RESEARCH REPORT

Eurofound

Future of manufacturing

Energy scenario: Employment implications of the Paris Climate Agreement

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European Foundation for the Improvement of Living and Working Conditions

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More information on the FOME project, including available and forthcoming publications and events and relevant data, can be found on the FOME page of the Eurofound website.

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Executive summary

This analysis assesses the potential employment and economic impacts on the EU, and other parts of the world, of a transition towards a low-carbon economy by 2030. The transition envisaged is in line with the 'below 2-degree' temperature change target and the associated reduction in carbon emissions. It analyses the impacts across sectors and occupations, with particular focus on manufacturing. The analysis is carried out using the E3ME macro-econometric model,[1] which provides information on sectoral impacts, together with the Warwick Labour Market Extension model for occupational analysis. Further analysis of the employment developments in Europe are undertaken using Eurofound's European Jobs Monitor.

The impact of a transition to a low-carbon economy is positive for the EU as a whole. The positive impact on the number employed is largely due to the investment activity required to achieve such a transition together with the impact of lower spending on the import of fossil fuels. The impacts vary considerably among sectors. For example, jobs are lost in fossil fuel extraction and processing, but gained in the construction and manufacturing of renewable and energy efficiency equipment, together with the associated supply chains.

This shift in production has implications for labour market demand. For example, the expected shift towards production of capital goods, such as equipment, machinery and buildings, will result in an increased demand for construction and for labour from the associated occupations, as well as increased demand for metal and machinery, and related labour.

The various estimates are compared to a largely 'business as usual' baseline forecast up to 2030. In the EU, the two headline measures of gross domestic product (GDP) and employment show growth of 1.1% and 0.5% respectively. The most positive results for both these measures are found in China and the EU. The United States, however, experiences a drop in GDP of 3.4%, with employment falling by 1.6%.

While overall the energy scenario implies more employment in Europe, much of the employment created is at the bottom and the middle of the wage distribution. These jobs, to a greater extent than in the baseline forecast, are filled by lower-educated employees and involve performance of less advanced tasks.

However, these projections do depend on modelling assumptions, some of which have important policy implications. Firstly, the model assumes no labour market frictions. In particular, the labour force is assumed to adapt to the structural change in skill requirements associated with the transition to a low-carbon economy; the faster the change, the more likely it is that there may be frictions that leave some workers unemployed and some demands for new skills unmet, preventing the full potential benefits from being realised. Moreover, the appreciable investment required assumes that there are no barriers in accessing the finance necessary for this transition. Finally, it is assumed that countries which currently have a lead in certain sectors are able to maintain it when switching to new technologies; for example, the main manufacturers of conventional cars and trucks become the main manufacturers of electric vehicles and their components.

1 Details are available on the E3ME website.

Introduction

In 2015, at the United Nations Climate Change Conference in Paris, 163 parties agreed to stabilise global warming by:

> *[h]olding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels.*
>
> (United Nations, 2015)

Countries submitted their own Nationally Determined Contributions (NDCs) to specify their conditional and unconditional targets.[2] The EU submitted a target of reducing carbon dioxide (CO_2) emissions by 40% below 1990 levels by 2030. However, even if all countries meet their NDC targets, the collective ambition is not sufficient to limit global warming to below the 2-degree target. In the baseline and energy scenarios presented in this report, we investigate the impact of policies that would achieve the 2-degree target, defined here as the level of global emissions that would have a 66% chance[3] of limiting the temperature increase to below 2°C according to the IPCC (2014). Achieving the target requires stronger climate policies than are currently in place and a different technological trajectory than can be expected under 'business as usual'.

Curbing emissions to meet the 2-degree target will change the types of activity taking place and have substantial impacts on the economy and employment levels across countries and across sectors. For example, employment gains are expected in low-carbon construction projects, while job losses will occur in the fossil fuel industry and other sectors that are energy (carbon) intensive. It is important to note that the degree target itself may not impact the economy so much as the rate at which society implements change (Grubb, 2014): the longer action is delayed, the more rapidly change must occur to meet the target.

This report is part of the Future of Manufacturing in Europe (FOME) pilot project, delegated to Eurofound by the Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs (DG GROW). Given that much of the energy required in advanced economies emanates from the manufacturing production process, responses to the Paris Agreement are highly relevant for the future of manufacturing in Europe.

The purpose of the scenarios is to explore the employment impacts in the EU of the set of policies that are in line with achieving the 2-degree target, with a specific focus on the manufacturing sector. The E3ME model is well-suited for this purpose because it calculates energy demand by sector and fuel type, allowing CO_2 emissions to be calculated and compared with the profile needed to reduce the pace of global warming. We first construct a business-as-usual[4] projection in which the emissions target is not met and contrast this with a projection which implements additional policies that do succeed in meeting the CO_2 emissions reduction target. The economic impact is calculated as the difference between the 2030 outcomes in the energy scenario and those in the baseline scenario.

From a modelling point of view, the main inputs to the energy scenario target the sectors that emit the most CO_2 – electricity generation and road transport – through minimising the use of fuels with the highest carbon content: coal, followed by oil and gas. To target the carbon content of fuels in the scenario, a carbon price is introduced at a global level. Policies are also required to encourage the uptake of alternative fuels and of renewables in power generation, not least because of the key role that electrification of energy demand is likely to play in decarbonisation efforts throughout the economy. The modelling proceeded in an iterative manner, adding emissions reduction measures until the global emissions reduction target was met.

The impact of these policies is expected to vary from country to country. Additional investment in renewable technologies and energy efficiency is likely to stimulate the economy if the new technologies are produced domestically. However, if they are imported, there is no additional stimulus.

Furthermore, the deployment of more renewables may lead to higher electricity prices, affecting both consumer real incomes and the competitiveness of exporters. Large producers and exporters of fossil fuels, which are located mainly outside of Europe, are expected to reduce fossil fuel extraction and processing as global demand and prices for these fuels fall.

Conversely, importers of fossil fuels are expected to benefit from the transition to a low-carbon economy, as fuel prices fall and imports decrease. Generally, as a net importer of fossil fuels, the EU overall is expected to benefit from the transition, but the GDP impact will vary between Member States, reflecting respective countries' different economic structures.

2 Unconditional NDCs are expected to be met by the country without international support, while conditional targets would be achieved by the country if it received the requested international support. In most cases, countries submitted a conditional contribution alongside an unconditional contribution, but about a third of NDCs include only a conditional contribution.

3 There is uncertainty about the extent to which greenhouse gas emissions impact on global temperature. Large-scale climate models report the probability that any given reduction in emissions will achieve a desired target for limiting temperature change. Targets for emissions reduction are then based on the level that is likely to achieve the target, where 'likely' is defined by the Intergovernmental Panel on Climate Change (IPCC) as a 66% probability or better.

4 We refer to the business-as-usual projection as the 'Cedefop baseline' because its employment projections are consistent with projections by the European Centre for the Development of Vocational Training (Cedefop), which were prepared by Cambridge Econometrics in January 2018, projection reference E3ME 6.1 C174, under the framework contract 2016-FWC4/AO/DSLJVKVET/skills forecasts/001/16. See Cedefop and Eurofound (2018).

