots, x_n$ and hence it may or may not be possible to find a unique solution. In fact, a unique solution depends on whether or not $[I - A]$ is singular, that is its inverse exists. Assuming that it does, by pre-multiplying both sides of equation (3) by $[I - A]^{-1}$ we obtain the following:

$$X = [I - A]^{-1} Y \qquad (4)$$

$[I-A]^{-1}$ is either called the Leontief inverse or the total requirements matrix. The so-called open IO model assumes that Y is completely exogenous, which means that demand is not related to production. Equation (4) can be used to calculate the multipliers mentioned above: by modifying the exogenous demand vector one can calculate the output necessary to sustain such alternative demands. This analysis relies on three assumptions: (a) the supply-side of the economy is entirely passive; (b) there are no supply constraints, nor unused capacity; (c) the production technology for all sectors is represented by fixed coefficients (meaning that an increase in the production of any sector's output means a proportional increase in that sector's input requirements). The latter means that inputs substitutability is neglected.

Thus, IO multipliers allow measuring how an increase in final demand for the output of one sector entails expansionary effects on the output of intermediate sectors which, due to such demand change, increase their own demand for their intermediates inputs. The activity generated by the sum of these demands for intermediate inputs is known as the indirect effect. The multipliers calculated by including both the direct and indirect effects of an exogenous change in final demand are normally referred to as type I multipliers.

The IO multiplier analysis can be useful to understand the potential impact of changes in final demand for certain products and sectors. Certain sectors will be associated with higher indirect (and induced) effects than others, permitting to form ideas about the sectoral interdependencies of the economy.

In this case, we use the RHOMOLO-IO model in order to estimate the indirect jobs related to the jobs in the activities related to coal, peat, and oil shale related to energy use. We start from the number of jobs directly involved in those industries and we calculate the related employment coefficients, defined as the employment (expressed in Full Time Equivalents - FTEs) to output ratio (*w*). The next step is to relate the total employment effect to a change in employment rather than a variation in final demand (and output) in monetary terms. Mathematically, the vector of the employment multipliers (*EmpM*) is given by:

$$EmpM = w[I-A]^{-1}w^{-1} \quad (5)$$

Following the same approach, and to complement the analysis, we calculate also the Value Added multipliers (*VAM*) for the Coal related activities case, substituting the employment output ratio (*w*) with the value added output ratio (*v*):

$$VAM = v[I-A]^{-1}v^{-1} \quad (6)$$

3 Indirect jobs in coal-related activities

Table 1 reports the number of direct jobs in coal-related activities in 2018 (source: DG ENER), and the number of indirect jobs estimated using the RHOMOLO-IO type-I multipliers. The latter jobs are those involved in the supply chain of coal mining and coal plants, and therefore may be impacted by the EU decarbonisation process. The last column provides a comparison between indirect jobs in coal-related activities and direct jobs as a ratio of indirect over direct jobs.

The indirect jobs are divided into "Domestic" and "Non-Domestic". The numbers of the Domestic column represent the jobs indirectly related to the activities of the workers employed by the coal industry within the region (they can be thought of as intra-regional indirect jobs). The Non-Domestic column shows the EU indirect jobs created outside the region by its coal-related activities (they can be labelled as inter-regional indirect jobs). The latter originate from trade flows indirectly related to coal activities.

Table 1. Number of direct jobs, estimated indirect jobs within region and in the rest of the EU, and indirect/direct jobs ratio (coal activities)

