Studies on Sustainability Issues – Green Jobs; Trade and Labour

Final Report for the European Commission, DG Employment

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PROGRESS

This report is commissioned under the European Community Programme for Employment and Social Solidarity - PROGRESS (2007-2013).

This programme is managed by the Directorate-General for Employment, social affairs and equal opportunities of the European Commission. It was established to financially support the implementation of the objectives of the European Union in the employment and social affairs area, as set out in the Social Agenda, and thereby contribute to the achievement of the Lisbon Strategy goals in these fields.

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- providing analysis and policy advice on PROGRESS policy areas;
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- relaying the views of the stakeholders and society at large.

For more information see:

http://ec.europa.eu/employment_social/progress/index_en.htm

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Executive Summary

Objectives and method

- This report presents the results of the project Studies on Sustainability Issues – Green Jobs; Trade and Labour (contract no.: VC/2010/0012), commissioned by the European Commission, DG Employment.
- The leading objective of this study has been to analyse the employment consequences of the implementation of policies to achieve the key EU environmental targets of a 20% cut in emissions of greenhouse gases by 2020 compared to 1990 levels (increasing to 30% if other countries make similar commitments), a 20% increase in the share of renewable energy, and the objective of a 20% cut in energy consumption (the 20-20-20 targets). The analysis considers the composition, quantity and quality of employment, and the effects of any policies aimed at mitigating any negative labour market impacts.
- The main quantitative element of this study has been developed using a version of Cambridge Econometrics' E3ME, energy-environment-economy model for Europe, that is extended to take into account occupation and skills dimensions. The modelling work has been supplemented by specific analysis in particular cases where a greater level of detail is required.
- This Executive Summary follows the structure of the main report, so that the supporting evidence for the points made here can be readily found in the relevant chapters of the main report.

Chapter 2: Lessons from previous studies

- The findings of the substantial literature review undertaken for this study suggest that after an initial cost to the EU economy to make the switch to a greener economy (i.e. implementation of the EU 20-20-20 targets), over the longer term, most studies indicate a modest positive outcome for GDP growth and employment increasing by around 1-1.5% (in net terms) by 2020.
- When looking at specific policies and areas, these impacts are much more differentiated. Some energy-intensive or high-GHG emitting sectors, such as iron, steel, cement and petroleum, are expected to experience a decrease in employment. Sectors such as construction and transport, and those in which Europe can gain and maintain a leading edge in export markets (e.g. renewables, environmental technology) are predicted to witness an increase in jobs by 2020 as a result of the policies.
- A unified and coordinated policy approach adopted within the EU (Emission Trading Scheme), globally (G8, Kyoto Protocol) or across industry sectors (sectoral agreements to mitigate carbon leakage) was deemed to be the least cost approach to achieving environmental and climate change targets. As part of this approach, the setting of a global carbon price was found to be crucial for lowering implementation costs and maximising positive employment impacts. Burden sharing is important to prevent negative employment impacts occurring in specific countries or sectors (i.e. through sectoral agreements, Clean Development Mechanisms (CDMs), investment in different renewable technologies). In this regard, support and targets should reflect country and industry differences.
- Measures to support innovation (often driven by regulation) can have substantial positive employment impacts. Revenue recycling of green tax revenues was found

to achieve the best employment and GDP outcomes when used to subsidise low-carbon technologies (not employment). Developing new technologies with environmental performance credentials not only contributes to energy and resource efficiency, but can also directly generate EU jobs where these technologies give EU companies a leading edge in manufacture/distribution, and drive further innovation.

- The effect of environmental legislation and the drive towards a low-carbon economy may involve or result in skills shortages but this is not specific to any one sector. Skills profiles are changing across the economy as a whole and retraining is needed both in technical and managerial occupations. Where skills shortages are specific to a certain sector, training can effectively be provided by sectoral or regional agencies but often cross-sectoral training is needed for green occupations, which are often 'hybrid', incorporating skills from various sectors and professions.
- The country case studies show that, to date, there has been limited integration between environmental policies and labour market policies. The key issue for policy makers contemplating attempts to integrate environmental policy with employment policy is the uncertainty attached to employment and skill demand emanating from the pursuit of policies to reduce carbon emissions. The dangers of too tightly aligning environmental and employment policy relates to making the wrong decisions, such as the State investing in training programmes which produce the wrong type of skills, or engaging in training activities which companies would have engaged in any case.

Chapter 3: Model-based assessment of impacts

- In order to evaluate the labour market impacts of the transition to a low-carbon and energy-efficient economy, a Baseline (a case in which there is some shift towards lower carbon intensity but in which the 20% CO_2 reduction target is not met) and a set of policy scenarios was defined, based on the 2020 EU targets for renewables and reductions in greenhouse gas emissions. These scenarios were assessed using the macroeconometric E3ME model, which integrates Europe's energy demands and emissions with the wider economy.
- The model results showed that, at the aggregate level, the policies had only a marginal impact on GDP and very little impact on total employment levels. The investment required to meet the renewables target and the energy-efficiency objective is likely to result in an increase in employment, while the effects of higher energy prices is likely to depress economic activity and employment. The use of revenues from market-based instruments (MBIs) to offset other taxes, or to finance investment in energy-saving equipment, could have positive economic, social and/or labour market benefits.
- At the NACE 2-digit sectoral level, the restructuring of the economy that is expected to occur over the decade to 2020 in the Baseline is quite substantial. This restructuring reflects the impact of carbon mitigation policies, but also includes the impact of other trends in economic development (notably increased globalisation and continued technological progress).
- The restructuring impacts of the *additional* policies tested in the modelling to achieve more stringent targets are, by comparison, quite modest at the 2-digit sectoral level. The outcomes from the scenarios suggest a small increase in jobs in the construction and engineering sectors in the period up to 2020 and a reduction in the energy supplying sectors. The results for the energy-intensive sectors are

unclear; some could lose out due to competitiveness effects, while some feature in the value chains of investment goods so could benefit. At this level, however, the impacts of the environmental policies are small in scale, especially when compared to the recession.

- When the model results are broken down by occupation and qualification there is almost no discernible impact of the policies. This could be partly because changes due to environmental legislation, such as the ETS, are already taking place and are included in the Baseline or it could be that the effects are too small to see at this level of aggregation.
- In case there are detailed effects that are being missed at the level of aggregation used by the modelling, a mismatch scenario was defined in which 0.5% of the labour force was unable to work due to lack of relevant skills. This was found to lead to a modest reduction in GDP and employment by 2020, due to the effects of higher wage demands (and implied lack of competitiveness) by the remaining part of the workforce.

Chapter 4: The type and quality of green jobs

- The general direction of occupational change in the labour market is towards an increase in the number of relatively high and low skilled jobs (as revealed under the Baseline Scenario). The more investments are made in new technologies – many of which are likely to be energy saving or related to new forms of energy generation – the more demand there will be for people in higher skilled jobs (especially professional and associate professional ones). In this way, the greening of the economy can stimulate the demand for highly skilled (and high waged) workers, although the extent to which this will occur even under the most optimistic of scenarios is relatively modest when compared to the Baseline Scenario.
- It is 'Green Increased Demand' jobs, in particular, that are likely to show significant growth over the medium term. Many of these jobs are associated with relatively high quality employment, especially in relation to managerial / professional / associate professional occupations. But there is also evidence to suggest that some of the green jobs are in occupations which are associated with lower quality jobs.
- In the case of 'Green Enhanced Skills' jobs, the acquisition of green skills enhances rather than changes the existing skill set. The job content is not being substantially altered. Hence, at least over the short term, the greening of the economy is unlikely to have a dramatic impact on the various dimensions of job quality.
- However, given the scale of structural and occupational change expected to occur over the long term as a consequence of policies introduced to manage climate change, there is every reason to expect that there will be some change in the quality of work. The extent and direction of this change is ultimately dependent upon the extent of structural change and the degree to which it leads to the creation of jobs in new sectors.
- In the longer term, insofar as the greening of the economy stimulates the demand for higher skilled jobs, this is likely to have a positive impact on job quality. In general, the higher the level of skill (or qualification) associated with an occupation, the higher the job quality. But it is also true that there are some lower

skilled occupations which are associated with relatively high levels of job quality which will be adversely affected (such as office clerks). The projections of future employment growth suggest that those policies which are likely to result in increased technical change will drive up the demand for green skills of one kind or another over and above the already substantial increase that is likely to occur under the Baseline scenario.

- Whilst the greening of the economy is associated with the expansion in employment of some high quality, high skilled jobs, some groups appear to have less access to green jobs than others. There is prima facie evidence that women and young people are less likely to be employed in green jobs. This may change over the medium term as the increase in demand for people to work in green jobs results in a widening of access, especially if supply struggles to keep pace with demand.

Chapter 5: Analysis of specific issues

- A series of small case studies was carried out to consider the impacts of environmental policies on a key set of industries defined at the NACE 4-digit level. This included industries that could be expected to see a decline in production and industries that may demand additional skills to meet production needs. The findings were that in most cases the green transition required a subtle shift in existing jobs rather than a large-scale change in the types of jobs required. In some cases, such as the car industry, companies were able to provide the training required to bring about this shift.
- The creation of 'bottlenecks' where supply-side constraints limit production has the potential to reduce EU output in key growth sectors. Bottlenecks can arise from limitations in skills, in technology or in other factors of production. The most likely occurrence of bottlenecks due to skills is if key sectors start competing for scarce skills resources, some of which could be in sectors that already have tight labour markets. Policies to encourage mobility of labour, both between sectors and between geographical regions, could alleviate any potential bottlenecks.
- Geographical labour mobility is also an issue in cases where communities are dependent on a single employer that could be vulnerable to environmental policy and international competition. The findings from the analysis suggest that the problems caused by such a structural shock can prove to be quite intractable for policy to address.
- The modelling results provide insight to other social issues. Although unemployment tends to fall slightly as a result of the policies, the costs of reducing emissions can fall disproportionately on low-income households and vulnerable socio-economic groups (primarily as they spend a larger share of income on heating fuels). However, if the environmental targets are met through the use of MBIs, a share of the revenues can be used to offset this effect to mitigate the impact.

Chapter 6: Designing policy to limit adverse effects on Europe's labour markets

Environmental policy

- All of the analysis presented in this study shows that the labour market impacts of climate change mitigation policies mostly depend on the scale of the impact on *economic activity and the associated restructuring of industry* (by sector and within sectors). Consequently, the goal of limiting negative *labour market* impacts has many of the same implications for the design of environmental policy as the goal of limiting negative impacts on *economic activity*.
- The most important issue is probably that of *uncertainty in the policy regime*, and particularly the price of ETS allowances in the long term. Many of the actions that firms and individuals need to take to facilitate the shift to a low-carbon economy require investment of capital, R&D resources, training resources and time. Uncertainty about the policy environment can act as a particularly severe deterrent to investment. The result may be unnecessarily high energy prices and loss of economic activity and jobs, a failure to develop European capacity in the supply of 'green' goods and services sufficiently rapidly so that the associated economic activity is lost to imports from the rest of the world, and a larger pool of labour with skills that are not matched to new circumstances.
- An *inadequately functioning energy market* could allow energy suppliers to adopt technology solutions that are not least-cost and require consumers to pay the cost, or allow energy suppliers to make excess profits. Consequently, the costs of adjustment to energy users, including the labour market impact, will be correspondingly higher.
- Some of the actions required to move towards a low-carbon economy offer the prospect of creating a substantial number of jobs because the associated activities are *labour intensive*. But the *market failures* that need to be addressed are not limited to the low cost of carbon. An example is the renovation of the energy-using characteristics of existing buildings, where the market failure is associated with the difference in interests between owners and tenants.
- The transition to a reduced size and lower carbon intensity of industries producing carbon-intensive products carries the risk of an excessive loss of activity, and hence employment in energy-intensive industries across Europe, if *carbon leakage* is severe. Clearly international negotiations to achieve a common approach to sectors where energy costs are a large proportion of total costs are a high priority, even if the aggregate labour market impact is unlikely to be large. However, the decision by companies to relocate production away from the EU may be related to other factors such as access to markets or raw materials or secure access to energy sources with long-term price guarantees.