Box 1: E3ME – econometric energy-environment-economy model

E3ME is a global, macro-econometric model designed to address major economic and economy-environment policy challenges. Developed over the last 20 years by Cambridge Econometrics, it is one of the most advanced models of its type. Its strengths are:

- A high level of disaggregation, enabling detailed analysis of sectoral and country-level effects from a wide range of scenarios. Social impacts are important model outcomes.
- Its econometric specification addresses concerns about conventional macroeconomic models and provides a strong empirical basis for analysis. It can fully assess both short and long-term impacts and is not limited by many of the restrictive assumptions common to Computable General Equilibrium (CGE) models.
- Integrated treatment of the world's economies, energy systems, emissions and material demands. This enables it to capture two-way linkages and feedback between these components.

E3ME covers 59 global regions, with a detailed sectoral disaggregation in each one, and projects forwards annually up to 2050. It is frequently applied at national level, in Europe and beyond, as well as for wider (European and global) policy analysis.

The baseline projection, to which the projections in this report are compared, incorporate the Eurostat population forecast available in 2017 and the short-term macroeconomic forecast produced by DG ECFIN in May 2017 (see Cedefop and Eurofound, 2018).

Source: *Cambridge Econometrics (2014)*

For example, countries with large energy sectors, such as Poland, where energy consumption is strongly dominated by the use of coal, are expected to see less of a net gain compared to large fossil fuel importers, such as Germany or France.

These expected outcomes depend on a set of implied assumptions in the modelling.

- The labour force can adapt to the structural change in skill requirements associated with the transition to a low-carbon economy; the faster the change, the more likely it is that there may be frictions that leave some workers unemployed and some demands for new skills unmet, preventing the full potential benefits from being realised.
- There are no barriers in accessing the finance necessary for the investments needed in this transition.
- Countries that currently have a lead in certain sectors are able to maintain it when switching to new technologies; for example, the main manufacturers of conventional cars and trucks become the main manufacturers of electric vehicles and their components.

Policies implemented in the 2-degree scenario

This section outlines the policies implemented in this scenario that would lead to a reduction in emissions on a scale similar to the relevant scenario results published in the IPCC Fifth Assessment Report (IPCC, 2014) and which are therefore consistent with meeting the 2-degree target.

The policies included in this scenario are:

- a carbon emission price – meaning the price paid for the right to emit a certain amount of carbon, which is usually collected as a tax – towards the lower end of the range considered in the Fifth Assessment Report ($155 in constant 2012 values in 2050); the carbon price is set at global level but is applied on a national basis through cap-and-trade systems and/or carbon taxes[5]
- public programmes to fund improvements in the efficiency of energy consumption in households, industry and commerce, consistent with the efficiency improvements included in the International Energy Agency's (IEA's) *World energy investment* report '450 parts per million of CO_2 equivalent' scenario (IEA, 2016); public programmes are funded using revenues from carbon pricing
- a biofuel mandate applied to aviation with the effect that about 18% of aviation fuel is to be derived from biofuels by 2050
- policies that target the highly relevant power generation and road transport sectors (described below)

Power generation policies

In addition to the carbon price, the following power generation policies are imposed to promote the uptake of renewables, particularly wind and solar power.

- Feed-in tarrifs[6] guarantee the price received by renewable electricity producers;[7] this means that the investor is guaranteed to be paid the difference between the electricity price required to recover the investment in renewables over the lifetime of the plant and the market electricity price, on top of which a small profit is added to incentivise the uptake of renewables.
- Direct subsidies, which cover up to 60% of the additional investment cost (although in most cases, 10–15%), provide a further incentive to increase the uptake of renewables across a range of technologies; the subsidies gradually decrease over time.

As wind and solar generation are intermittent power sources, it is assumed that additional investment is required in flexible generation capacity (usually gas) to ensure uninterrupted supply.

In countries for which the above policies do not provide sufficient incentive to prevent continued investment in unabated coal-fired power plants, a mandate is included to prohibit such investment, notably in South Africa after 2020.

The energy scenario does not include specific support for carbon capture and storage (CCS)[8] as there has been limited progress in developing this technology thus far. While some development or retrofitting of fossil plants with CCS is expected, this is driven mainly by the carbon prices that plant operators face.

Road transport policies

In addition to the carbon price, the following road transport policies are imposed to encourage a shift to low-carbon vehicles:

- proportional tax on the registration of vehicles related to their carbon emissions per kilometre
- higher road fuel taxes
- regulation, starting in 2018, to phase out the least fuel-efficient vehicles as they reach the end of their natural life
- limitation of the market share of luxury vehicles in some countries after 2020, as these have large engine sizes and are highly polluting
- introduction in 2020 of electric vehicles by local authorities to advance their diffusion (for example, taxis and public transport); the uptake of electric vehicles in the public sector creates an incentive to progress the implementation of the infrastructure required by these vehicles, such as charging stations

5 The decision was made not to apply a higher carbon price as the modelling indicates that this is ineffective compared with lower-cost alternatives for cutting emissions. The carbon price would have to rise to very high levels to achieve the target and would imply a very large increase in the cost of living for poor households, which would be politically unacceptable.

6 Feed-in tarrifs are a policy mechanism designed to accelerate investment in renewable energy technologies. The policy achieves this by offering long-term contracts to renewable energy producers, typically based on the cost of generation of each technology. Technologies that are more mature, such as wind power and solar photovoltaics, are awarded a lower per-kWh price than other renewable technologies, while technologies that are less mature, such as tidal power, are offered a higher price.

7 In technical terms, this means 100% of the difference between the levelised cost for renewables and the spot price, plus a 10–20% additional incentive to promote renewable uptake (wind and solar only).

8 Carbon capture and storage (or carbon capture and sequestration, or carbon control and sequestration) is the process of capturing waste CO_2 from large point sources, such as fossil fuel power plants, transporting it to a storage site and depositing it where it will not enter the atmosphere.

- setting higher carbon emission standards for new vehicles, including internal combustion vehicles, from 2018 onwards
- introduction of a biofuel mandate[9] in countries where this is required to meet the emissions reduction target

Government revenue

National government budget deficits remain unchanged from the Cedefop baseline. While this scenario includes additional government revenues from carbon pricing mechanisms and vehicle taxes, as well as costs such as investment in energy efficiency, subsidies for renewables and compensation for stranded assets, the overall budget balance is maintained through changes in income tax, social security contributions and value-added tax (VAT) rates, meaning that there is no fiscal stimulus or tightening introduced in the scenario. The balancing is carried out separately for each country.