Region	Direct	Indirect Domestic	Indirect Non-Domestic	Indirect/Direct	Region	Direct	Indirect Domestic	Indirect Non-Domestic	Indirect/Direct
AT12	202	190	257	2.2	FI19	574	526	713	2.2
AT22	120	156	186	2.9	FI1B	221	31	22	0.2
BG32	167	26	32	0.3	FI1C	300	26	25	0.2
BG33	76	20	35	0.7	FR23	113	45	53	0.9
BG34	11262	2459	2277	0.4	FR41	115	58	55	1.0
BG41	1370	433	254	0.5	FR51	225	142	156	1.3
BG42	69	26	22	0.7	FR82	115	65	62	1.1
CZ02	667	500	798	1.9	HRV	157	119	7	0.8
CZ03	59	43	40	1.4	HU21	166	99	176	1.7
CZ04	9188	3123	2631	0.6	HU31	2045	745	1149	0.9
CZ05	670	405	502	1.4	IE05	342	179	49	0.7
CZ08	7245	953	882	0.3	ITC3	153	5	15	0.1
DE11	433	299	323	1.4	ITF4	713	72	101	0.2
DE12	799	325	355	0.9	ITG2	285	22	20	0.1
DE21	194	145	123	1.4	ITH3	253	355	671	4.1
DE30	187	158	105	1.4	ITH4	93	151	773	9.9
DE40	4471	11839	16498	6.3	ITI2	38	67	424	12.9
DE50	185	25	49	0.4	ITI4	544	292	417	1.3
DE60	385	119	219	0.9	NL32	173	115	177	1.7
DE80	124	15	12	0.2	NL33	285	189	277	1.6
DE91	347	104	133	0.7	NL41	352	294	350	1.8
DE92	65	19	21	0.6	PL11	7681	3355	3977	1.0
DE94	357	71	69	0.4	PL91	1185	617	634	1.1
DEA1	4442	1133	1186	0.5	PL92	1641	854	877	1.1
DEA2	6205	1549	1984	0.6	PL21	5699	827	838	0.3
DEA3	356	102	97	0.6	PL22	76564	7545	6363	0.2
DEA4	211	58	72	0.6	PL31	4508	493	661	0.3
DEA5	990	425	521	1.0	PL32	128	128	162	2.3
DEC0	427	154	229	0.9	PL33	848	476	904	1.6
DED2	3438	298	237	0.2	PL34	80	48	57	1.3
DED5	1435	246	342	0.4	PL41	2525	894	1471	0.9
DEE0	1072	101	90	0.2	PL42	817	421	731	1.4
DEF0	138	41	39	0.6	PL51	3331	845	870	0.5
DK01	82	11	14	0.3	PL52	1705	898	2080	1.7

DK02	258	57	110	0.6	PL61	202	111	170	1.4
DK03	246	49	73	0.5	PL63	165	105	147	1.5
DK05	125	27	39	0.5	PT16	211	268	330	2.8
EL13	4649	3002	1572	1.0	PT18	432	190	237	1.0
EL25	1038	92	144	0.2	RO41	12960	4184	2243	0.5
ES11	651	1105	662	2.7	RO42	3670	3901	1536	1.5
ES12	1978	1126	824	1.0	SI01	1743	547	275	0.5
ES24	350	304	323	1.8	SI02	54	35	23	1.1
ES41	861	888	683	1.8	SK02	1747	754	719	0.8
ES61	660	453	333	1.2	SK04	229	358	279	2.8
					TOTAL	**203641**	**64123**	**66670**	**0.64**

Source: DG ENER (direct jobs) and RHOMOLO-IO simulations (indirect jobs).