Labour market policy

- Since the labour market impacts associated with the shift to a low-carbon economy represent a particular form of restructuring among industries, within industries, across geographies and among skill types, *the general importance of labour market flexibility to respond to restructuring of any kind is reinforced*.

- The key priorities for managing the labour market aspects of the transition are:
  - the renewables sector has the skills it needs to develop in the future
  - the final energy users have the skills which will allow them to transform their products and processes in the light of EU and national policies to reduce carbon emissions, such that employment growth opportunities are not jeopardised
  - the direction of change enhances rather than worsens the quality of work
  - vulnerable groups are not further excluded as a consequence of the changes highlighted above simultaneously (notably a further shift in favour of higher-skilled jobs)
- There are four interrelated sets of policy at play here: (a) energy/environment policy; (b) employment policy; (c) skills policy; and (d) social policy. Although the notion that an integrated view should be taken across these policy areas has a natural appeal, it may be unrealistic to expect this in practice. We have not found successful examples in Member States of such integration. This seems to reflect the considerable uncertainties about the nature of the changes in demand for specific skills that will arise in the transition, so that *it is not feasible for governments to predict and provide for those changes*. Instead, a realistic approach is *to devise energy or climate change policy as required*, and then *to ensure that employment systems are able read the signals and respond in a timely fashion*.
- Different Member States have developed their own ways of dealing with change in labour market conditions, and it is not straightforward to transplant a system from one country to another. We distinguish four different models of social systems (including labour market arrangements) that appear to be sustainable (in the sense that they can be maintained over the long term). Over the short to medium term Member States are unlikely to change the orientation of their employment systems, so EU policy has to work to play a useful role within these various systems. While it is not easy to transfer policy across Member States, there is nonetheless the capacity to learn from the successes, and failures, of Member States which have adopted different policy approaches.

Other policy areas

- We review the contribution that could be made by policy actions in a number of different policy areas, organised in the structure of the Eurostat Sustainable Development Indicators. Mostly these are of a second order of importance. The most important, from the perspective of achieving better economic and labour market outcomes, is the importance of *innovation*, which applies in the field of the technologies required to produce energy efficiently from low-carbon sources, but also in the field of the production of energy-efficiency solutions for industry, transport and buildings. Innovation policy therefore has a key role to play in the period up to 2020. This includes providing research funding to support new technologies at an early stage, creating a more attractive climate for innovation by reducing policy uncertainty, and supporting specific demonstration projects for technologies that are close to market.

1 Introduction

1.1 Study objectives

This report presents the results of the project Studies on Sustainability Issues – Green Jobs; Trade and Labour (contract no.: VC/2010/0012), commissioned by the European Commission, DG Employment.

As set out in the original Terms of Reference, the leading objective of this study is to analyse the employment consequences of the implementation of policies to achieve the key EU environmental targets of a 20% cut in emissions of greenhouse gases by 2020 compared to 1990 levels (increasing to 30% if other countries make similar commitments), an increase in the share of renewable energy to 20%, and the objective of a 20% cut in energy consumption (the 20-20-20 targets). The analysis considers the composition, quantity and quality of employment, and the effects of any policies aimed at mitigating any negative labour market impacts.

1.2 Our approach

Our approach to this study has been to undertake model-based analysis, and where the model does not yield sufficient detail we have also undertaken supplementary reviews of evidence and specific analyses of particular cases. Figure 1.1 provides an overview of the modelling framework that was used and how environmental policy fits into it.

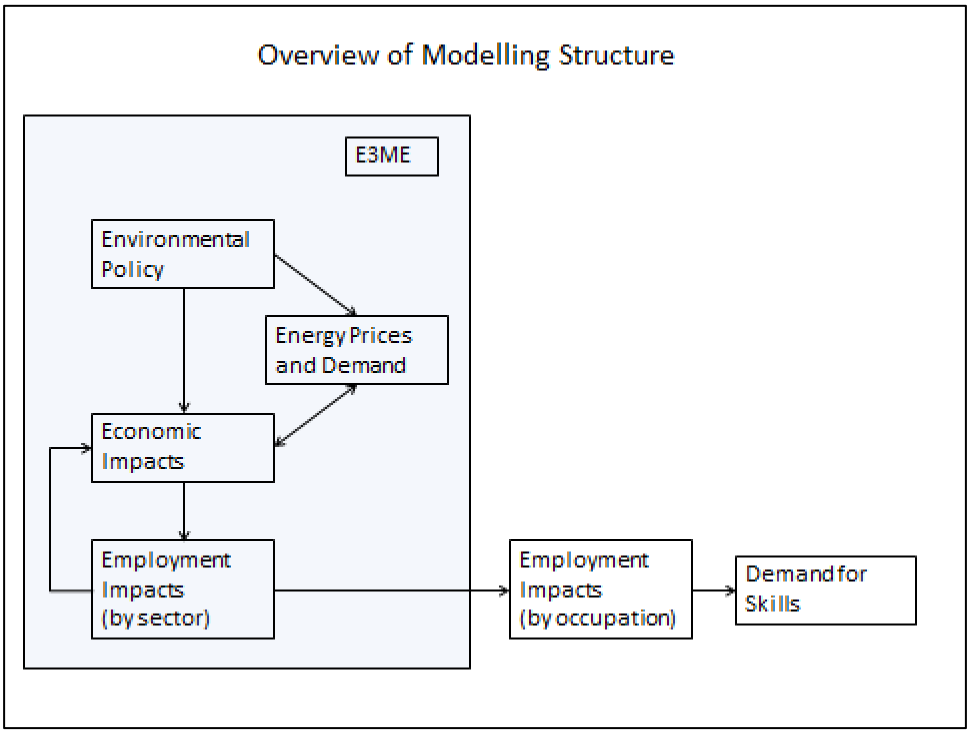
For the model-based analysis, we used a version of the E3ME, energy-environment-economy model for Europe that is extended to take into account occupation and skills dimensions. The advantage of using computer-based economic models is that, in principle, they automatically provide and quantify the linkages between parts of the economy, between economic sectors and between countries (to the extent that it is possible to formally model these relationships). E3ME was used to establish a Baseline set of projections and to then perform scenario analyses; to assess the impacts of the policies designed to meet the 2020 targets; to investigate alternative uses of revenues from market-based instruments; and to investigate the sensitivity of the model results to key assumptions.

Supplementary analysis has been undertaken for cases when the model does not go into enough sectoral detail (typically it operates at NACE 2-digit level) and for aspects that the model cannot adequately cover, such as quality of jobs, or impacts on vulnerable groups.

Further information about the E3ME model can be found at www.e3me.com. The extension of the model to cover occupations and skills is described in CEDEFOP (2010e).

The core team is thankful for inputs to the study from an external panel of experts, including contributions to the literature review, scenario design and interpretation of the main findings. These inputs have been reflected as much as possible in the content of this report.

Figure 1.1: Overview of Modelling Structure



1.3 Structure of this report

The lessons from previous studies, summarising the substantial literature review undertaken for this study, are presented in Chapter 2. The results from the model-based analysis are presented in Chapter 3. In Chapter 4 an assessment of the impact of environmental policies on the quality of work and jobs is presented. The results of supplementary, specific analyses are presented in Chapter 5. Chapter 6 presents the policy analysis and recommendations.

In Appendix A a detailed description of the E3ME model is given, while Appendix B provides further details of the treatment of the labour market within the model. Appendix C presents detailed modelling results for 2020. Finally, Appendix D describes how the quality of jobs is measured.

2 Lessons from Previous Studies

2.1 Introduction

This chapter summarises the findings of the substantial literature review undertaken for the study. In addition, it includes the findings of five brief country case studies (Denmark, Sweden, Germany, Spain and the UK) that investigate the nature of integration between environmental policies and labour market polices.

The aims of the literature review

The literature review aimed to:

- **identify the key challenges** posed by the move towards a greener, low-carbon, economy (both policy driven and more generally), especially those relating to the labour market
- **help fine tune** the assumptions to be used in developing the modelling scenarios, which in turn will aid the development of future policies that promote transition towards a low-carbon economy, while minimising economic and social costs

The scope of the review

A comprehensive analysis of the literature was undertaken, the scope of which included all policy areas relevant to the Europe 2020 and 20-20-20 agenda. This holistic approach included emissions pricing, resource efficiency, clean energy and natural environment domains and supporting measures specific to agriculture, transport, eco-design, industrial emissions, buildings, etc. Finally a review of financial support mechanisms was conducted, including green elements of Member State stimulus packages, EU funding under Framework Programme 7, cohesion funds and environmental funds such as LIFE+.

Consequently, a broad range of literature was collected amounting to over 200 leading articles, studies and reports investigating the linkages between climate change policies and their impacts on employment and the labour market more generally. Following a screening of the literature to identify those studies of most relevance, 13 global studies, 33 European studies and numerous Member State and sectoral case study documents were identified and evaluated. This literature included:

- European Commission studies from DGs Environment, Employment, Climate, Move and Energy
- Member State publications by government authorities
- research produced by international organisations (WWF, ILO, UNEP, etc.)
- independent research by academia and consultants
- publications from third countries in EFTA/EEA, USA, etc.
- industry literature

To simplify the analysis, each study was grouped by scope as either global, European, national or sectoral. The results are presented on this basis.

2.2 Literature review findings

Scale of impacts and policy findings

The findings of the literature review suggest that after an initial cost to the EU from switching to a greener economy (i.e. implementation of the EU 20-20-20 targets), over the longer term most studies indicate a modest positive outcome for GDP growth and employment, increasing by around 1-1.5% (in net terms) by 2020. When looking at specific policies and areas, these impacts are much more differentiated, with some sectors such as iron, steel, cement and petroleum experiencing a decrease in employment and sectors such as renewables, construction and transport witnessing positive jobs growth by 2020. Table 2.1 provides a summary of the leading results from the studies assessed, including a description of the policy area and scope of the study in question.

Across the various studies, the most consistently reported findings include:

- Energy-efficiency measures, renewable energy polices and associated investment appear to have the most significant positive impacts on employment and GDP growth across Member States and the EU as a whole. A policy mix to include a broad range of coherent measures is therefore foreseen as optimal (i.e. should include market-based and command and control measures).
- Revenue recycling of green tax revenues was found to achieve the best employment and GDP outcomes when used to subsidise low-carbon technologies (not employment).
- A unified and coordinated policy approach adopted within the EU (Emission Trading Scheme), globally (G8, Kyoto Protocol) or across industry sectors (sectoral agreements to mitigate carbon leakage) was deemed to be the least cost approach to achieving environmental and climate change targets. As part of this approach, the setting of a global carbon price was found to be crucial for lowering implementation costs and maximising positive employment impacts.
- Energy-efficiency policies (i.e. retro-fitting buildings, eco-design requirements) were found to have significant positive employment impacts in areas such as construction and technology, and research and development. Measures to support innovation (often driven by regulation) can have substantial positive employment impacts. An added advantage of these measures is that they are often replicated globally and generate less carbon leakage than market-based measures.
- Burden sharing is important to prevent negative employment impacts occurring in specific countries or sectors (e.g. through sectoral agreements, Clean Development Mechanisms (CDMs) or investment in different renewable technologies). In this regard, support and targets should reflect country and industry differences.
- Sectors where Europe can gain and maintain a leading edge in export markets were found to generate the greatest employment opportunities. This includes renewables and environmental technology sectors more generally. Specialisation of countries on specific technologies is also supported in this regard.
- Energy-intensive or high GHG emitting countries and sectors are predicted to incur the worst negative impacts on employment.
- Sequencing of measures to ensure that the least-cost measures are adopted over time should deliver the most cost-effective outcomes, beginning with those measures with the lowest marginal cost in each country or sector. Employment policies should be aligned with this iterative process.