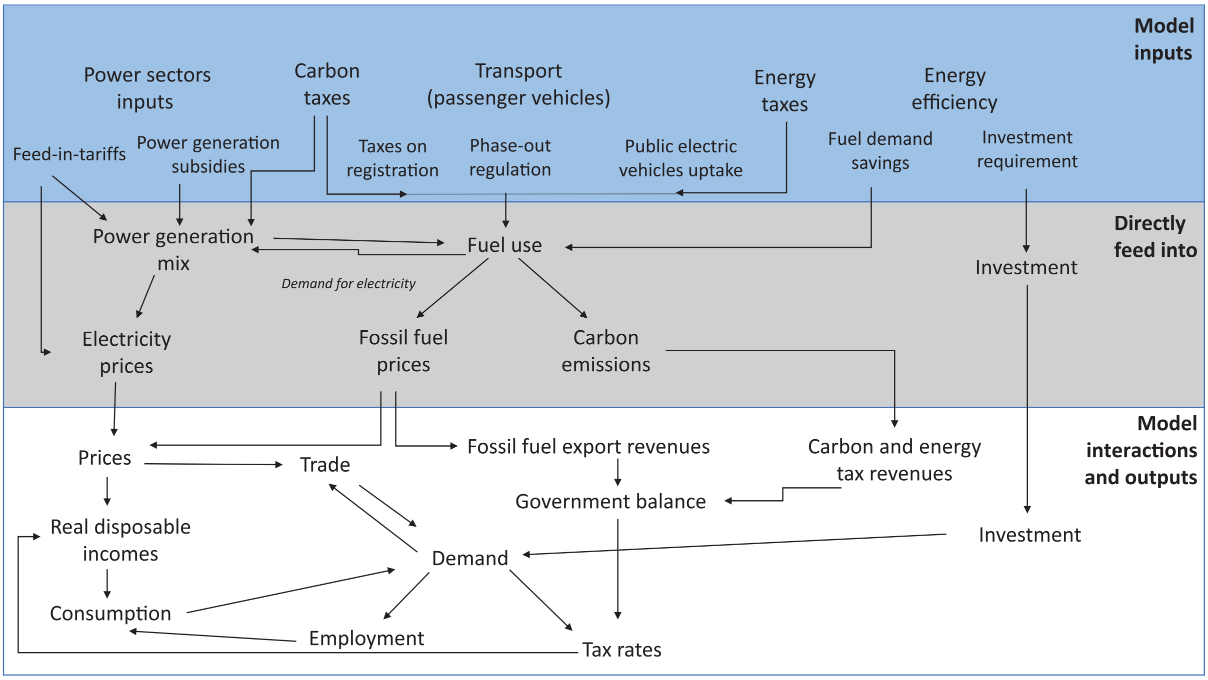
9 This is a policy that increases or maintains rates or levels of biofuel blends in transportation fuel.

Modelling: Technical aspects of the implementation

To model the impacts in E3ME, the policies described earlier are represented by making adjustments to the model's inputs. Figure 1 illustrates the model inputs and how these link to other model variables and shows the economic logic of how changes in policy are expected to impact the economy. Most of the policy inputs in the blue area of Figure 1 directly reduce carbon fuel use. This decline in demand for coal, oil and gas leads to a reduction in the CO_2 emissions produced by combustion. This reduction in demand leads to lower global fossil fuel prices. The main points of feedback between the grey and white areas of Figure 1 are energy prices (electricity and fossil fuel prices), carbon tax revenues and investment. The changes to energy prices affect the overall price level and, hence, real disposable incomes and consumer expenditure.

In the top left corner of Figure 1, the power sector inputs, such as feed-in tariffs and subsidies, mainly impact the power generation mix, as the main purpose of these policies is to encourage renewable uptake in electricity generation. These policies may lead to an increase in electricity prices, unless greater uptake stimulates cost reductions. Changes to the power generation mix reduce demand for conventional fuels – for example, lower use of coal and increased use of solar power – which affects electricity prices. Additionally, carbon taxes also affect the power generation mix and final energy demand for fuels, as they make carbon-intensive fuels more expensive.

Figure 1: Energy scenario inputs and model links



Source: *Authors' own visualisation*

At the centre of the blue panel of Figure 1 are transport sector policies, which serve to discourage the use of inefficient and conventional vehicles in favour of more efficient cars or electric vehicles. The main implication of these policies is that by 2050 most of the global vehicle fleet would be made up of electric vehicles. In the model, the main impact of transport sector policies is on final energy demand by road transport, with demand for petrol and diesel declining in favour of electricity.

Energy efficiency policies, in the top right corner of Figure 1, aim to reduce demand for fuels. For example, more efficient household appliances and better insulated homes lead to less consumption of gas and electricity and, additionally, boost investment associated with energy efficiency activities, such as retrofitting. In this scenario, energy efficiency investment is assumed to be funded by the government through revenues from taxation. Where carbon pricing revenues are not sufficient, income tax and other types of tax may be used. This means that for each year the model looks at the revenues collected from carbon pricing and compares this to the energy efficiency investment requirement. If the revenues are higher than the investment cost, the investment cost is recovered and the surplus revenues are used to reduce taxation. However, should the investment requirement be higher than the carbon revenues, governments increase tax rates to make up the difference.

In the top right corner of Figure 1, the investment in energy efficiency and the electricity supply sector increases demand for the associated domestic and imported goods and services. Any changes to domestic demand and, therefore, production lead to changes in employment, which affect disposable incomes and consumer expenditure. In large fossil-fuel-exporting regions, illustrated in the diagram in the middle of the white block, the government balance is affected by loss of revenue from reduced activity in the extraction and trade of these fossil fuels. In these countries, governments increase taxation to make up for the loss of these revenues.

In the white panel of Figure 1, the interaction shows that changes to prices can affect the competitiveness of each country, insofar as the net impact of the policies on prices varies from one country to another. This in turn affects demand for a country's production.

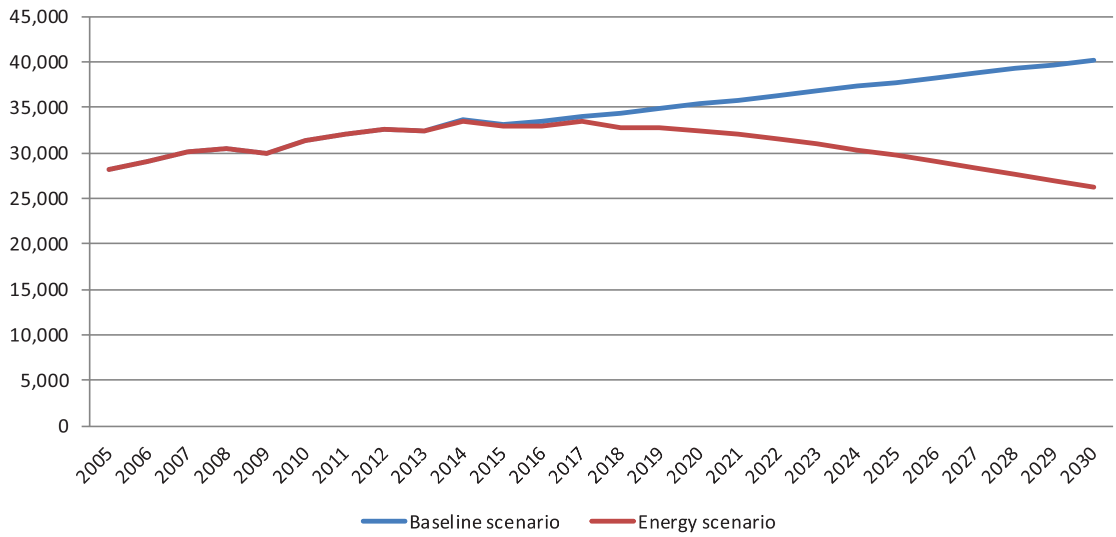
The centre of the white panel indicates that the revenues from carbon taxation feed directly into the government budget balance and, consequently, into tax rate changes. Tax rate changes affect disposable incomes, which in turn affect consumer expenditure and also the demand for consumer goods and services.

Implications for GDP and employment

Global impacts

As seen in Figure 2, the energy scenario expects global CO_2 emissions to fall to a level nearly 35% lower than the baseline by 2030. These results are generally in line with emissions reduction results seen in other research, such as Mitchell et al (2016), IEA (2016) or Peters (2016). A more substantial decrease is expected by 2050. This trajectory for emissions is estimated to have a 66% chance of being sufficient to limit global temperature increase to 2°C.