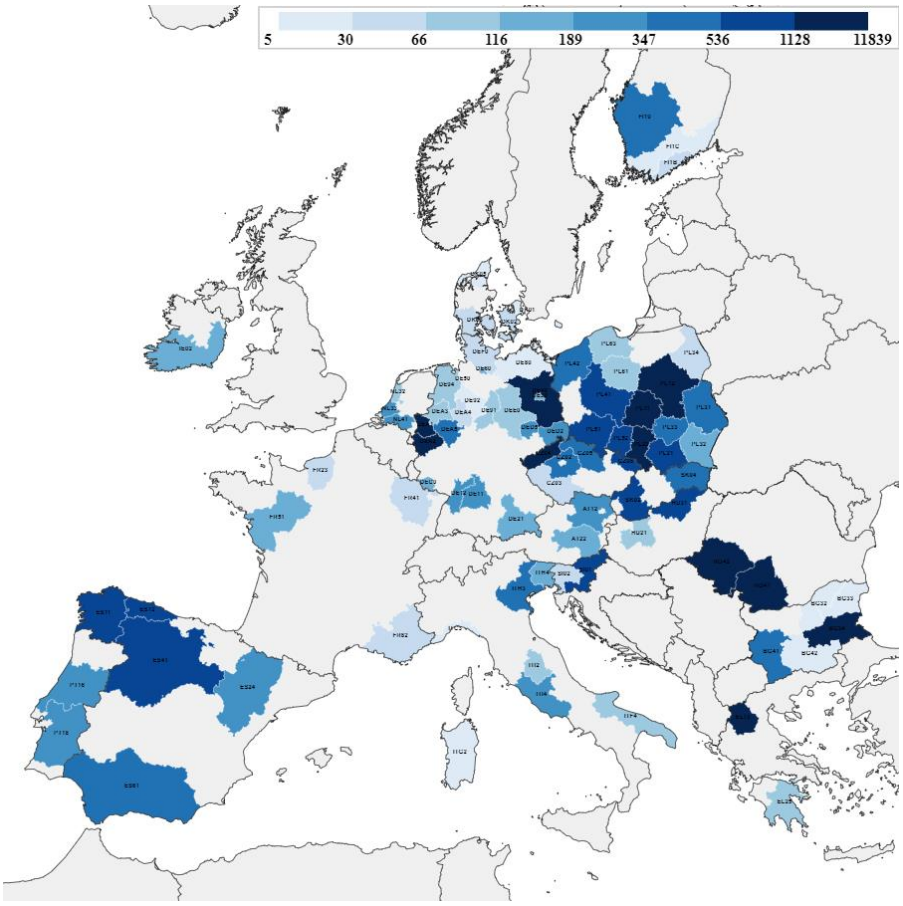
In 2018, slightly more than 200,000 jobs were directly related to the coal industry in the EU, although most of them were located in a few countries. More than half of the total number of the EU coal employees, almost 108,000, were working in Poland. More than 25,000 were in Germany, and Bulgaria, Czech Republic and Romania were all hosting between 10,000 and 20,000 workers. This means that more than 181,000 coal employees (almost 90% of the total) were working in these five countries alone.

According to the RHOMOLO-IO estimates, the EU coal industry was responsible for the creation of about 131,000 EU jobs along its supply chain. The estimated ratios between indirect and direct jobs vary considerably across the various EU regions. The weighted (by the number of workers) and unweighted averages of the ratios are equal to 0.64 and 1.3, respectively, and most values are close to that range. However, there are outliers so that very little indirect jobs are created by the coal industry of certain regions (for instance, CZ08 has an estimated ratio of only 0.3), while the opposite is true in other regions (for instance, the indirect/direct jobs ratio for DE40 is equal to 6.3).

These numbers are informative of the integration of the regional coal industry both in the domestic and in the international supply chains. A ratio higher than one means that a regional industry sustains more indirect jobs than direct ones. Of the regions hosting the most workers directly employed in the coal industry, those of Poland and Bulgaria have the smallest ratios that is, the proportion of direct jobs with respect to indirect ones is the highest. On the other hand, almost 30% of all the EU coal-related indirect jobs are due to the German coal industry (especially that of DE40, DEA1, and DEA2). High ratios are also estimated for the regions of Austria, the Netherlands, and Italy.

Figures 1 and 2 show the distribution of indirect jobs in intra-regional and inter-regional supply chains, respectively, in all the NUTS-2 regions of the EU. The five regions with the largest intra-regional indirect jobs (DE40, PL22, RO41, RO42, and PL11) belong to Germany, Poland, and Romania, and account for the 50% of all domestic indirect jobs in the EU (almost 31,000 jobs in total).