Table 2.1: Summary of Impacts (Scale)

SUMMARY OF IMPACTS (SCALE)			
Study	**Scope**	**Employment Impact**	**Output or GDP Impact**
Global studies			
Cutting the Cost: The Economic Benefits of Collaborative Climate Action (Climate Group/ Office of Tony Blair, 2009)	National and EU environmental policy – including emission reduction targets; fiscal stimulus measures	10m new jobs are predicted worldwide by 2020, no breakdown for EU	Ambitious collective action scenario would lead to a minor but positive global and national rise in global GDP by 2020; a comprehensive global agreement would lead to an increase of nearly 1% in global GDP
Green policies and jobs: A double dividend? (IILS, 2009)	Green policies across a range of energy sectors	14.3m net new jobs could be generated for the world economy as a whole (including 2.6m in the OECD) over a five-year post-policy-implementation period.	N/A
Energy Sector Jobs to 2030: A Global Analysis (Institute for Sustainable Futures, 2009)	Energy policy	200,000 more net jobs by 2010, 2m more by 2020, 2.7m more by 2030	N/A
Environment and Employment: An Assessment (OECD, 2004)	Social and Environmental Policy Integration	Small net employment gain relative to baseline	N/A
Economic Assessment of Post-2012 Global Climate Policies (Russ et al, 2009)	International climate change targets, implementing a 27% cut in CO_2 emissions in developing countries	0.6% decrease in employment in developing countries, 0.4% in the EU	Emission reductions will cost 1% of GDP in developed countries by 2020
Rethinking the Economic Recovery: A Global Green New Deal (UNEP, 2009)	Environmental policy in various jurisdictions - 20/20/20 targets in the EU, similar strategies in the US and other economies	935,000 direct jobs in the US (2008 CAP report); 950,000 new net jobs by 2010 and 1.4m by 2020 in renewables (wind, solar, biofuels) in	N/A

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
		the EU under a 20% renewables expansion by 2020	
Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – A Synthesis for Policy Makers (UNEP, 2011)	Environmental policy in various jurisdictions - 20/20/20 targets in the EU, similar strategies in the US and other economies	Net direct employment impact under 'green' investment scenario would initially be negative, but would comfortably exceed that under business-as-usual scenario between 2030 and 2050; 2 – 3.5m new jobs projected in energy-efficient building sector in the EU and the US by 2020; 10% increase in job numbers (over business-as-usual figures) in waste sector	'Green' investment scenario (with about €900bn[1], or about 2% of annual global GDP, invested in 'green' sectors over the coming decades) leads to higher annual growth rates within ten years, along with a rise in renewable resource stocks and, therefore, in global wealth
EU studies			
Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables (Capros, P., Mantzos, L., Papandreou V. and Tasios, N., 2008)	Climate change and renewable energy package (20-20-20 targets)	N/A	Increase of 0.45-0.71% of GDP in 2020 for the EU as a whole
The economic effects of the EU biofuel target (Kretschmer, B., Narita, D. and Peterson, S., 2009)	Implementing 10% biofuel target in 2020	N/A	Range from a relatively small negative impact to a slightly positive impact depending on scenario
Work Package 5.1. - Economic Evaluation (LSE, TAES, WIFO, 2005)	Sustainable development	Strong sustainability policies lead to 0.2% increase in employment while weak sustainability policies lead to -0.3% change relative to BAU in 2020	GDP 2% higher in weak sustainability scenario and 3.9% higher in the strong sustainability scenario compared to Baseline in 2020

[1] €900bn = US $1.3tn; exchange rate of US $1.3 = € 0.9 sourced using www.xe.com as at 2 June 2011.

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
EmployRES - The impact of renewable energy policy on economic growth and employment in the European Union (DG Energy and Transport, 2009)	Supporting policies for 20% RES share in 2020	Net employment increase of 417,000-432,000 (Astra) or 396,000-428,000 (Nemesis) in 2020	€130bn value added in 2020, equivalent to 1.1% GDP
Climate change and employment – Impact on employment in the European Union-25 of climate change and CO_2 emission reduction measures by 2030 (ETUC, ISTAS, SDA, Syndex, Wuppertal Institute, 2007)	Various emission reduction measures across sectors	Positive employment impact in electricity generation, transport and the construction sector. Negative impacts in the petroleum sector, iron and steel and cement	N/A
Climate disturbances, the new industrial policies and ways out of the crisis (Syndex, S. Partner and WMP Consult, 2009)	Various emission reduction measures across sectors	Gross estimates: 278,000-307,000 additional jobs in electricity in 2030; 175,000 jobs threatened in the steel industry in 2020; 6,000 lost jobs in refineries in 2020; Up to 130,000 additional jobs in the automotive sector by 2030; 920,000 additional jobs in machinery and electric equipment by 2020.	N/A
Roadmap 2050: a practical guide to a prosperous, low-carbon Europe; Volume 1 – Technical and Economic Analysis (European Climate Foundation, 2009)	2009 G8 targets, reduction in GHG emissions, energy-efficiency legislation	Net employment 1.5% higher than in counterfactual by 2050, and only 0.06% lower in 2020. Significant difference across sectors highlighted	GDP assumed to rise from €10tn to €22tn over 2010-2050 period; GDP growth assumed to be 1% to 1.5% year-on-year owing to significant efficiency gains
Study on the relationship between environment/energy taxation and employment creation (University of Bath, AEA	EC proposal for Directive restructuring the framework for the taxation of energy products	Shifting of tax from labour to energy generates 31,270 - 118,540 jobs (gross estimate)	N/A

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
Technologies, 2000)			
Ex-Post Evaluation of Cohesion Policy programmes 2000-06 co-financed by the ERDF (Objective 1 & 2) – Synthesis (European Commission (EC), 2010)	Cohesion Policy	1.4m net new jobs due to Cohesion Policy	0.2% p.a. on average across the EU over the period 2000 to 2020
Low Carbon Jobs for Europe (WWF, 2009)	Focus on renewables	1.4m jobs (gross) in EU by 2030 in Photovoltaics	N/A
Sectoral studies			
IA: Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020 (EC, 2008)	20/20/20 targets	Slightly positive (0.05%) to slightly negative (-0.09%) on employment	Cost of reaching targets 0.58% of EU GDP or €91bn in 2020
IA: Renewable Energy Road Map Renewable energies in the 21st century: building a more sustainable future (EC, 2007a)	Energy Green Paper (2006), 20/20/20 targets	Net positive impact of approximately 0.3% by 2020 compared to 2004	Cost of reaching 20% target €210-290bn in additional production costs between 2005 and 2020
FORRES 2020: Analysis of the renewable energy sources' evolution up to 2020 (Fraunhofer et al, 2005)	White Paper on 'Energy for the future: Renewable sources of energy', based on Directive on RES electricity and Directive on biofuels	N/A	Costs of BAU RES development 0.23% of GDP in 2020. Additional costs of Policy to BAU: 0.28% of GDP in 2020
THE EU 20/20/2020 targets: An overview of the EMF22 assessment (Böhringer et al, 2009)	20/20/20 targets	N/A	Least-cost GDP decrease of 0.5–2.0%,
Employment Impacts of EU Biofuels Policy: Combining Bottom-up Technology Information and Sectoral Market Simulations in an Input-output Framework (Neuwahl et al for ZEW,	EU biofuels policy	Net jobs around +/- 300,000 jobs against a Baseline in EU25	Broadly, quasi-neutrality (in tune with conclusion on job impacts)

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
2008)			
Kyoto Protocol and Beyond: Economic Impacts on EU Countries (Thorning (ICCF), 2002)	Kyoto Protocol	Varies by country. For instance, Germany: 2008-12 - employment falls by 1m annually; UK: 2008-12 - employment falls by 410,000 annually	Varies by country. For example, Germany: GDP would fall by over 2.9% below baseline forecast over 2008-12
Meeting the Targets & Putting Renewables to Work: Overview Report (EC – ALTENER Programme: MITRE 2004)	EU renewable energy targets (carbon tax, ETS, duties on biofuels)	Overall net employment growth of 1.4m in the EU15 by 2020 (710,000 above Baseline) to 2.5m (1,020,000 above Baseline)	No estimates
Climate change impacts in Europe: Final report of the PESETA research project (EU JRC, IES, IPTS 2009)	EU climate policy - 20/20/20 targets	N/A	0.2-0.5% increase for the EU depending on the climate scenario modelled
Compliance costs for meeting the 20% renewable energy target in 2020 (Pöyry, 2008)	20% RES target	N/A	Total cost of reaching 20% RES target €259bn equivalent to €18.8bn annually
Member State studies			
Supply Chain Constraints on the Deployment of Renewable Energy Technologies (Douglas-Westwood/ BERR, 2008)	UK's EU-led renewables target (2020)	If the Renewables Advisory Board's (RAB's) capacity target for 2020 is met, job requirement expected to rise from 16,000-26,000 range (2008) to 122,000-133,000 range (2020); if DWL's market forecasts for 2020 capacity are met, the 2020 range would be 85,000-97,000	N/A
Investments for a Climate-Friendly Germany (BMU, 2008)	German climate policy - emissions-trading legislation, the 'Meseberg programme' (includes sector- and technology-specific	500,000 gross new jobs by 2020; and 900,000 by 2030	Long-run: increase in GDP of at least €70bn per year

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
	measures)		
A closer look at the development of wind, wave & tidal energy in the UK (Bain and Company, 2008)	The 2002 UK Renewables Obligation	36,000 gross new jobs (base case), 57,000 (best case), 23,000 (worst case)	Cumulative investment of £26bn (base case), £39bn (best case), £19bn (worst case)
Building a low-carbon economy - the UK's contribution to tackling climate change (The Committee on Climate Change, 2008)	The Climate Change Act (UK, 2008)	Varies by sector - e.g. 160,000 new jobs (UK wide) across all renewable-energy sectors by 2020 (BERR)	Different models have different predictions: e.g. GDP in 2020 is likely to be about 30% greater than the current level, in spite of costs that need to be borne initially
The road to 2020: An analysis of renewable energy options in the South West of England (Regen SW, 2008)	UK renewables target (2020), the Renewable Energy Strategy	Based on 2008 DTZ study: net employment effect of 4,000 in renewables in 2008 in SW England	Net GVA effect: £288m in 2008, productivity (GVA per employee) in renewables rose from £30,000 to £51,000 over 2005-2008 period
Gross employment from renewable energy in Germany in 2009 - a first estimate (BMU - Germany, 2009)	Renewable-energy legislation in Germany (e.g. The Renewable Energy Sources Act / EEG in Germany)	294,000 jobs in renewables sector in 2009 - 68% in electricity generation (incl. CHP), 22% in installation and production of heat-generation facilities, 10% in production of biofuels for transport. Potential to generate at least 400,000 jobs in the sector by 2020	N/A
The Economic Impact on Italy of Implementing the Kyoto Protocol and Additional Greenhouse Gas Reductions Planned for the Post-2012 Period (Global Insight, 2003)	Kyoto Protocol (context of Italy)	Annual employment losses of 51,000 by 2010, rising to 280,000 by 2025	Real GDP predicted to fall by up to 0.5% below base-case levels over 2008-12 period, and to be 1.9% and 2.9% lower in 2020 and 2025 under a scenario where emission credits cost €100 per tonne (‘worst’ scenario)
Modelling environmental, economic and employment effects of resource savings in	Sustainability (Austria)	Implementing a reduction in material costs of 20% between 2005 and 2020 will increase employment by 2.4% above Baseline scenario	Measures projected to lead to €76.5bn value added above Baseline in 2020