Figure 2: Global CO_2 pathways, 2005–2029, $MtCO_2$



Source: *FOME energy scenario projections*

Table 1 shows that the EU's CO_2 emissions are expected to be about 20% lower than the baseline level by 2030, while India, the United States and China are expected to see larger reductions. The impact on global GDP may appear small, with a 0.1% increase compared to baseline in 2030, but there are large variations between countries and regions. For example, the EU is expected to see a 1.1% increase in GDP as a result of increased investment activity and lower imports of fossil fuels, compared with a 3.4% decrease in GDP for the United States, driven by reduced oil and gas production activities such as shale gas extraction. China and India are both expected to see an increase in GDP, driven by increased investment into transforming their electricity supply sectors and by energy efficiency policies.

Table 1: Regional summary table, 2030, percentage difference from baseline

	Global (%)	United States (%)	China (%)	India (%)	EU28 (%)
GDP	0.1	−3.4	4.7	0.6	1.1
CO_2	−34.7	−45.5	−26.5	−53.2	−20.3
Employment	0.5	−1.6	2.3	0.1	0.5
Investment	1.0	−2.5	3.2	1.1	1.7
Consumption	0.4	−2.0	11.2	−1.1	0.7

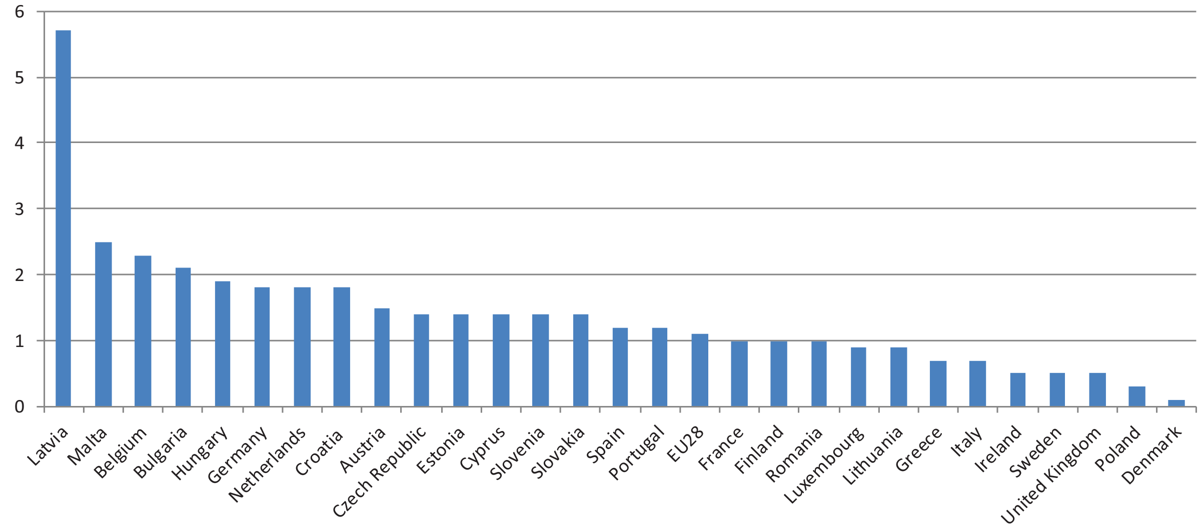
Source: *FOME energy scenario projections*

European Union impacts

Figure 3 summarises the GDP impacts in 2030 for each EU Member State. The key economic drivers are that most EU Member States benefit from additional investment in energy efficiency and renewable power generation as well as lower dependence on fossil fuel imports and lower fossil fuel prices. The impacts are positive in all countries, but show a wide range of effect size. At one extreme, Latvia shows a comparatively large impact due to the large scale of energy efficiency investment and the reduction in fossil fuel imports relative to GDP. At the other extreme, as of 2018, Denmark is already advanced in renewables uptake and energy efficiency, so the additional investment required to meet the CO_2 emissions reduction target is smaller. Poland also has a small GDP impact, but for a different reason. Here, job losses in the country's substantial coal production sector offset gains made in other sectors.

The energy efficiency investment financed by the government is paid for in the same year through taxation. The cost of the investment undertaken by the electricity supply sector is recovered over the lifetime of the plants through electricity prices. For example, the duration of a solar power plant is, on average, 25 years; the electricity supply company commissions the investment to build the plant in the first year but recovers the cost and repays its loan gradually over 25 years. This means that some of the investment is still being paid for in the years after 2030, and the 2030 snapshot does not capture this longer-term effect.

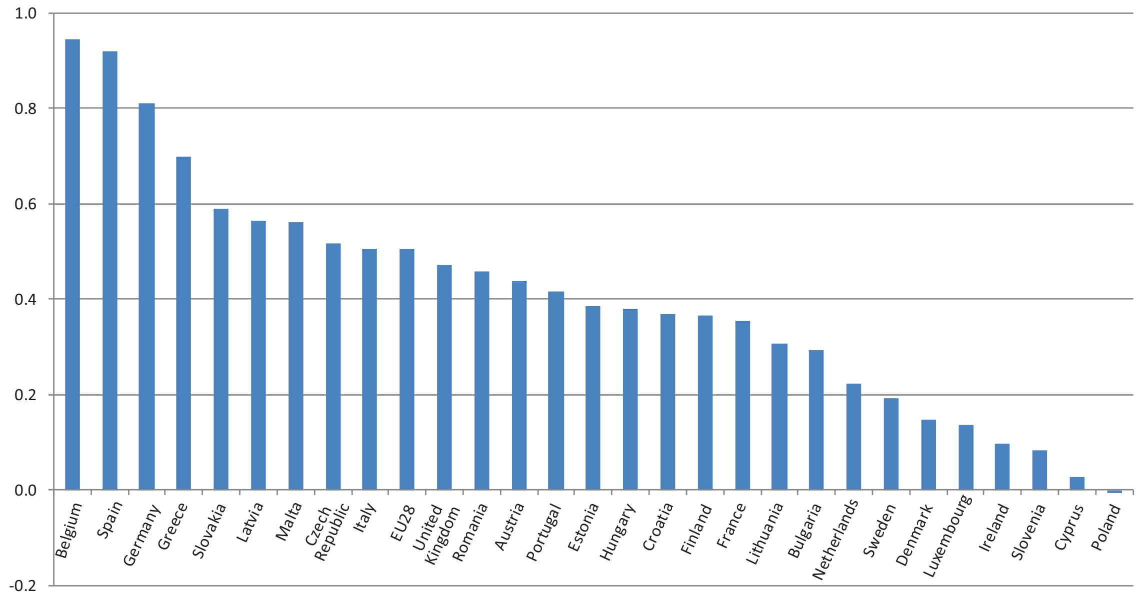
Figure 3: Impact on GDP by country, 2030, percentage difference from baseline



Source: *FOME energy scenario projections*

The employment results by Member States (Figure 4) broadly follow the GDP results, though on a smaller scale. As indicated for the GDP results, the positive impacts are a result of increased investment activity and lower fossil fuel imports, which boost domestic demand, output and employment. EU employment is 0.5% higher in 2030 than in the Cedefop baseline, roughly half the size of the GDP impact. The broadly similar relationship between GDP impact and employment impact is reflected in most countries, with the exception of Spain, Poland, Latvia and Cyprus, which are discussed in more detail below.

Figure 4: Impact on employment by country, 2030, percentage difference from baseline



Source: *FOME energy scenario projections*

Figure 4 shows that Spain expects comparatively high employment growth, which is driven by lower consumer prices. These lower consumer prices are due to the importance of solar photovoltaic electricity and the impact of lower solar electricity prices, which boosts disposable incomes, consumer expenditure and, consequently, the demand for consumer services, which are generally labour intensive.