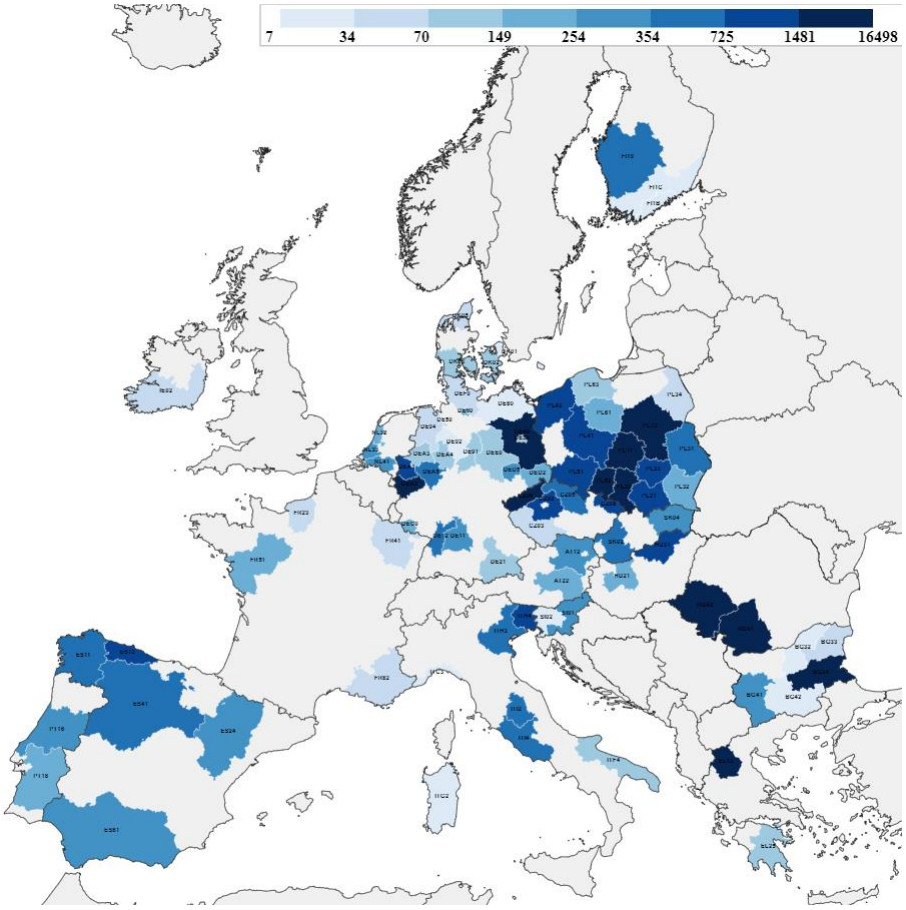
Figure 1. Distribution of indirect jobs in intra-regional supply chains



Source: RHOMOLO-IO estimates.

As for the distribution of indirect jobs in the inter-regional supply chains (Figure 2), the five regions with the highest inter-regional indirect jobs (DE40, PL22, PL11, CZ04, and BG34) account for 48% of all the EU inter-regional indirect jobs (around 32,000 jobs in total).

Figure 2. Distribution of indirect jobs in inter-regional supply chains

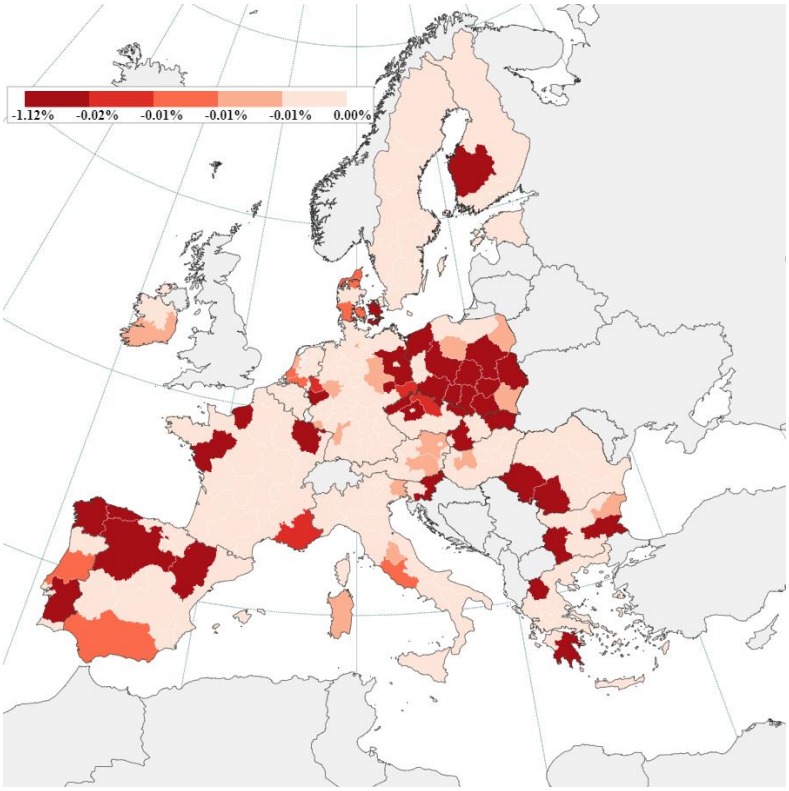


Source: RHOMOLO-IO estimates.