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
Austria (Stocker et al, 2007)		in 2020	
Study of the effects on employment of public aid to renewable energy sources (Alvarez et al, 2009)	RES policy and potential for green jobs (Spain)	Jobs in renewables require 2.2 times more capital than jobs in the private sector – the implication being that subsidies for renewables have the potential for leading to overall job loss in the economy	N/A
The Economic and Environmental Impact of Promoting Energy Efficiency in Housing (KfW Bankengruppe Workshop, 29 April 2009)	Policy targeting energy efficiency in construction (Germany)	Jobs amounting to 35,000 man-years overall (gross) could be generated by a 'CO_2 Buildings Rehabilitation Program' initiative – 20,500 direct and 14,500 indirect man-years. 16.5 man-years would be created per €1m of additional investment. A yearly average of about 203,000 jobs could be created or protected	N/A
Economic effects of a more ambitious carbon target in Hungary (Ecofys,18 January 2011)	A -20% and -30% EU reduction target for GHGs in Hungary across ETS and non-ETS sectors	The 20% target creates 10,000 full time equivalent (fte) direct net jobs and the 30% target a further 1,000 fte. Job losses are predicted in the energy supply sector, with increases in the manufacturing and construction sectors	Savings of €2.6bn under a 20% target and €2bn under a 30% target. Energy security is also expected to marginally improve
Prata Dias, G. and T. B. Ramos (2010), Assessment of Green Employment Impact of Renewable Energies in Portugal at Local Level	Investment of €220m in renewable wind farm technology in Portugal	Creation of 1,700 direct job and 5,500 indirect jobs (gross) by 2013	€286m per year value added
Review of competitiveness, trade and employment effects of environmental taxes (A. Markandya & R. Ortiz, Charles University Environment Center, Prague 2008)	Review of environmental policy impact in the Czech Republic	Suggests that positive employment impacts would be small if any in the Czech Republic Environmental taxes may benefit labour-intensive sectors, while energy-intensive industries might suffer. Impacts are greatest	Small competitiveness benefits highlighted

SUMMARY OF IMPACTS (SCALE)

Study	Scope	Employment Impact	Output or GDP Impact
		where present taxes are distorted, when recycling is via reductions in high labour taxes, the economy has high unemployment and there are no offsets by increased wage demands	
Impact on activity and employment of climate change and greenhouse gas mitigation policies in the enlarged Europe: Final Country Report – Hungary (Wuppertal Institute)	Kyoto Protocol, EU emissions trading initiative (Hungary focused)	No quantitative forecasts (although net employment impact likely to be slightly positive), exploration of trends in some sub-sectors	N/A
Impact on activity and employment of climate change and greenhouse gas mitigation policies in the enlarged Europe: Final Country Report – Slovenia (Wuppertal Institute)	Kyoto Protocol, national legislation (Ministry of the Environment and Spatial Planning) – Slovenia focused	No quantitative projections, positive employment impacts expected in general from expected expansion in use of biomass and other renewable energy sources and from strengthening energy efficiency in construction	N/A
Impact on activity and employment of climate change and greenhouse gas mitigation policies in the enlarged Europe: Final Country Report – The Czech Republic (Wuppertal Institute)	Kyoto Protocol, EU Emissions Trading Scheme, national targets – Czech Republic focused	No quantitative estimates, but only a small net negative impact posited for employment, if any (due to potential for relocation of energy-intensive production facilities to other countries following rise in energy prices)	N/A

Qualitative impacts on employment and skills needs

Few studies addressed the sectoral impacts of climate or environmental policy directly, and where employment changes are evaluated, more in-depth analysis is mostly limited to quantitative forecasting. Quantitative estimates of the employment impacts of climate policy in specific sectors are presented in Fraunhofer ISI and partners (2009), MOSUS (2005) and a few country-centric studies, such as ETUC (2008 – UK focused). Major studies that discuss qualitative effects of climate change and environmental policy include the ETUC (2007, 2009), UNEP (2008), CEDEFOP (2009) and GHK (2010) studies. These studies form the basis of the assessment of skills and job quality impacts in the sectors presented below.

UNEP (2008) identifies four kinds of changes to occupations due to the shift to a low-carbon economy:

- job creation
- employment substitution (e.g. shift from fossil fuels to renewables)
- job loss without replacement
- transformation of job profiles (relating to skill sets and work methods)

Job profiles are becoming greener as new skills are integrated into existing occupations and new green jobs are created. A report by GHK (2010) investigating green skills requirements across six Member State economies[2], suggests that sectors undergoing green restructuring are generally able to adjust production models to take advantage of growing markets for green products and services and that training systems have coped with the demand for new skills both in new green occupations and in existing green jobs. However, a systemic deficit in management skills and job-specific technical skills (related to science, technology, engineering and mathematics [STEM]) was also identified across the EU. With regard to training systems for green skills, the report concludes:

'To the extent that existing systems are considered less than adequate, this is seen as a systemic weakness rather than specific to the environmental sector. There are common problems across Member States relating to the labour market that undermine economic performance and labour-market efficiency as a whole, even if they also apply to the environmental sector. These problems include weaknesses in integrating labour demand assessments and skills responses and lack of take-up of technical education and training in science and engineering.'

The effect of environmental legislation and the drive towards a low-carbon economy may involve or result in skills shortages but this is not specific to any one sector. Skills profiles are changing across the economy as a whole and retraining is needed both in technical and managerial occupations. Where skills shortages are specific to a certain sector, training can effectively be provided by sectoral or regional agencies but often cross-sectoral training is needed for green occupations, which are often 'hybrid', incorporating skills from various sectors and professions. Examples of how occupations are greening in various sectors through additional training are shown in Table 2.2.

[2] Denmark, Estonia, France, Germany, Spain and the UK.

Table 2.2: Cross-Sectoral View of Greening Occupations

CROSS-SECTORAL VIEW OF GREENING OCCUPATIONS

Member State	Occupation(s)	Core training	Upskilling	New occupation
DK	Industry electrician/ energy technologist	VET qualifications/ tertiary engineering qualifications	Knowledge of energy sources, ability to integrate energy systems, project management	Manager in renewable energy
DK	Industrial operator/ industry electrician	VET qualifications/ upper secondary qualifications	Assembly, installation of parts, use of tools	Wind turbine operator
EE	Construction worker	No professional standard	Knowledge of energy systems, data analysis, project management	Energy auditor
FR	Recycling sector worker	General certificate of vocational training (CQP)	Sorting and reception techniques, knowledge of conditioning and storage	Waste-recycling operator
FR	Product design and services	22 initial training courses with varying specialisation	Integrating environmental criteria in design process, integrated assessment and life cycle analysis	Eco designer
DE	Electronic/ mechatronic technician	Initial vocational training	Electronics and hydraulic systems, safety procedures, operation and services	Wind power service technician
DE	Plumber/ electric and heating installer	Initial vocational training	Technical training, knowledge of administrative procedures, entrepreneurial skills	Solar energy entrepreneur/ installations project designer
UK	Engineer in energy section	Tertiary engineering qualifications	Installation and maintenance of low-carbon technologies, customer service skills	Smart-energy expert/ smart-energy manager
UK	Commodity trader/ Broker	Tertiary qualification	Practical skills on functioning of carbon market, understanding of trading tools	Carbon trader/ broker

Source(s): GHK Consulting (2010): 'Skills for green jobs – European synthesis report', CEDEFOP, Thessaloniki.

Low-carbon industries are often more labour intensive (e.g. renewable energy occupations), and job creation associated with the shift towards a greener economy is thought to balance job losses in carbon-intensive sectors. With electricity and construction showing the largest projected growth, manual skills are going to be in demand, while R&D and technology deployment will mean that STEM skills are increasingly needed. Skills in sunset industries can often be utilised in new industries.

There are, for example, numerous examples of ship-building companies diversifying and retraining to service the growing renewables industry. Sectors that are projected to suffer the largest job losses, e.g. cement, petroleum or iron and steel, are already seeing changes in occupational skill profiles as production becomes greener. This is not solely due to low-carbon restructuring but also technological improvements and higher labour productivity. A summary of the studies on the impacts of climate change policy on employment profiles is presented in Table 2.3 below. The conclusions of this exercise relevant to employment policy are as follows:

- Training and 'upskilling' initiatives should be aligned to the demands of the sector needs outlined in Table 2.3, if the positive employment opportunities are to be maximised.
- Improved forecasting of skills needs (particularly over the longer term) through industry dialogue could help facilitate employment opportunities.
- The importance of eco-innovation to the generation of future jobs should be recognised.
- More stringent energy-efficiency standards in buildings and products could be introduced to engender more jobs and induce further environmental related innovation.
- More training programmes in renewables sectors are required, specifically in consultancy, servicing and maintenance, engineering, service provision, etc.
- New and 'greener' plants in heavy industry are often more automated and require less labour. Equally, energy-intensive sectors are expected to be the most negatively affected from climate/environmental policy; therefore significant support in restructuring is required in these sectors.

Table 2.3: Impact on Occupational Profiles of Economic Restructuring

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING			
Sector overview	**Key policies or industry drivers relating to green jobs**	**Projected change in job numbers**	**Associated impact on occupational profiles**
<u>Renewable energy</u> (Manufacturing/ Services) EU employment: 1.4m in 2005 (0.65% of EU 27 workforce[3]) Total gross value added: €58m in 2005 (0.58% of EU GDP)	EC Renewable Energy Directive, COM (2008) 20% renewables-centric target (2020) EU ETS Fiscal stimulus measures ('green' counter-recessionary investment) Subsidies	Projected to create about 396,000-432,000 net jobs in the EU27 by 2020, i.e. **28-31%** of 2005 employment figure for the sector (Fraunhofer ISI and partners, 2009) UNEP (2008): Between 1.4m and 2.5m net full-time jobs (direct and indirect) in renewables development in EU 15 by 2020[4] (i.e. up to 2.5m net jobs, or about 1.5% of overall EU 15 employment in 2010[5]) Employment generation likely to be greatest in biomass, hydro power, wind and solar energy (ETUC, 2009)	Jobs generated in construction, manufacturing and installation of renewables – in particular, in installation and maintenance of solar PV and solar thermal systems ETUC (2007): More stringent energy-efficiency norms should engender more jobs in energy consultancy, engineering and energy service provision (mainly power suppliers, operating service providers and installers (e.g. of grids or co-generation units)
<u>Conventional power generation</u> (Manufacturing/ Services) EU employment: 1.62m in 2010 (0.77% of EU 27 workforce[6])	EU 20/20/20 targets EU ETS Infrastructural investment	At a broader level, up to 48,000 refining jobs could be lost at a gross level by 2020 (a decline of about **40%** from current levels) owing to development of organic fuels and tightening of carbon constraints (ETUC, 2007) Closure of 10 (relatively small) refineries could lead to loss of 6,000 gross jobs (half direct and half indirect) by 2020 (ETUC, 2009)	More jobs likely in natural gas sector, primarily owing to current dominance of the industry in power generation, rapid investment return and relatively low carbon footprint – however, future price and availability of gas reserves could be a major challenge (ETUC, 2007) Maintenance likely to continue to remain an area of importance (even assuming shift in favour of renewables) – training

[3] Source: EmployRES (2009).

[4] Based on World Wide Fund for Nature (2009): 'Low Carbon Jobs for Europe: Current Opportunities and Future Prospects'.