In contrast, Poland, at the far right-hand side of Figure 4, is the only EU country showing negative employment impact, as its sizeable coal extraction sector expects to see large job losses. At the same time, petrol and electricity prices increase, resulting in a fall in consumer expenditure compared with the baseline. As a result, this offsets the benefits from increased investment in energy efficiency and renewable technologies.

In the case of Latvia, with a 0.6% increase in employment, the impact is relatively modest compared to the GDP increase of nearly 6%; this is because the economic benefits are expected to accrue more to firms in equipment supply than to consumer incomes, so there will be less stimulus for labour-intensive consumer services.

Similarly, Cyprus sees a disproportionately small employment impact compared with the GDP impact, which is due to increased electricity prices resulting from the transition to a low-carbon technology. These increased prices curb the increase in real average wage rates and, as a result, depress consumer expenditure, which is often the main driver of growth in labour-intensive sectors of the economy. The higher prices also lead to a loss of competitiveness, with the country's exports expected to decrease slightly compared to the baseline. For these reasons, the employment impacts are more modest compared to the GDP gains.

EU28 sectoral employment impacts

Employment impacts are expected to vary across sectors, as shown in Table 2.

The mining sector is expected to see a substantial loss of employment in the energy scenario compared to the baseline, reflecting lower production in the energy-extracting sector. In comparison, in the utilities sector, which also sees decreased employment, higher energy efficiency savings lead to lower demand for gas supply and therefore a reduced number of jobs.

Table 2: EU28 sector employment, 2030, percentage difference from baseline

	2030 (%)
Agriculture	0.5
Mining	−16.6
Manufacturing	0.7
Utilities	−2.4
Construction	1.1
Distribution, retail and hotels and catering	0.6
Transport and communications	0.5
Business services	0.7
Non-business services	0.3

Source: *FOME energy scenario projections*

The construction sector is expected to benefit from the higher energy efficiency investment – for example, due to retrofitting – as well as from increased investment by the electricity supply sector into building renewables plants. Generally, manufacturing sectors that are directly linked to, or part of, the supply chain for renewables and energy efficiency equipment are expected to see an increase in employment. However, some of these are also energy-intensive sectors affected by higher carbon taxes, which may dampen some of the initial positive gains.

Services sectors benefit from increased consumer activity but also from being part of the supply chain of renewables and energy efficiency equipment and installation processes. Distribution, retail and hotels and catering benefit from increased consumer expenditure. Most business services are in the supply chains of construction and manufacturing sectors and benefit from increased demand from these sectors. Transport and communications benefit from increased consumer expenditure, reflecting more travel, and also from the transport of consumer goods as well as the transport of construction goods and equipment associated with higher investment.

Implications for occupations, wages and tasks

The methods applied in this section are those developed in various publications based on Eurofound's European Jobs Monitor (EJM) (Eurofound, 2017). The basic methodology, with a wide range of applications, can be found in Fernández-Macías et al (2012). A job is defined as an occupation in a sector. The jobs are ranked by wage and then assigned to wage quintiles. In the analysis below, the job-wage profile of the employment forecasts of the energy scenario are compared to those of the baseline scenario. In addition, Eurofound (2016) developed a detailed measurement of the type of tasks that are performed in these jobs, and a similar comparison of the baseline and the energy scenario is presented below. See the Appendix for a brief description of the EJM methodology.

It is important to emphasise that the wage and task profiles generated by both the baseline and energy scenarios capture only compositional differences. The wage rankings and the identification of the task content of the jobs are defined at the beginning of the forecast period, and the jobs themselves do not vary in any respect over the forecasting period. The change that is reported in wages and tasks is attributable only to the compositional changes in the number employed in these jobs (sectors and occupations). While there is reason to believe that the wage ranking, especially within the quintile aggregation, is in fact rather stable over time, one should be less confident about the stability of the task content.

Before looking at the analysis of these wage and task structures, this section first presents a comparison of the occupational structure in the baseline and energy forecasts.

Occupations

The E3ME model forecasts employment by sector. The shares of the various occupations in employment *within* each sector are assumed to be unchanged between baseline and energy scenarios. This is a simplified assumption in the absence of any robust information about how these patterns might be affected by the scenarios. The projected impacts of the transition towards a low-carbon economy on occupational employment patterns are therefore driven solely by the changes in *sectoral* employment patterns described earlier and the differences between sectors in the shares of the various occupations. However, in practice, one might expect that shifts in the occupational shares within sectors might reinforce the changes shown in Table 3.

Table 3: Projections of occupational employment in baseline and energy scenarios, EU28, 2018–2030

Occupation	Baseline scenario				Energy scenario			
	2018 (000s)	2030 (000s)	Net change (000s)	Growth (% per annum)	2018 (000s)	2030 (000s)	Net change (000s)	Growth (% per annum)
01*. Armed forces	1,196	1,034	−161	−1.2	1,196	1,037	−159	−1.2
11. Chief executives, senior officials and legislators	1,810	1,998	188	0.8	1,812	2,010	198	0.9
12. Administrative and commercial managers	3,816	4,367	551	1.1	3,816	4,387	570	1.2
13. Production and specialised services managers	4,765	5,330	564	0.9	4,767	5,351	584	1.0
14. Hospitality, retail and other services managers	4,254	4,664	410	0.8	4,253	4,703	450	0.8
21. Science and engineering professionals	6,567	7,572	1,005	1.2	6,569	7,600	1,030	1.2
22. Health professionals	5,895	6,218	323	0.4	5,894	6,240	346	0.5
23. Teaching professionals	10,027	9,788	−239	−0.2	10,027	9,812	−215	−0.2
24. Business and administration professionals	8,519	9,882	1,363	1.2	8,518	9,927	1,409	1.3
25. Information and communications technology professionals	3,581	3,976	395	0.9	3,582	4,005	424	0.9
26. Legal, social and cultural professionals	6,051	7,107	1,056	1.3	6,052	7,142	1,090	1.4
31. Science and engineering associate professionals	7,936	8,290	355	0.4	7,941	8,323	383	0.4
32. Health associate professionals	6,219	6,755	536	0.7	6,218	6,782	564	0.7
33. Business and administration associate professionals	16,743	18,415	1,671	0.8	16,745	18,517	1,772	0.8
34. Legal, social, cultural and related associate professionals	5,263	7,495	2,231	3.0	5,263	7,534	2,270	3.0
35. Information and communications technicians	1,897	1,995	98	0.4	1,897	2,009	112	0.5
41. General and keyboard clerks	6,848	6,142	−707	−0.9	6,851	6,180	−671	−0.9
42. Customer services clerks	6,192	7,740	1,548	1.9	6,193	7,786	1,593	1.9
43. Numerical and material recording clerks	7,712	6,860	−852	−1.0	7,714	6,903	−811	−0.9
44. Other clerical support workers	2,828	2,346	−482	−1.5	2,828	2,355	−473	−1.5
51. Personal service workers	11,657	11,905	248	0.2	11,656	11,986	330	0.2
52. Sales workers	16,019	16,599	579	0.3	16,019	16,677	658	0.3
53. Personal care workers	7,884	8,249	365	0.4	7,885	8,268	383	0.4
54. Protective services workers	3,796	3,752	−44	−0.1	3,796	3,774	−22	0.0
61. Market-oriented skilled agricultural workers	7,642	7,094	−548	−0.6	7,647	7,135	−512	−0.6
62. Market-oriented skilled forestry, fishery and hunting workers	378	383	5	0.1	378	385	7	0.2
63. Subsistence farmers, fishers, hunters and gatherers	495	422	−73	−1.3	495	424	−71	−1.3
71. Building and related trades workers, excluding electricians	8,768	9,435	666	0.6	8,794	9,518	725	0.7
72. Metal, machinery and related trades workers	8,187	7,277	−910	−1.0	8,189	7,313	−876	−0.9
73. Handicraft and printing workers	1,208	1,147	−61	−0.4	1,208	1,154	−54	−0.4