We complement the analysis by providing estimates on the potential loss in terms of value added and production associated to the EU de-carbonization process (coal only) by using the output and value added multipliers introduced in equation (6).

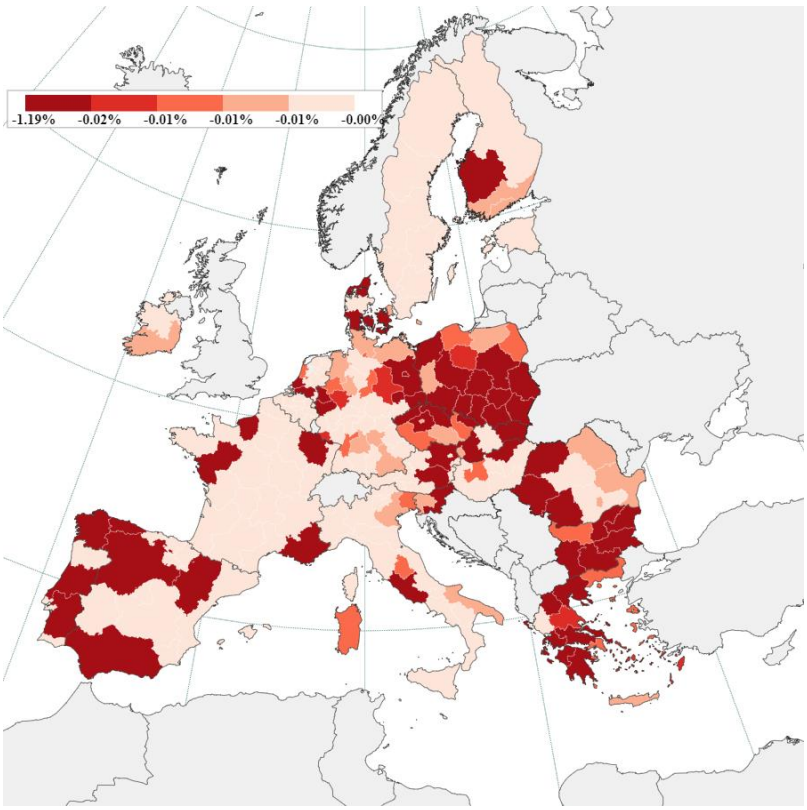
Figure 3 shows the share of value added at risk which across all the EU regions ranges between 0 and -1.12%. As expected, higher losses are concentrated in those regions relying more on coal as a source of electricity production. Figure 4 shows a similar picture for output (production), in which the potential loss is slightly higher than that of value added, but with a similar regional pattern.

Figure 3. Regional value added at risk due to decarbonisation (coal only)



Source: RHOMOLO-IO estimates.

Figure 4. Regional output at risk due to decarbonization (coal only)