[5] Eurostat: Overall employment in EU 15 in 2010 approximately 170 million (see http://epp.eurostat.ec.europa.eu/portal/page/portal/employment_unemployment_lfs/data/database)

[6] Eurostat: Employment in electricity, gas, steam and air conditioning supply (see http://epp.eurostat.ec.europa.eu/portal/page/portal/employment_unemployment_lfs/data/database)

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING

Sector overview	Key policies or industry drivers relating to green jobs	Projected change in job numbers	Associated impact on occupational profiles
		Employment in coal-fired plants likely to decline by 2030, unless CCS procedures advance sufficiently (ETUC, 2007). Significant gross job losses owing to shift towards renewables, but these are largely offset by jobs indirectly created in renewables construction, manufacture and installation – only an ambitious 4.4% annual emission reduction target leads to net job losses of around 140,000 (ETUC, 2007)	programmes desirable (ETUC 2007, 2009) Jobs in marketing, project management and customer service also likely to hold ground
Cement (Manufacturing – Basic industry) EU 25 employment: 53,300 in 2003 (0.03% of overall EU 25 workforce)	EU ETS (ETUC, 2007: over allocation of permits to sector in 2005 led to sales of unused quotas worth nearly 1% of sector's turnover in the EU 25) Energy-efficiency policy CDM – demand for new technologies R&D investment	8,000-20,000 gross job losses expected by 2030 (**between 15% and 40%** of total EU sectoral employment) as labour productivity improves, given current industry trends; import restrictions and curbs on relocation could mitigate these figures (ETUC, 2007) MOSUS (2005): Predicts EU 15 industrial employment in 2020 to be 1% lower in a 'high' ('strong sustainability') scenario (reduced material and energy use of 30-40%) than in a baseline scenario (no additional policy measures implemented for sustainable resource management)[7]	UNEP (2008): Shift towards energy-efficient plants, both newly constructed and retrofitted, will probably generate some jobs in short run, but might prove counterproductive over a longer period as 'greener' plants tend to be more automated and require less labour Surviving jobs could require higher skill levels and retraining ('green' jobs), but would not be a major employment source
Iron and steel (Manufacturing – Basic industry) EU 27 employment: circa. 550,000 in 2006 (0.26% of	European Ultra-low CO_2 Steelmaking programme (ULCOS) – flagship project of the European Steel Technology Platform (ESTEP)	ETUC (2007): Reduction in production by 2030 likely to put 80,000-120,000 gross jobs at risk, R&D investment and low-carbon production estimated to be able to offset 50,000 of these, thus 30,000-70,000 net job losses expected (i.e. circa. **8-18%** of a total of 370,000 employed in integrated	Making steel mills greener and more competitive – essential for job retention, although these mills not necessarily labour intensive (UNEP, 2008) Business-as-usual outlook refers to ongoing employment retrenchment, but a proactive policy favouring jobs in green, high-

[7] MOSUS evaluation scenario descriptions available at http://seri.at/wp-content/uploads/2009/09/SERI-Studies1.pdf

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING

Sector overview	Key policies or industry drivers relating to green jobs	Projected change in job numbers	Associated impact on occupational profiles
overall EU 27 workforce in 2006[8])	EU ETS (ETUC, 2007: relative proportionality between production and emission levels as regards ETS quotas for steel industry)	sites) Further, ETUC (2009) estimates that taking account of jobs in cold processing and tubes domains would raise overall sectoral employment figure to almost 550,000; estimate of net jobs lost by 2020 revised to 24,000-45,000 (i.e. **less than 10%** of overall employment in the sector) MOSUS (2005): Industrial employment in EU 15 1% lower in 2020 under a 'strong sustainability' scenario as compared to baseline (as described above)	quality space could encourage job retention (e.g. the EU's 'Ultra-low CO_2 Steelmaking' (ULCOS) initiative) ETUC (2009): Potential for specialist qualifications to replace jobs currently held by general technicians; energy-efficiency culture would be key for production and maintenance operators Productivity gains will necessitate greater emphasis on computer-centric processes, worker security (vis-a-vis rigorous operating standards) and training Potential for a third of jobs at risk likely to be replaced by positions vulnerable to poorer working conditions and increased health risks, owing to need for greater contractual flexibility and outsourcing (ETUC, 2007)
Machinery and electrical equipment (Manufacturing) EU 27 employment: 3.7m in 2006 (ETUC, 2009)	EU ETS Energy-efficiency policies SME-centric policies (given importance of SMEs in this industry)	ETUC (2009): Energy efficiency and production (core of industry) could see gross increase of about 670,000 jobs; an additional 250,000 jobs possible via advanced supplier investment – thus, potential for gross job creation amounting to 920,000 (nearly **25%** of total employment in sector as of 2006 – 3.7m)	Findings subject to assumptions regarding relocation potential, role of imports and labour productivity in the EU Market-share trends will hinge on industry-academia proximity and supply of highly skilled labour As SMEs comprise 50% of market, their integration into support programmes and regional competence networks will prove crucial (ETUC, 2009)
Construction (Services/ Manufacturing)	Energy Performance of Buildings Directive (EPBD) – Directive	ETUC (2007): Alternative 'Eurima' (European Insulation Manufacturers Association) scenario: 70,000-200,000 gross jobs created annually across the EU 25 by 2017 (i.e.	Green job creation primarily in installation and delivery of material and equipment, but also in management, administration, auditing

[8] Eurostat: Overall employment in 2006 in EU 27 was about 213 million (see http://epp.eurostat.ec.europa.eu/portal/page/portal/employment_unemployment_lfs/data/database)

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING

Sector overview	Key policies or industry drivers relating to green jobs	Projected change in job numbers	Associated impact on occupational profiles
EU 27 employment: about 16.1m in 2010[9] (7.65% of overall EU 27 employment)	2002/91/EC Directive on the final use of energies (2006/32/EC) EU GreenBuilding Programme (launched 2004)[10] EU ETS, especially for construction and insulation materials	700,000-2m gross jobs over 10 years, or **4-12%** of 2010 sector employment), owing to extended reach of regulation Implementation of an aggressive residential-sector focused investment strategy aiming at €137 billion a year could create up to 2.59m FTE jobs (gross impact) per year in the European sector over the 2006-30 period, or an annual gross rise of 16% on 2010 estimate of 16.1m jobs (hypothesis of €53,000/year/FTE job) Implementation of aggressive investment programme (‘Factor 4’ scenario) would lead to highest cost of works (per sq m) in Finland and Belgium (owing to high energy intensity of homes), whereas costs would be much lower in Spain, Portugal and other Member States MOSUS (2005): 1.6% more employment in EU 15 construction sector in 2020 under a ‘strong sustainability’ scenario compared to the baseline (as described above)	and R&D (UNEP, 2008) Job generation potential positively linked to energy savings potential (ETUC, 2009)
Transportation (Services/ Manufacturing) EU 27 employment in transportation and storage: around 10.8m in 2010 (5.12%	EC transport-related directives and measures, e.g: Road transport: Regulations 443/2009 and 715/2007, Directive 2009/33/EC	ETUC (2009): Replacement of conventional engines by greener alternatives (e.g. electric engines) by 2030 could lead to net job gains in range of 62,000-125,000 (i.e. **2.7 to 5.4%** of the 2.3m people directly employed in vehicle production in 2007, although only **0.5 to 1%** of overall EU	UNEP (2008): More sustainable systems will have to be based on shorter distances. Balancing shift in modes of transportation would give greater weight to public transit systems, walking and biking - could lead to considerable net employment gains, reduced emissions and better air quality

[9] Source: Eurostat.

[10] Voluntary initiative aimed at non-residential buildings: see http://www.eu-greenbuilding.org/

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING			
Sector overview	**Key policies or industry drivers relating to green jobs**	**Projected change in job numbers**	**Associated impact on occupational profiles**
of overall EU 27 employment)	Air transport: Regulation 82/2010, Decisions 2009/339/EC and 2009/450/EC Maritime transport: Recommendation 2006/339/EC, Directive 2005/33/EC	employment in transport, storage and communication – 13.4m[11] – in 2007). ETUC (2007): 'Extended Policy' scenario visualises shift in favour of public and rail transport (vis-a-vis BAU case): by 2020, would lead to employment increases of over 24% in public passenger road transport, of 20% in rail passenger transport – employment in private transport domain, predictably, rises less rapidly than in BAU case as focus shifted to public transport domain (more environmentally friendly and labour intensive) Overall, over 2000-30, such policies could lead to 2% average annual employment growth in passenger transport and 1.25% in freight transport Railways – over last few decades, trend of decreased development noticed in several countries, accompanied by corresponding employment declines. EU: railway employment down to about 900,000 jobs; number of workers in manufacturing rail and tram locomotives and rolling stock down to 140,000. Policies focusing on sustainability and strategic investment necessary to counter these trends	More jobs in vehicle maintenance and servicing than in manufacturing – e.g. in fuel refining, wholesaling and retailing; freight services; rental and repair activities etc. Degree to which jobs may be classified as 'green' dependent on vehicles and fuel type, content of biofuels and sustainability ETUC (2009): Restructuring of value chain would necessitate mobilisation of resources to finance professional mobility and skill upgrading ETUC (2007): emphasises importance of legislation on social conditions in influencing distribution of transport across modes (particularly road and rail transport) Skills shortages emerging in rail transport – apprenticeships and vocational training in decline although significance remains high given this mode is greener and more labour intensive than car industry

[11] Source: Eurostat.

Based on Table 2.3, the occupations which would benefit from a low-carbon transition within key sectors across the EU in the coming decades might be highlighted by way of a matrix, as shown below in Table 2.4. Net job numbers are likely to rise in R&D, manufacturing, operations & maintenance and management across a range of sectors, although the gains may be small, and there will probably be significant reallocations within sectors, as highlighted above.

Table 2.4: Occupations with Potential to Benefit from the Low-Carbon Transition, by Sector

OCCUPATIONS WITH POTENTIAL TO BENEFIT FROM THE LOW-CARBON TRANSITION, BY SECTOR						
	R&D	**Manufacture & installation/ engineering**	**Operation & maintenance**	**Management**	**Administration**	**Sales**
Renewable energy	✓	✓	✓	✓	✓	✓
Conventional power generation			✓	✓	✓	
Cement		✓				
CCS	✓	✓	✓			✓
Iron & steel	✓		✓	✓		
Machinery & electrical equipment	✓	✓		✓		
Construction	✓	✓		✓	✓	✓
Transportation			✓	✓	✓	

Innovation policy

The promotion of green jobs and the achievement of environmental and climate change objectives are often supported by innovation policy. Developing new technologies with environmental performance credentials not only contributes to energy and resource efficiency (e.g. low-energy light bulbs, improved materials-recover technology, building insulation, etc.), but can also directly generate EU jobs where these technologies give EU companies a leading edge in manufacture/distribution, and drive further innovation. Indirectly, the adoption of these technologies by businesses and consumers can have additional benefits, as the users experience cost savings, thus potentially generating employment in downstream sectors. Table 2.5 presents complementary policy measures which promote eco-innovation and the uptake of environmental technologies and therefore contribute to sustained job creation. These include measures aimed at supporting Research, Testing and Development (RTD) and commercialisation of technologies, in addition to measures aimed at supporting demand for and adoption of new technologies.