(*Continued*)

Table 3: Continued

Occupation	Baseline scenario				Energy scenario			
	2018 (000s)	2030 (000s)	Net change (000s)	Growth (% per annum)	2018 (000s)	2030 (000s)	Net change (000s)	Growth (% per annum)
74. Electrical and electronic trades workers	3,395	3,194	−201	−0.5	3,398	3,210	−188	−0.5
75. Food processing, wood working, garment and other craft and related trades	4,081	3,588	−493	−1.1	4,085	3,615	−470	−1.0
81. Stationary plant and machine operators	5,001	4,971	−29	0.0	5,000	4,967	−33	−0.1
82. Assemblers	1,724	2,123	399	1.7	1,725	2,137	412	1.8
83. Drivers and mobile plant operators	9,443	9,428	−15	0.0	9,451	9,482	30	0.0
91. Cleaners and helpers	10,000	10,859	858	0.7	10,003	10,909	906	0.7
92. Agricultural, forestry and fishery labourers	1,920	2,162	242	1.0	1,921	2,171	250	1.0
93. Labourers in mining, construction, manufacturing and transport	6,673	7,933	1,260	1.5	6,676	7,971	1,295	1.5
94. Food preparation assistants	1,882	1,880	−2	0.0	1,881	1,900	20	0.1
95. Street and related sales and service workers	204	185	−19	−0.8	204	186	−18	−0.8
96. Refuse workers and other elementary workers	2,579	2,671	92	0.3	2,579	2,681	102	0.3
All occupations	**231,056**	**243,232**	**12,176**	**0.4**	**231,127**	**244,464**	**13,338**	**0.5**

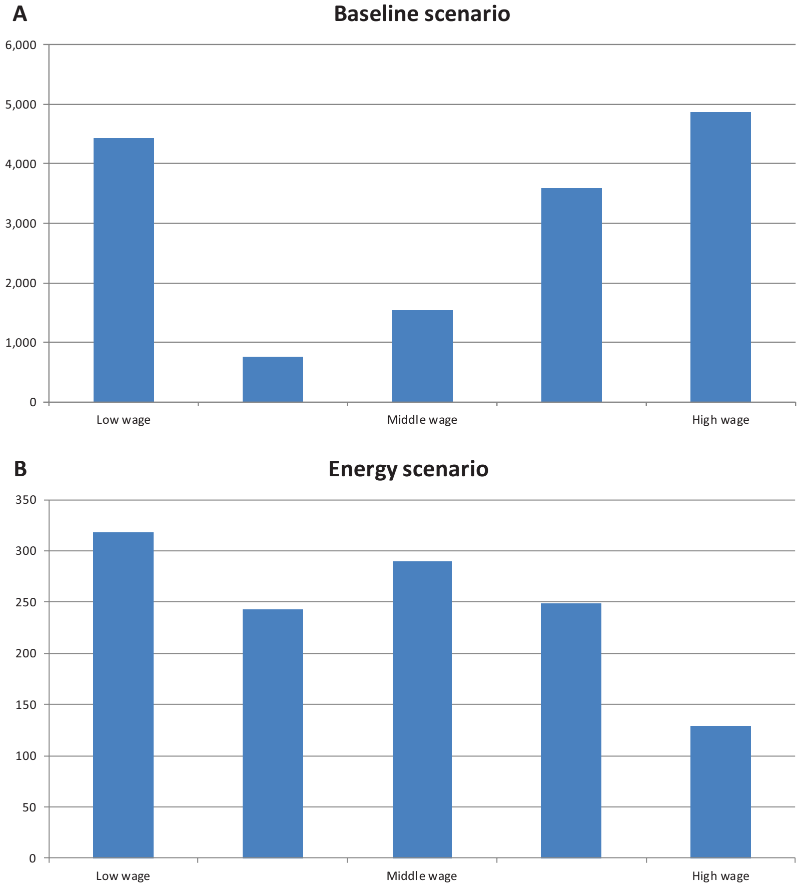
Source: *FOME energy scenario projections*
** ISCO code*

Table 3 shows that the projected patterns of net change in employment by occupation in the energy scenario are very similar to those in the baseline scenario. In terms of annual percentage changes shown to one decimal place, the patterns are virtually identical for both scenarios. However, the sectoral shift in favour of production of investment goods in the EU is reflected in a more positive projection for building and related trades workers and metal, machinery and related trades workers.

Changes in the wage and task structure

The baseline scenario in Figure 5, Panel A projects a rather similar development of the job-wage profile to that during periods of employment growth in Europe both before the recession of 2008 and since 2013. The main difference between the baseline projection up to 2030 and these previous periods is a somewhat more pronounced polarisation in the baseline forecast. Polarisation is taken to mean a stronger growth at the top and bottom wage quintiles than in the middle ones. Of particular note in these baseline projections is a much stronger growth at the bottom than was previously the case. See Eurofound (2018) for a comparison of the baseline forecast to 2030 of job-wage and task profiles with those in previous periods.

Figure 5: Projected job-wage profile in the baseline and energy scenarios, 2015–2030, thousands

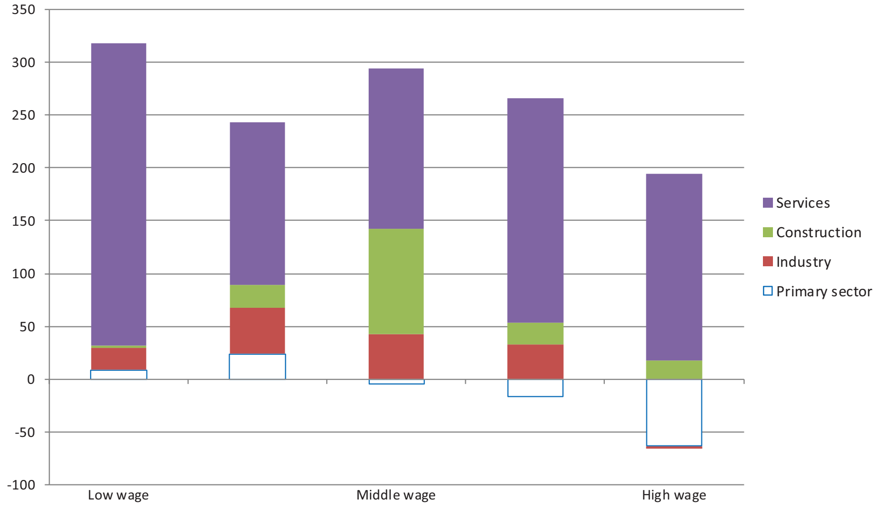


Source: *FOME energy scenario projections and the European Jobs Monitor*

Looking at the additional jobs implied by the energy scenario in Figure 5, Panel B, one notes no such polarisation, not least due to more modest net growth in the top wage quintile. Indeed, most jobs implied in the energy scenario are located in the bottom and middle quintiles.