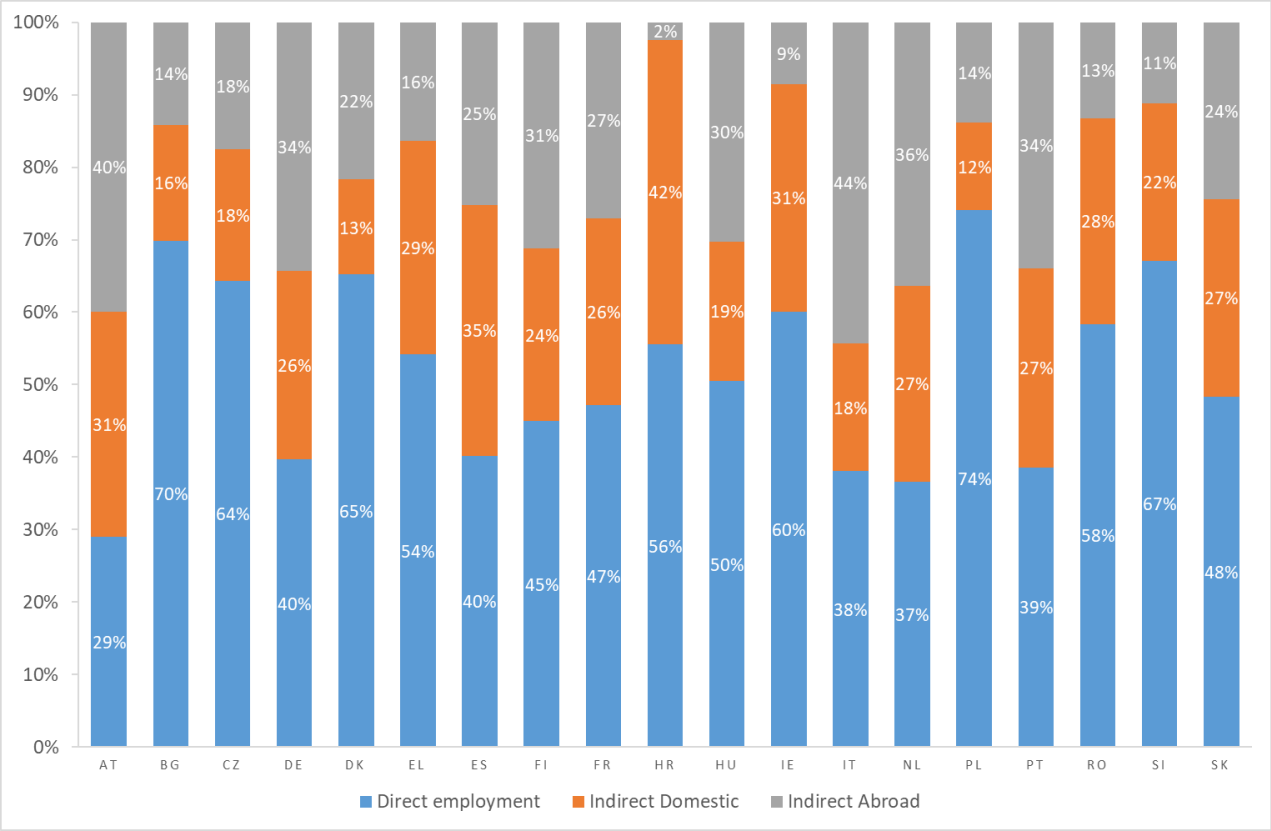


Source: RHOMOLO-IO estimates.

Moving to a country-level perspective, Figure 5 shows the proportions of direct jobs and of intra-regional and inter-regional indirect ones. The country whose coal activities are responsible for the creation of the most indirect jobs appears to be Germany. According to our estimates, only 40% of its total coal-related workers are employed directly in the German coal industry. 26% of the total jobs are indirectly related to coal within the country, and 34% of the jobs are located outside Germany, indicating a significant degree of internationalisation of the German coal supply chain.

These numbers differ substantially from those of Bulgaria and Poland, for instance, in which 70% and 74% of the total workers related to the domestic coal industry, respectively, are directly employed by the domestic coal industry. This reflects a productive structure which is considerably less open than the German one.

Figure 5. Country-level proportions of coal-related direct and indirect jobs



Source: DG ENER (direct employment) and RHOMOLO-IO estimates (indirect jobs).

4. Indirect jobs in peat- and oil shale-related activities

Table 2 reports the number of direct jobs in activities related to peat and oil shale in 2018 (source: DG ENER), and the number of indirect jobs estimated using the RHOMOLO-IO type-I multipliers. Similarly to Table 1 for coal, the last column provides a comparison between indirect jobs in coal-related activities and direct jobs as a ratio of

indirect over direct jobs. The indirect jobs are once again divided into domestic (intra-regional) and non-domestic (inter-regional) ones.