Table 2.5: EU Initiatives to Support Eco-Innovation and Environmental Technologies

EU INITIATIVES TO SUPPORT ECO-INNOVATION AND ENVIRONMENTAL TECHNOLOGIES

Measure	Description	Impact
Ecodesign Directive	Establishes design requirements for energy-using products from a life-cycle perspective, thus creating an internal market for more efficient technologies	Promotes development and encourages take-up of eco-technologies
Energy Labelling Directive	Obliges household appliances (e.g. washing machines, light bulbs, refrigerators etc.) manufacturers to label their products and display energy consumption so as to facilitate comparisons of efficiency with alternative makes and models	Promotion of energy-efficient products over competitors; gradual shift in consumer preferences in favour of efficient appliances; eventual withdrawal and decommissioning of relatively inefficient alternatives
Ecolabel Regulation	Labelling of the total environmental performance of products over its life cycle	Increasing awareness and encouraging the uptake of more efficient solutions
Green Public Procurement	Voluntary instrument focusing on reduced environmental impact of public procurement of goods services and works (throughout life cycles)	Promotes sustainable consumption and production; incentivises development of ‘green’ products and technologies in a range of sectors and contributes to attainment of resource efficiency goals
IPPC Directive	Provides guidance by industry sector on the Best Available Techniques (BAT) which could be adopted to reduce industrial emissions. Presented in reference documents (BREF notes), they can help promote the adoption of more innovative solutions	Encourage the adoption of innovative technology solutions and promote site testing of technologies as part of the development of BREF notes. Therefore accelerating access to market and uptake of the technology
Lead Market Initiative (LMI)	Promotion of innovative technology solutions through EU mechanisms such as funding, research studies , regulatory instruments, etc. in six key sectors (eHealth, Protective textiles, Sustainable construction, Recycling, Bio-based products and Renewable energies)	Reduction in time-to-market of innovative products or services; potential for job creation (up to 3m by 2020) and economic growth (about €300bn by 2020) and improved access to products and services with significant social benefit potential
Eco-innovation Platform (Eco-IP)	Forum for development, testing and promotion of tools and instruments aiming at innovation; a platform for innovative professionals	Helps innovative firms to undertake innovation more rapidly; promotes knowledge sharing; provides a supportive

EU INITIATIVES TO SUPPORT ECO-INNOVATION AND ENVIRONMENTAL TECHNOLOGIES

Measure	Description	Impact
		policy environment for innovators and better practical information services vis-a-vis sectoral innovation patterns
Eco-innovation observatory	Structured portal for information on eco-innovation in the EU and other major economic regions	Facilitates integrated information collection and analysis of trends and practices in eco-innovation pertaining to a range of sectors; draws out implications for companies and service providers
Competitiveness and Innovation Framework Programme (CIP)	Focuses on provision of support to all forms of innovation (including eco-innovation), especially for SMEs	Improved access to finance and business support services, in particular for SMEs; increased use of renewable energy and increased energy efficiency
7th Framework Programme for Research and Technological Development (FP7)	Instrument that provides funding (by way of grants) to research enterprises and other actors across the EU to facilitate research, innovation and technological progress	Promotes scientific research and innovation; in longer run, helps build a solid foundation for scientific and technological development of EU industry and, ultimately, increased international competitiveness in line with EU policy goals
EU Environmental Technology Verification (ETV) Scheme	Allows developers of environmental technologies to have its environmental performance independently verified to facilitate market entry, accelerate uptake and give investors/users confidence in such products	By promoting the uptake and future development of environmentally beneficial technologies, helps achieve environmental objectives and increase employment

2.3 Selected country case studies

This section provides five brief country case studies (Denmark, Sweden, Germany, Spain and the UK) that investigate the nature of integration between environmental policies and labour market polices. The choice of countries reflects the level of information that is easily available; it is noted that all the countries are in western Europe.

Denmark

Research evidence suggests that there is only limited integration between green policies and labour market policies (and green job creation) in Denmark. Danish climate policy is very much centred around reaching agreed international targets for reducing CO_2 emissions and encouraging growth in the development of green technologies to meet domestic and export demand.

The barriers to the integration of green policies and labour market policies relate to:

- problems in determining the labour market consequences of green policies
- the fact that labour market considerations have to compete with a number of other areas where green policies also have implications
- the lack of a method for decision makers to integrate the two types of policies (research into a general methodology is being developed at the moment by government)

For these reasons, government policies are integrated at only a rather general level. The green initiative which is, perhaps, most integrated with labour market policy is the Innovation Fund (Fornyelsesfonden) under the Ministry of Economy and Business. This Fund provides financial support to businesses with green growth potential which are located in geographical areas with a relatively high unemployment rate.

The Danish government promotes green growth (and green jobs) by subsidising businesses that are in ‘fossil-fuel-alternative’ sectors; that is, those businesses which are producing energy from sources that do not contribute to CO_2 emissions (windmills, solar power etc.). The Danish government also undertakes its own investments in green energy (e.g. geothermal energy), and supports all links in the green innovation chain with substantial amounts of funding every year, but these initiatives and policies are, in general, not directly linked to labour market policies.

As mentioned the Danish government is increasingly focusing on lowering CO_2 emissions and obtaining growth from green technologies. The main policies and initiatives within these areas which have been introduced since 2008 are:

Reducing energy use:

- lowering the thresholds of permitted usage in buildings
- campaigns
- establishment of knowledge centres

Sustainable energy:

- more biomass and less fossil fuels: subsidies to power generation using biomass for electricity production
- wind farms (land): higher subsidies to new mills, establishment of two new farms at sea
- biogas plants: all existing plants are offered a predetermined, above market level price for their electricity production

- heatpumps: €3.96m. to an information campaign on pump-replacement
- solar power and wave power: Subsidies of EUR €3.3m for 4 years

Energy taxes:

- higher taxes on CO_2 emissions, new tax on NO emissions

Transportation:

- tax exemptions for H_2 cars
- tax exemptions for electric cars until 2015
- support to private and public actors wishing to test the economic and environmental effects of establishing a fleet of electric cars (€1.3m per year 2008–09 and €0.67m in 2010-12)

Research & Development (€132m in 2010)

- support to research in future energy systems
- Energy Technology Development and Demonstration Programme (EUDP) – demonstration of new technology prior to market launch
- research in electricity production and usage
- Green Labs DK – green test laboratories aimed at attracting international development and demonstration activities
- research in technologies with evident commercial potential
- The Innovation Foundation

Making more businesses part of the EU CO_2-quota system:

- Including the aviation industry under EU CO_2-quota regulations and thereby putting a price on its emissions. These policies are aimed at reaching Danish CO_2 emission targets, as well as creating growth and jobs in the process, but they are not accompanied by specific labour market policies.

Though the policies are not explicitly accompanied by or integrated with employment policies aiming to increase the number of green jobs, the policies do, directly or indirectly, support the creation of new jobs in the short term (new windmill parks, green promotional information campaigns) or in the long term (R&D investments). As mentioned above, specific policies are mainly combined with general growth promotion policies by maximizing the competitiveness of Danish firms.

There is a regional dimension too. The six regional authorities in Denmark, in different ways and to different extents, support green growth by directing regional growth funds (from EU structural funds and national funding) towards R&D, testing and demonstration of green technologies, and through counselling to entrepreneurs. For example, one of the regions supports plans to transform former shipyard facilities into green-tech test centres. In this case the plans also include providing appropriate training in testing. These plans however are still in preparation. Regional support is expected to generate employment in the future, but it is not always accompanied by explicit labour market policies.

Some of the Danish municipalities have recognised the importance of green initiatives in creating jobs. Typical examples are:

- efforts to establish an innovative green centre consisting of researchers, businesses and students within reach of each other (municipality of Aarhus)

- working to create an urban environment that will attract foreign high qualified labour to work for business in the green sector (municipality of Aarhus)
- planning to put up a minimum of 5,000 m^2 of solar cells (municipality of Aalborg)

Like the green policies and initiatives at governmental and regional level, these will probably affect employment in the long or short run, but cannot be categorised as labour market policies.

Sweden Over the long term, Sweden's green policies are designed to ensure that the country meets internationally agreed targets on carbon emissions and, at the same time, place Sweden at the forefront of developing and utilising certain green technologies (equivalent to Danish policy). Sweden reduced its employment tax when a green tax was introduced some ten years ago, but this can hardly be considered an explicit labour market policy designed to foster green job creation.

As in the case of Denmark, the integration of green policies and labour market policies is mostly at a general level where future growth will be generated through the development of green technologies. Some of the main Swedish policies in this field are:

Energy efficiency:

- €27.3m a year between 2010 and 2014 to be spent reducing knowledge gaps in how households and enterprises can reduce their energy consumption
- the public sector will be expected to lead the way in demonstrating energy efficiency
- enterprises which are not currently covered in scope of existing energy-efficiency programmes (i.e. non-energy-intensive ones) will be supported economically to carry out an 'energy audit' between 2010 and 2014 (an energy audit is a complex process which evaluates where energy is being used in a building and identifies opportunities for reductions in energy consumption)
- the introduction of energy-efficient technologies will be strengthened
- energy statements for individual houses will be required before sale

Plan for a vehicle fleet independent of fossil fuel:

- vehicle tax relief on green cars
- subsidy to establish filling stations for renewable fuels
- increased admixture of bio fuel – implementation of new quality directive
- binding emission standards for automotive manufacturers
- sustainability criteria for the production of biofuels
- biogas production from organic waste
- development of second generation biofuels will be supported with €79.4m between 2009 and 2011
- development of an integrated knowledge base on electric vehicles and hybrid cars
- including aviation in the EU emissions trading scheme from 2012

Climate tax package:

- carbon component of vehicle tax increased
- tax on diesel increased

- phasing out of previous reduction in carbon tax for energy-intensive enterprises
- reduction in carbon tax for heating in agriculture, forestry and aquaculture and industries not covered in EU trading scheme will decrease
- the power certificate system taxing traditional power production for funding of the production of renewable energy

Green investments in developing countries:

- green investments such as CDM (Clean Development Mechanism)

Climate policy and development cooperation:

- Investments of €363m between 2009 and 2011 of its development assistance in climate development. These investments to support adaptation to climate change can involve measures aimed at reducing human vulnerability, e.g. investments in health, sanitation and access to clean water.

Support:

- Investment in technological development and information. Measures to remove institutional barriers to innovation.

R&D and demonstration:

- investment in areas that focus on the achievement of reduction targets, where Sweden has a relatively strong national position and where export potentials exist

Strategic priorities:

- large-scale renewable electricity production and the development of electricity networks, this includes:

– investments in wave power, solar power and gasification of biomass

– electric drive systems for vehicles and hybrid cars

– combined bio-energy plants for environment and climate-sensitive production of fuel and other products

Like Denmark, green policies and initiatives will affect employment over the short and long run, some to a substantial extent, but to date they have not been accompanied by explicitly formulated labour market programmes and thus cannot be categorised as labour market policies. A specific example of a policy that presumably affects employment over the short term is the policy of rewarding enterprises which initiate energy audits since these audits are performed by people who need to be trained in this activity.

The aim of regional policy is to obtain growth by increasing local or regional competitiveness, which is to be partly achieved by focusing on promoting environmentally friendly and efficient technologies and renewable energy (partly funded the EU structural fund).

Like in Denmark, the individual municipalities are free to pursue and support local green initiatives. These too have employment effects, e.g. investment in the development of a solar driven stirling engine (municipality of Malmö).

Germany The Federal government described in its Umweltbericht [Environmental Report] their understanding of the connection between environmental policies and the promotion of employment. This was defined as innovation-orientated environmental policies which help to combat environmental pollution and to reduce the risk of ecological damage. These policies stimulate, via the creation of ambitious standards, innovative products and production processes which secure the international competitiveness of the German economy. Therefore, innovation-orientated policies contribute to the maintenance of industrial competitiveness in Germany and help to secure or create jobs. Furthermore, if the manufacturing industry requires fewer inputs of raw materials, it is less dependent on commodity markets.

Germany has been successful in the production of green technologies. In 2004 the output of environmental and CO_2 reduction goods (e.g. photovoltaic cells, emissions filters) was valued at €55bn. This represented an increase of around €5bn (almost 10%) since 2002. Germany holds the highest share (19%) of the world trade in environmental technology, followed by the USA and Japan. There are about 1.5m employees in the environmental sector (Umweltbericht 2006:8ff).[12]

The main government policy in Germany regarding green jobs is the Umweltinnovationsprogramm (UIP) [Environmental Innovation Programme] which started in 1979 in West Germany. Projects funded by the UIP not only aim to improve the environment and contribute to meeting the aims of the federal government in terms of CO_2 reduction targets, but also to impact on economic and employment policy.