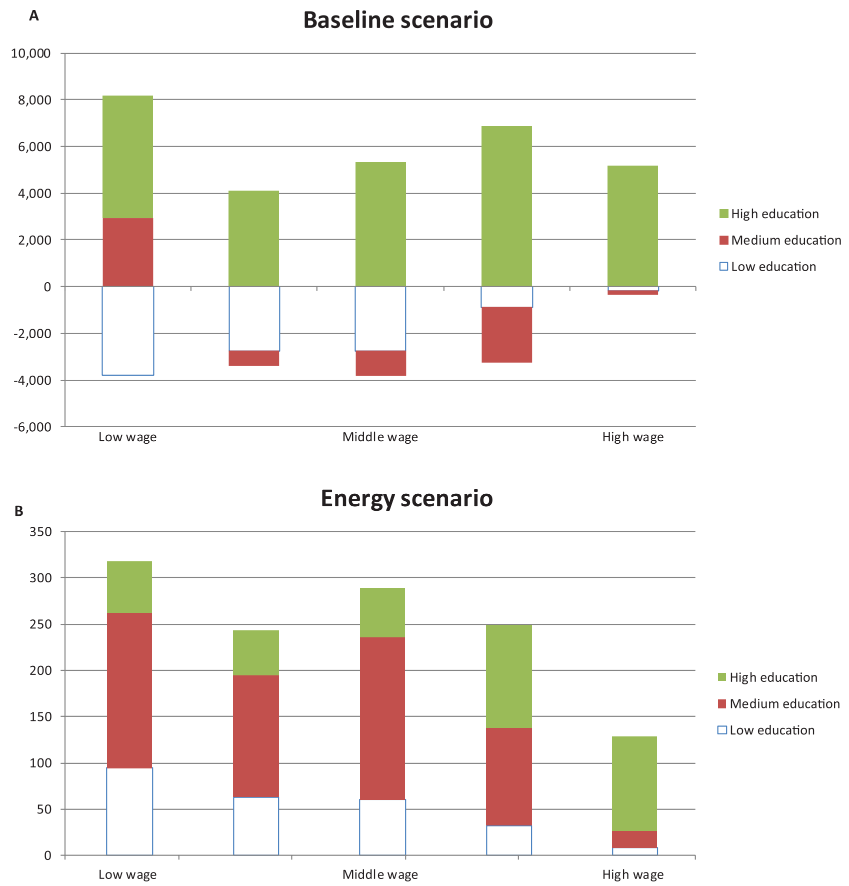
The energy scenario broken down by broad sector (Figure 6) indicates quite clearly why this is the case. The strong growth in the middle is driven by employment in the construction sector (see Table 2), which is typically located in the middle of the wage distribution. This is

Figure 6: Projected job-wage profile in the energy scenario by sector, difference from the baseline, 2015–2030, thousands



Source: *FOME energy scenario projections and the European Jobs Monitor*

Figure 7: Projected job-wage profile in the baseline and energy scenarios, by education level, 2015–2030, thousands



Source: *FOME energy scenario projections and the European Jobs Monitor*

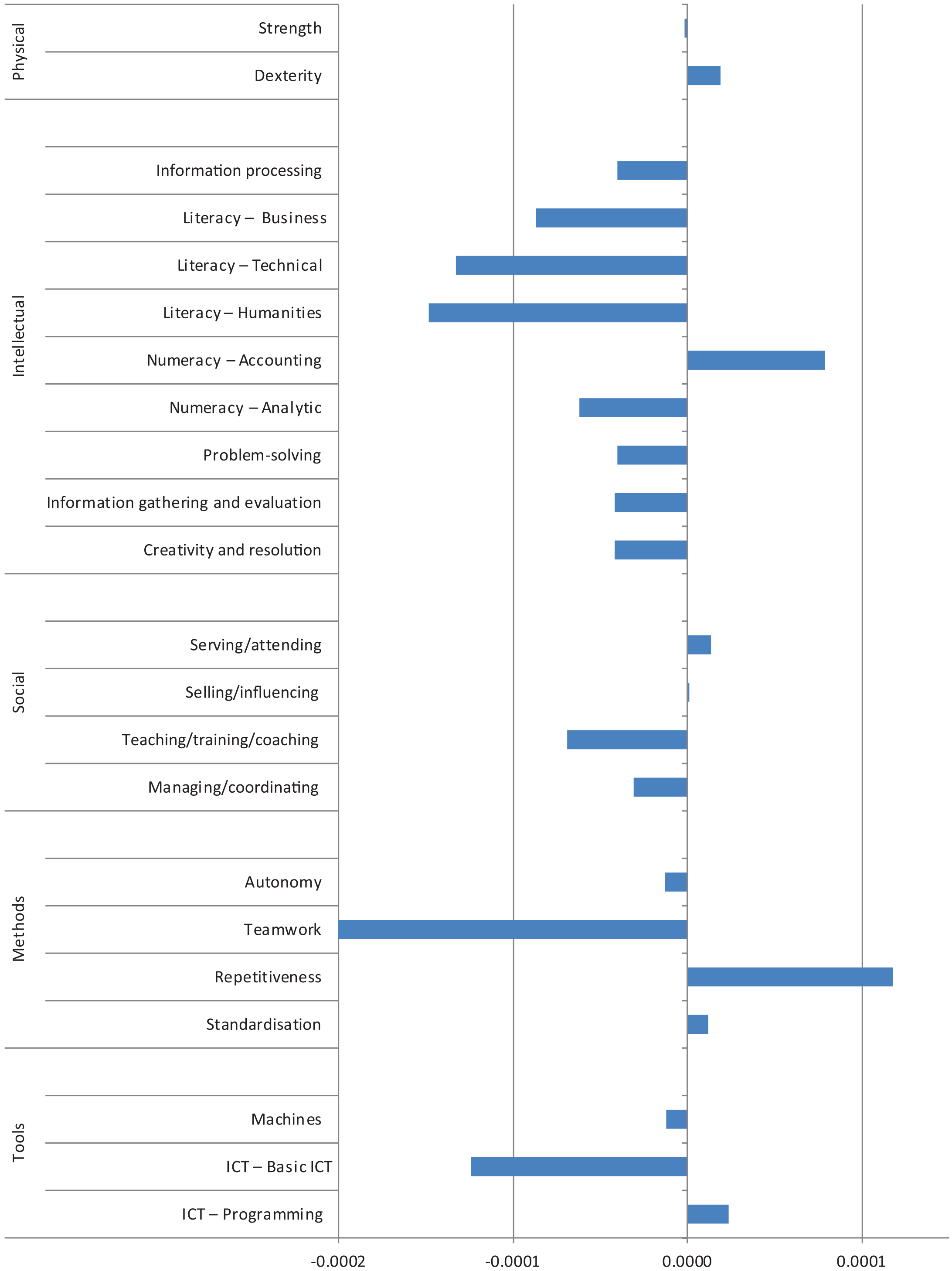
particularly pronounced in Estonia, Hungary, Latvia, Lithuania and Spain. The growth in the bottom wage quintile is mainly due to increased consumer expenditure, a large part of which is spent in the distribution, retail and hotels and catering sector (see Table 2). This is prominent in Austria, Belgium, Sweden and the United Kingdom.

The sector breakdown also indicates that the relatively slow growth in the top wage quintile is attributable to a significant loss of high-paid jobs in the primary sector. This is mainly to be found in the mining sector (predominantly coal) in both the Czech Republic and Poland.

Figure 7 shows that the various developments outlined above are also reflected in the comparison of education level in the baseline and energy scenarios, which shows much more job growth within each quintile at the low and medium education levels than in the high. This is in line with the, admittedly very small, differences between task intensity in the energy scenario compared to the baseline, showing a decline in intellectual tasks, less autonomy and more routine (Figure 8).