Table 2. Number of direct jobs, estimated indirect jobs within the region and in the rest of the EU, and indirect/direct jobs ratio (peat and oil shale activities)

Region	**Direct**	**Indirect domestic**	**Indirect non-domestic**	**Indirect / Direct**
Peat				
EE00	782	471	97	0.73
FI19	1800	1571	2129	2.06
FI1B	21	3	2	0.24
FI1C	358	44	31	0.21
FI1D	1926	256	86	0.18
IE05	107	40	18	0.54
IE06	219	74	38	0.51
LT01	6	1	0.4	0.32
LT02	32	28	4	1.00
LV	26	29	3	1.25
SE11	40	22	17	0.97
SE12	325	211	197	1.26
SE21	80	46	42	1.10
SE22	8	5	4	1.12
SE23	20	10	6	0.83
SE31	92	38	34	0.78
SE32	146	65	59	0.85
SE33	325	139	87	0.70
TOTAL	**6313**	**3053**	**2856**	**0.94**
Oil shale				
EE00	5243	2400	510	*0.66*

Source: DG ENER (direct jobs) and RHOMOLO-IO simulations (indirect jobs).

In 2018, slightly more than 6,000 jobs were directly related to the peat and oil shale industry for energy use in the EU. About 4,100 of them were located in the regions of Finland, constituting 65% of the total EU workforce. As for the rest of the employees, more than 1,000 workers were in Sweden, and roughly the same number were located in Estonia, Ireland, Lithuania, and Latvia. As for oil shale, all the EU workers directly employed in oil shale activities for energy use, more than 5,200 people were located in Estonia.

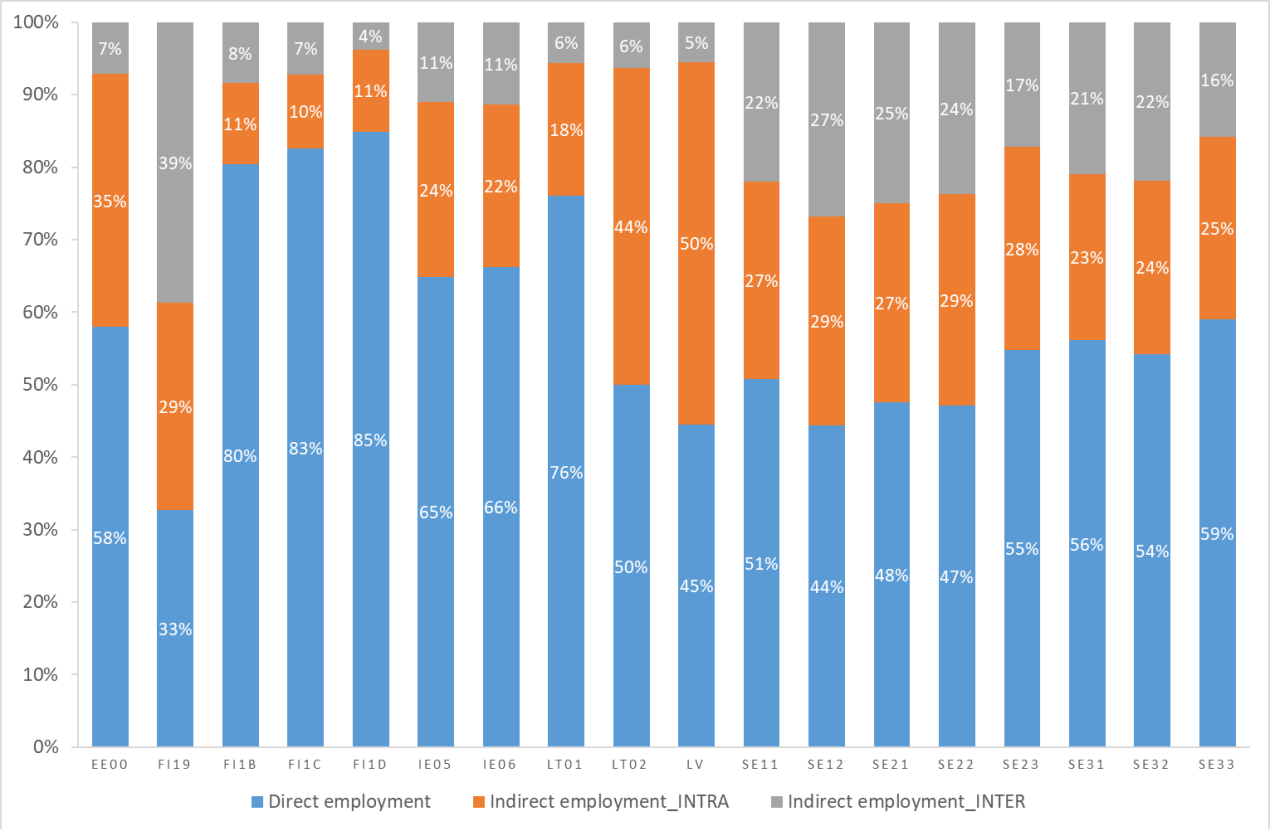
According to the RHOMOLO-IO estimates, the EU peat industry was responsible for the creation of almost 6,000 EU jobs along its supply chain, and the oil shale one for almost 3,000 more. The estimated regional ratios between indirect and direct jobs vary significantly less than in the case of the coal analysis. The unweighted average of the ratios is equal to 0.8, while the weighted one is equal to 0.9. Not surprisingly, most