The UIP supports initial pilot schemes, preferably in SMEs, if they realise innovative facilities, process techniques and products on an industrial scale. Funding is available for projects that show:

- significant reduction of previous environmental impact (e.g. emissions, waste, noise)
- improvements in technical knowledge in order to develop legal and technical environmental specifications
- transferability of innovations in similar enterprises in order to multiply the impact

The UIP has developed into bridging research, between development of novel environmental techniques and their realisation on an industrial scale in various sectors. In the last thirty years, more than 700 pilot programmes were supported by the UIP. Since the introduction of the UIP, the focus of the programme has changed. The initial aim was air pollution control, followed by acidic rain, forest dieback and the hole in the ozone layer. After reunification in 1990, new agendas included the decontamination of the GDR Uranium areas and the modernisation of wastewater treatment in the former GDR. Today, the main goals of the UIP are energy saving, energy efficiency, and renewable energy. This is reported to have led to the creation of new jobs over the last ten years (BMU, 2009).

[12] Umweltbericht (2006) is published by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety www.umweltdaten.de/rup/umweltbericht_2006.pdf

Spain

Strategic lines in the fight against climate change

The Government Delegated Commission for Climate Change (CDGCC) defined, in July 2008, the strategic lines in the fight against climate change. The 'Sustainable Buildings' line of the strategy was aimed at promoting energy efficiency and a higher percentage of self-sufficiency in residential and institutional buildings. In a report published in March 2010 tracking the implementation of this strategy[13], it was stated that in December 2009 the Government implemented a plan to stimulate the hiring of Energy Services Enterprises in 330 General Administration Buildings. The aim of this plan was to reduce energy consumption in these buildings by at least 20%. The associated investment of this plan amounted to €2,350m with the expectation of creating 50,000 direct and indirect jobs.

The Renewable Energy Plan 2005-2010, detailed in a Spanish Communication to the European Commission[14], established the objectives for this period for the electric, thermal and biofuels sectors. The aim was that, by 2010, the overall contribution of renewable sources to primary energy consumption would be 12.1% and that this source of energy would cover 30.3% of net energy consumption. This represented a challenge as well as an opportunity for technological innovation and funds were to be made available for this purpose from the Technical Investigation Stimulation Programme.

As mentioned in the Communication, the way in which energy needs are satisfied has important social, economic and environmental implications. In socio-economic terms, the Renewable Energy Plan 2005-2010 contributed to improving the Spanish industry base, led to regional development, and generated employment. In the latter case, it was added that the geographic distribution of renewable energy sources contributes to a more effective distribution of employment, benefiting in many cases areas which were typically characterised by fewer employment opportunities.

The Union Institute of Work, Environment and Health (ISTAS) is a self-managed foundation which aims to foster social progress in order to improve workers' conditions, to protect the environment, and to promote health among Spanish workers. ISTAS was created in 1996 under the Ministry of Work. In 2006, the Reference Centre for Renewable Energies and Employment was created within this Institute to promote employment creation in the renewable energies sector (see Box 2.1 below). It also recognises the potential of the sector to make a positive contribution to employment creation.

[13] http://www.mma.es/secciones/cambio_climatico/areas_tematicas/mitigacion_cc/pdf/inf_seg_llee_mar2010.pdf

[14] http://www.mma.es/secciones/cambio_climatico/pdf/dec280_final.pdf

Box 2.1: The Reference Centre for Renewable Energies and Employment[15]

The Reference Centre for Renewable Energies and Employment was created in 2006 to promote renewable energies and contribute to employment creation in the sector. Its main activities are the monitoring and analysis of renewable energy, generation of employment and professional development. One of the features of the Centre is the international dimension of either north-south cooperation for renewable energy development, and collaboration with other institutes and organisations, technical or unions in the relevant field. Partnerships established across several institutions highlight the activity related to the study of green jobs.

Under a project developed by the United Nations Programme for the Environment (PUMA) and Sustainlabour (International Labour Foundation for Sustainable Development), the Spanish Government took part in the development of the Training Manual entitled 'Climate Change: Consequences on Employment and Union Participation'[16]. The aim of the Manual was to contribute to filling the knowledge gaps that may exist among Union workers in relation to current environmental issues at a global and local level.

Among the objectives set, the Manual is expected to strengthen understanding on climate change, including the policies being implemented to mitigate it and adapt to it, and their consequence on employment. It is established that unions play a crucial role in creating awareness among employees about the impact of climate change on employment, the promotion of (and demand for) programmes to mitigate it and adapt to it, and in furthering access to training.

The Autonomous Community of Extremadura, in western Spain, is considered as a case where the renewable energy sector can be seen as an employment niche and an economic activity with sustainable development prospects. In this region, it is estimated that there are around 3,050 jobs in enterprises which install and provide maintenance services to plants whose fuel comes from a 'clean' source. In addition to this, more than 2,000 people work in recycling or water treatment activities, a further 1,000 in the eco-construction and energy-efficiency sector and a further 1,250 jobs are attributed to businesses which supply the eco-constructions sub-sector. In addition to this, 290 jobs were created in 2009 in businesses that manufacture electric equipment for efficient lighting.

As of March 2010, Extremadura was to participate with Austria, the UK and Poland in the OECD project labelled 'Climate Change, Employment and Local Development: Promoting Green Jobs'. The aim of the project was to identify good international practices in relation to public policies to promote a green economy, quality employment and environmental conservation.

[15] http://www.istas.net/web/index.asp?idpagina=3604

[16] http://www.unep.org/labour_environment/PDFs/training/CC-COVERTOINTRO-SP.pdf

United Kingdom

The UK's policies relating to climate change and reducing CO_2 emissions are well documented and reflected in a number of policy documents[17] and The Climate Change Act 2008. Though the UK government changed in 2010, its commitment to mitigating and reversing the effects of climate change did not change, so there may not be a significant amount of change in policy over the short to medium term. However, the new government will take a less interventionist line in terms of industrial policy. UK policy in this area more generally is directed at ensuring carbon reductions of 80% by 2050 through, for example, levying high road tax on fuel inefficient cars, subsidies to suppliers of renewable energies, and a requirement for large energy users to carry out energy audits.

Policy documents all make reference to skills, whether these relate to the high-level scientific skills which will be required to bring about the innovations which will safeguard the environment, to sector-specific skills, especially those in agriculture, construction, manufacturing (via designing waste out of products), and the energy sector. But there is an implicit assumption that the existing mechanisms for the delivery of employment policy and training are sufficient to meet the demand of a greener economy. Government's role in many instances is to ensure that there is sufficient information to guide those agencies which are charged with delivering employment and training policy. Hence Sector Skills Councils, which are responsible for the design and delivery of training programmes for their respective sectors, are expected to adapt their programmes in the light of information which arises about green jobs.

The UK vocational education and training (VET) system is characterised by its market-oriented, voluntarist approach. In other words, the various agencies responsible for the design and delivery of VET are expected to anticipate trends in the market and adapt their provision accordingly (the demand-led approach). It is up to employers and individual learners if they wish to engage with the system (the voluntarist aspect). By delivering training which is relevant to the needs of employers and learners, in that it delivers economic value, this will drive up levels of participation. Hence there is a great deal of emphasis upon collecting labour market information and communicating this effectively to employers and the workforce.

A break with this policy emerged with the publication by the previous government of the policy document New Industry New Jobs (NINJ)[18] in 2009, which advocated skills activism. This might be interpreted as a need for the public sector to intervene where the current VET system might be at risk of sub-optimally delivering the skills the economy needed. NINJ identified the low-carbon sector and ultra-low-carbon vehicles as ones which were economically valuable and which might require support to reach their potential.

Skills for Growth, the policy document published at the end of 2009, commented:

'As we emerge from the banking crisis and rebuild the British economy, the skills system needs a stronger focus towards strategic skills, businesses need to contribute more to shaping demand for skills, and learners need to be able to choose where they train and what they study to drive competition and improve courses.

[17] http://www.defra.gov.uk/environment/climate/documents/climate-change-plan-2010.pdf

[18] http://www.berr.gov.uk/files/file51023.pdf

This skills strategy addresses all these problems. It is, in many respects, a radical shift in our national priorities. It sets out an active approach to equipping this country for globalisation by making sure we have the skills that underwrite the industries of the future; skills for high-tech, low carbon driven growth. We are committed to investing in these strengths, not least because it is employment in these high-value added, skilled occupations that drives the growth that underwrites everything else we want to achieve as a society.' (p.2 Skills for Growth, 2009)[19]

The same document went on to say in regard to policy developments in the low-carbon sector (Sector Skills Accord for renewable energy):

'As part of the renewable energy skills strategy, the British Wind Energy Association (BWEA) is leading collective employer action to tackle skills gaps at technician level and attract people to their rapidly expanding industry. Lead employers, sector bodies and awarding bodies have developed a voluntary Sector Skills Accord. Employer commitments include resources to develop industry specific National Occupational Standards and qualifications, new apprenticeship frameworks, career pathways and STEM guidance.' (p. 57, Skills for Growth).

The inquiry entitled, *Strategic Skills Needs in the Low Carbon Energy Generation Sector*, which was conducted as part of the National Skills Audit[20], published in 2010, revealed that there is considerable uncertainty attached to the extent of job creation in the sector over the medium term. In particular, it was unclear how Government would develop policy in relation to energy generation and how employers might react, but all of the pointers suggested significant gross employment growth. However, the sector was perceived to be hampered by skill shortages for people typically qualified in science, technology, engineering, and mathematics (STEM) subjects. This is an area in which the country as a whole has observed economy-wide shortages. So it is difficult to be sure about the extent to which this reflects a specific problem relating to green jobs, resulting from green technical change occurring at so fast a pace that the supply side cannot keep pace, or more general problems which just happen to be felt by low-carbon sectors. Nevertheless, it is clear that skill shortages can act as a drag on industrial development and thereby employment growth.

Despite the prominence given to low-carbon industries in skills policy it is difficult to identify a specific UK green employment policy. Rather the existing system is being pressed into assessing the potential for green employment growth and the skill needs which are likely to arise, and to adapt its policies accordingly. Hence the references above to the Sector Skills Councils assessing the demand for different types of green skills.

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[19] http://webarchive.nationalarchives.gov.uk/tna/+/http://www.bis.gov.uk/wp-content/uploads/publications/Skills-Strategy.pdf/

[20] http://www.ukces.org.uk/upload/pdf/UKCES%20Low%20Carbon%20Full%20Report%20v4.pdf

3 Model-Based Assessment of Impacts

3.1 Introduction

Overview

This chapter describes the results of the modelling exercise carried out using a version of the E3ME model that has been extended to cover occupation and skills requirements. Although the E3ME model can be used for forecasting (determining the most likely outcome under certain assumptions), our approach to this analysis is *scenario-based*. It is important to emphasise that the future is not fixed and preordained, but subject to the effects of a huge range of decisions being made both within Europe and more broadly about both environmental and other matters. The quantitative scenarios that are sketched out highlight the range of possibilities as well as the sensitivity of particular outcomes to different assumptions.

A baseline set of projections is set up and then a series of impact scenarios are defined. The differences in outputs between the model runs (usually given in percentage terms) show the impacts of the changes in the inputs in each scenario.

Structure of this chapter

The following section describes the baseline that was used and the method by which the E3ME model was calibrated to the published figures. Section 3.3 describes the scenario inputs that were used.

Sections 3.4 to 3.8 describe the impacts of the policies designed to meet the 2020 targets, including environmental, economic and labour market effects.

Sections 3.9 and 3.10 describe supplementary scenarios, covering the use of revenues from market-based instruments and the sensitivity of results to key assumptions.