So, while overall the energy scenario implies more employment in Europe, much of the employment created is at the bottom and the middle of the wage distribution. These jobs, to a much greater extent than in the baseline scenario, are filled by lower-educated employees and involve the performance of less advanced tasks. However, the changes in the wage and task structure are relatively minor simply due to the fact that the overall employment change is in itself relatively small.

Figure 8: Differences in task intensity in jobs projected by the baseline and energy scenarios, 2015–2030



Source: *FOME energy scenario projections and the European Jobs Monitor*

Concluding remarks

Despite the 2015 Paris Climate Agreement to curtail global warming, data released at the end of 2018 show that carbon emissions are now accelerating at their fastest pace in seven years. The data, published in the scientific journals *Nature, Earth System Science Data* and *Environment Research Letters*, suggest that global peak emission is not yet in sight. The surge in 2018 was mainly due to developments in China, where coal consumption continues to grow, despite its decline elsewhere. Globally, oil and gas consumption continues to grow (see Le Quéré et al, 2018).

Climate change is expected to have very serious implications for living and working conditions both globally and in the EU. Moreover, it is people who are socially, economically or otherwise marginalised that are particularly vulnerable. This may be pensioners left on their own during a heatwave or employees that spend most of their days outdoors. Overall, the poor will be most affected by higher food prices due to falling crop yields, and it is the poor that suffer most from natural disasters. Climate change could also lead to unprecedented mass evacuation of people from poor countries that would dwarf recent migration into Europe.

If these are the costs of limited action on the Paris Agreement, what then are the economic consequences of its full observance? In the scenarios presented here, we investigated the impact of policies likely to limit the temperature increase to below 2°C. Achieving this target requires stronger climate policies than are currently in place and a different technological trajectory than can be expected under business as usual.

The modelling showed that the transition to a low-carbon economy is positive for the EU as a whole, both in terms of GDP and employment growth. This is mainly attributable to the investment activity required to achieve such a transition, together with the impact of lower spending on the import of fossil fuels. The shift towards production of capital goods, such as equipment, machinery and buildings, results in an increased demand for construction and for labour from the associated occupations as well as increased demand for metal and machinery, and related labour. The various estimates presented were compared to a largely business-as-usual baseline forecast up to 2030. In the EU, GDP and employment show growth of 1.1% and 0.5% respectively. The most positive results in both these respects are found in China and Europe. The United States, however, experiences a drop in GDP of 3.4%, with employment falling by 1.6%.

While overall the energy scenario implies more employment in Europe, much of the employment created is at the bottom and the middle of the wage distribution. These jobs, to a greater extent than in the baseline forecast, will be filled by lower-educated employees and involve the performance of less advanced tasks.

The positive projected results for employment in Europe assume issues of particular relevance for employment, finance and industrial policy. Firstly, the model assumes no labour market frictions. The faster the change, the more likely it is that there may be frictions that leave some workers unemployed and some demands for new skills unmet, preventing the full potential benefits from being realised. Moreover, the appreciable investment required assumes that there are no barriers in accessing the finance necessary for this transition. Finally, it is assumed that countries that currently have a lead in certain sectors are able to maintain it when switching to new technologies; for example, the main manufacturers of conventional cars and trucks become the main manufacturers of electric vehicles and their components.

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Appendix: The wage and task structure methodology of the European Jobs Monitor

In the European Jobs Monitor, a job is defined as an occupation in a sector, as in the standard international classifications of occupation (ISCO-08) and sector (NACE Rev 2.0) at two-digit level. The number of jobs so defined varies from 400 in the smaller Member States, to just over 2,000 in the larger ones. As this framework of jobs is empirically defined by standard statistical classification, a further description of these jobs can be added using data from a variety of sources that follow these standard classifications of occupations and sectors. Most of the previous Eurofound research focused on the average wage corresponding to these jobs, which is a useful metric for capturing some of the characteristics and drivers of recent and future structural change in Europe. The wage data are compiled by combining data from the EU Labour Force Survey and the Structure of Earnings Survey (SES). The jobs are ranked from the highest to the lowest wage in each Member State. They are then allocated to quintiles based on the job-wage ranking for that Member State. Each quintile in each country represents 20% of employment at the starting period. The job-to-quintile assignments remain fixed over time so that the charts presented map the growth of jobs assigned to that quintile at the start of each period of observation.

More recently, Eurofound (2016) developed a detailed measurement of the type of tasks that are performed in these jobs (see Table A1). The content part of the task framework is mainly related to what is being produced and varies by economic sector. It identifies three main classifications of task content: physical, intellectual and social, each with various sub-indicators. The methods and tools of work, on the other hand, are determined more by the technological and social organisation of production and may be more dependent on institutional and historical factors.

Using data from various international sources – Eurofound's European Working Conditions Survey, the OECD Survey of Adult Skills (PIAAC), the United States O*NET database and the EU Labour Force Survey – Eurofound (2016) constructed a database containing scores for all the elements listed in Table A1 for all jobs; that is, for all two-digit occupation-by-sector combinations in Europe. Such detailed data are either not available in some Member States or are available only for small sample sizes that are insufficient for a reliable measurement of tasks at country level. For this reason, the task indices are an aggregate measure based on data from 15 Member States (EU15). This was not the case with the wage data, which are country specific. While of course country-specific data would be preferable, one might expect that very many jobs entail very similar tasks in all European countries.

Table A1: A classification of tasks according to their content and methods

A. In terms of the content:	B. In terms of the methods and tools of work:
1. **Physical tasks:** aimed at the physical manipulation and transformation of material things: *a. Strength* *b. Dexterity* 2. **Intellectual tasks:** aimed at the manipulation and transformation of information and the active resolution of complex problems: *a. Information processing:* I. Literacy: i. Business ii. Technical iii. Humanities II. Numeracy i. Accounting ii. Analytic *b. Problem-solving* I. Information gathering and evaluation of complex information II. Creativity and resolution 3. **Social tasks:** primary aim is interaction with other people: *a. Serving/attending* *b. Teaching/training/coaching* *c. Selling/influencing* *d. Managing/coordinating*	1. **Methods:** forms of work organisation used in performing tasks: *a. Autonomy* *b. Teamwork* *c. Routine* I. Repetitiveness II. Standardisation 2. **Tools:** type of technology used at work: *a. Machines* (excluding information and communication technologies) *b. Information and communication technologies* I. Basic information and communication technologies II. Programming

Source: *Eurofound (2016)*

TJ-06-18-407-EN-N

This report explores the potential employment and economic impacts of an EU transition to a low-carbon economy by 2030 – on the EU, and on other regions of the world. It analyses the impacts across sectors and occupations, with a particular focus on manufacturing.

The report highlights that the impact of such a transition is positive for the EU as a whole, although with considerable variation between sectors. The positive impact on employment is largely due to the investment required to achieve this transition, along with the impact of lower spending on imported fossil fuels. The consequent shift in production has implications for labour market demand.

The analysis is carried out using the E3ME macro-econometric model, which provides information on sectoral impacts, together with the Warwick Labour Market Extension model for occupational analysis. Further analysis of the employment developments in Europe is undertaken using Eurofound's European Jobs Monitor.

The European Foundation for the Improvement of Living and Working Conditions (Eurofound) is a tripartite European Union Agency whose role is to provide knowledge in the area of social, employment and work-related policies. Eurofound was established in 1975 by Council Regulation (EEC) No. 1365/75 to contribute to the planning and design of better living and working conditions in Europe.

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