regional values are close to those two values. The most notable outlier is the FI1D region (the region with the highest number of workers directly employed in the peat industry) for which the estimated ratio is below 0.2.

Of the three industries studied in this analysis, that of peat appears to be the more integrated in both the domestic and the international supply chains, since it presents an indirect/direct jobs ratio about 50% higher than that of the coal and oil shale industries (0.94 vs 0.64 and 0.66, respectively).

Similarly to Figure 5 for the coal-activities, Figure 6 shows the regional proportions of peat-related direct and indirect jobs, the latter divided between intra-regional and inter-regional ones. Interestingly, three out of four Finnish regions (FL1B, FL1C, FL1D), are characterised by a share of direct jobs above 80% of the total (direct plus indirect). Together with the regions of Lithuania and Latvia, they are among the regions responsible for the creation of the smallest proportion of inter-regional indirect jobs (less than 8%). On the other hand, another Finnish region, FL19, seems to have a productive structure very open to trade, given that 39% of the jobs directly and indirectly related to its peat industry are located outside the region itself.

Figure 6. Contribution (%) of direct and indirect (intra and Inter) jobs in peat-related activities



Source: DG ENER (direct employment) and RHOMOLO-IO estimates (indirect jobs).

5. Conclusions

The European Commission is working to ensure a smooth transition away from the use of fossil fuels for energy production in order to support the EU objective of reaching climate neutrality by 2050. One important instrument for that is the JTM, under the umbrella of the European Green Deal, which provides targeted support to help mobilise at least €150 billion over the period 2021-2027 in the most affected regions hosting relevant activities related to coal, peat, and oil shale for energy use.

These traditional energy sectors that rely on the production and use of fossil fuels will shrink, with concomitant negative socio-economic impacts. It is important to understand how many jobs are related to the activities that will cease in the near future in order to fully appreciate the potential impact of the transition in terms of employment. This technical report presents some estimates of the number of jobs indirectly related to the about 215,000 jobs directly involved in the coal, peat, and oil shale industries in the regions of the EU. The estimates are based on the RHOMOLO-IO model and suggest that 140,000 additional EU jobs rely on those industries due to linkages along the intra- and inter-regional supply chains. The analysis also reveals a specific territorial distribution of these jobs across the NUTS 2 regions of the EU.

The estimates indicate that, although the shift away from coal would affect the whole EU, some regions are particularly at risk in terms of employment vulnerability. This suggests the need for territorial-specific policies aimed at supporting workers in their search for alternative occupations during and after the transition away from coal activities.

As for any modelling outcome, the numbers reported here should be interpreted with care as they inevitably result from a number of assumptions. For example, this is a static analysis which denies any potential dynamic aspects such as reaction and adaptation to the move away from fossil fuels. As a consequence, the numbers reported here may overstate the number of jobs at risk due to the transition, as workers can adapt and find alternative occupations as these ones progressively disappear. Nevertheless, they provide evidence on the economic importance that coal activities have in the EU and highlight the importance of the need for a strategically planned retirement of coal assets and a gradual industrial restructuring process to support redundant coal-related workers.

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