3.2 The Baseline case

The role of the Baseline in the modelling

Considerable time and effort is devoted to setting up baseline forecasts for modelling exercises and this is an important part of the overall assessment. There is sometimes a perception that the baseline may not be that important as attention focuses on differences from base, so that the values in the baseline itself do not matter. However, this viewpoint misses some of the more subtle aspects of the analysis and may introduce bias into results. For example:

- in scenarios that include fixed targets, the figures in the Baseline indicate the amount of further work that must be done in the scenarios to meet the targets
- in scenarios with changes in energy or emission prices, the Baseline energy prices are important; a tax of €10/tCO_2 has double the impact if the starting price is €50/tCO_2 than if it is €100/tCO_2 (a 20% increase rather than 10%)

The first of these points is clearly important in the scenarios that we assess in this study (see Section 3.3), as they are largely defined by fixed targets.

Clearly for presentational purposes a credible baseline is also important. It is therefore important that the underlying assumptions in the Baseline scenario are outlined so that it is clear that the modelling is not introducing bias by using extreme or unrealistic values.

The PRIMES Baseline

The E3ME model comprises a historical database and baseline forecast. The software allows for the calibration of the baseline forecast to a published set of projections, using a system of internal scaling factors. For this project the model has been calibrated against a set of projections published by the European Commission. These projections are commonly referred to as the PRIMES projections, reflecting the model used to produce the figures (E3MLab, 2008). In this study we use the 2009 Baseline version (European Commission, 2010).

This is an appropriate baseline to use because:

- it covers the EU by Member State
- it covers the time period up to 2030
- it includes consistent projections of economic development and energy demand
- it has previously been verified at European and Member-State level
- it is widely used, providing consistency with other studies

Environmental policy in the baseline

It is important to note that the Baseline includes already includes a lot of existing environmental policy and any related labour market changes that it leads to. Roughly half of the reduction in CO_2 emissions from 1990 levels required to meet the 20% emissions target is included in the baseline case.

Details of the policies that are included are provided in the accompanying documentation (European Commission, 2010, pp17-19) but they include the ETS and other policies such as the Large Combustion Plant Directive and IPPC Directive. The scenarios that are described in the next section show the impacts of additional policy to that which is already covered.

This means that results from the modelling exercise should be interpreted as the impacts of new policies, rather than the general effects of all environmental measures. An alternative approach would have been to create a scenario with no policy with which to compare the results but this would have been very difficult to implement in practice as it would have required a detailed identification of all existing policy (and been inconsistent with the historical data)[21].

Had we used a starting point in which there is no environmental policy, the impacts would undoubtedly have been larger but within the same order of magnitude. The general trends and conclusions from the exercise would not be changed.

Treatment of the recession

The economic crisis and subsequent recession are included in the Baseline used for this study. The PRIMES Baseline includes a treatment of the recession, including potential longer-term impacts. We have supplemented this with the most recent data available to get as accurate a picture as possible. On the labour market side, the CEDEFOP projections include estimates of the impacts of the recession, made in 2009.

Policy inputs

The European Recovery Programme of 2008 focused on reforming the financial sector, sustaining demand, boosting investment, consolidating the fiscal stance, and retaining and creating jobs. The green dimension of this recovery plan is reflected by the fact that the recovery measures are complemented by frontloading structural measures to improve energy efficiency, strengthening the use of renewable energy, and promoting the rapid take up of green products. Such measures are included in the 2010 PRIMES Reference Scenario.

[21] The only realistic possibility that was considered was to use an ETS price of zero, but the aim of this study was not to assess specific policies, and there is still the problem of dealing with history (e.g. new investment in renewables that would not have taken place had there been no ETS).

Member States' green recovery plans

E3ME was also used recently to provide an evaluation of the environmental components of several Member States' stimulus packages (see Cambridge Econometrics and Ecorys, 2011, forthcoming). The study was carried out on behalf of DG Environment.

Results from the project showed that the green elements of most European countries' recovery plans were quite small in scale and focused on:

- energy-efficiency measures
- transport infrastructure
- vehicle scrappage schemes
- investment in renewables
- funds to support eco-innovation

Although none of the measures included specific employment subsidies, the modelling results showed that the net impact was a temporary increase in employment of around 0.1-0.2% during the recession period. These were mainly jobs 'saved' (i.e. not lost in the recession) rather than new jobs that would have been created, and mainly in the construction and engineering sectors.

Perhaps surprisingly, very few of the green policies specifically targeted vulnerable groups. This could have been because other policies, including changes to general taxation and benefits, were seen to be performing this role. Nevertheless, it is noted that this separation of environmental and social policy is consistent with the previous findings in Chapter 2.

These policies are for the most part excluded from the baseline (and scenarios) as they were announced too late. However, their impacts on energy use and emissions were found to be modest (up to 0.5% change) so would not change the general conclusions from the analysis.

Additional processing

The majority of published outputs from the PRIMES Baseline can be incorporated into the E3ME solution. This includes the sectoral economic projections, energy and ETS prices, projections of energy demand by sector and by fuel, and sectoral CO_2 emissions. E3ME's Energy Technology sub-model of electricity capacity and generation also makes use of some of the more detailed outputs. However, in order to meet E3ME's requirements, it was necessary to carry out some additional expansion and processing.

- Classifications were converted – as E3ME and PRIMES use similar data sources, the classifications also tend to be quite similar. There are, however, some differences, for example E3ME has more disaggregation of service sectors.

- Point estimates for occasional years were converted to annual time series – a simple interpolation method is used, except between 2005 and 2010 where we used a combination of historical data and short-term forecasts from the AMECO database (to take into account more recent data from the recession).

- Additional social and economic variables were estimated – only a small set of economic variables (GDP and the ones that are direct drivers of energy demand) are published in the PRIMES Baseline. E3ME requires a complete specification of the national accounts so other variables must be estimated. The procedure followed to achieve this is described below.

These additional steps were carried out using software algorithms based in the Ox programming language (Doornik, 2007). The result of this exercise is a set of baseline projections that is both consistent with the published figures and the integrated economy-energy-environment structure of E3ME.

Expanding the economic variables

The published PRIMES figures include a comprehensive set of projections for Europe's energy systems and the resulting emissions. Economic activity is provided as a driver of energy demand, but the figures tend to be provided only at an aggregate level (e.g. GDP, household spending or value added for some energy-intensive sectors). As the E3ME model is built around the complete structure of the national accounts, this means that the projections for other economic variables must be estimated.

This process was carried out using a methodology that is as consistent as possible between the economic variables, for example ensuring that the components of GDP sum to the correct total, and that similar indicators, such as gross and net output, follow the same patterns of growth. A set of software algorithms was used to carry out this exercise, written in the Ox software package.

Proxy variables that were used

The published figures provide economic projections for GDP, gross value added (GVA), and household incomes in constant prices. It was necessary to estimate values for other variables.

Real economy

E3ME's projections of GDP and GVA were set to match the published figures. Economic output (which is gross, defined as intermediate demand plus GVA) was set to grow at the same rate as GVA.

E3ME's total consumer spending was set to grow at the same rate as published household income figures, following the standard economic assumption that, in the long run, all income is spent. Detailed consumer spending by spending categories was set to grow using historical trends and was then constrained to the total.

Other components of output (at sectoral level), mainly investment and trade, were also set to grow based on historical rolling averages and then constrained to the total output that was based on the GVA projections.

Price variables

Prices for energy-related industries were set to be consistent with the published energy price assumptions. Prices for other industries were projected using historical trends.

Labour market variables

Employment, labour supply (participation rates), and unemployment rate projections in E3ME are based on recent work on Forecasting Skills Demand and Supply carried out for CEDEFOP (Wilson et al, 2010). The historical data for employment are taken from the Eurostat national accounts breakdowns and converted into the E3ME classification, while the labour supply data are taken from the European Labour Force Survey (LFS). Unemployment data are based on the definition used in the AMECO database.

The Baseline projections of all of these are the result of E3ME modelling combined with comments from national experts[22]; they are based on the GDP and economic growth projections that were used for the previous version of the PRIMES Baseline (adjusted for the recession) and can therefore be regarded as reasonably consistent with the economic figures and projections of energy demand and emissions. The

[22] Details of comments from national experts and how they were incorporated into the E3ME model are described in Wilson et al. (2010).

methodology that was used to produce the baseline employment projection is described in more detail in Wilson et al (2010).

The Baseline growth rates for employment at the European level, by broad sector, are presented in Table 3.1, which is taken from the most recent CEDEFOP report and updated for more recent data. A version that shows disaggregation by Member State is provided in Appendix C.

Table 3.1: Baseline Employment by Broad Industry (Average Annual Growth Rate)

BASELINE EMPLOYMENT BY BROAD INDUSTRY (AVERAGE ANNUAL GROWTH RATE)

Broad industry	2000-08	2009-25
Agriculture	-2.3	-2.0
Extraction industries	-0.6	-2.0
Basic manufacturing	-0.8	-0.7
Engineering & transport equipment	0.1	-0.4
Utilities	-1.5	-0.6
Construction	1.8	-0.1
Distribution & retail	1.5	0.4
Transport & communications	0.9	0.4
Business services	3.1	1.2
Public services	1.6	0.1
Total	1.1	0.1

Note(s): Figures are for EU27 + Norway and Switzerland.
Source(s): CEDEFOP, E3ME, Cambridge Econometrics.

Occupational structure in 2010

Occupational change is driven by a combination of sectoral change and technological change taking place in each Member State. Appendix B provides further details of how the projections by occupation are produced. In order to show how the green agenda is likely to affect the occupational distribution of employment it is helpful to provide baseline information relating to the current occupational structure of the EU27 (plus Norway and Switzerland) and how this is changing (including effects of current environmental policy). Figure 3.1 and Figure 3.2 show the current occupational structure in broad terms. It shows Europe's dependence upon jobs which are traditionally associated with highly skilled and qualified people (senior managers, professionals, and associate professions) as well as those which are relatively low skilled (such as service workers, plant and machine operatives, and elementary occupations).

Figure 3.1: Current Occupational Structure of EU27+NO+CH, 2010 (ISCO 1 digit)

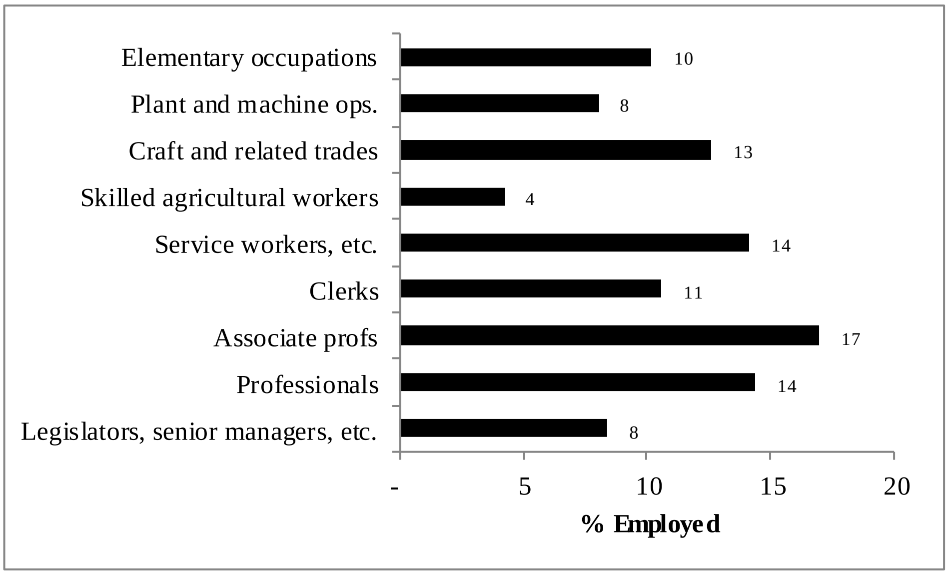
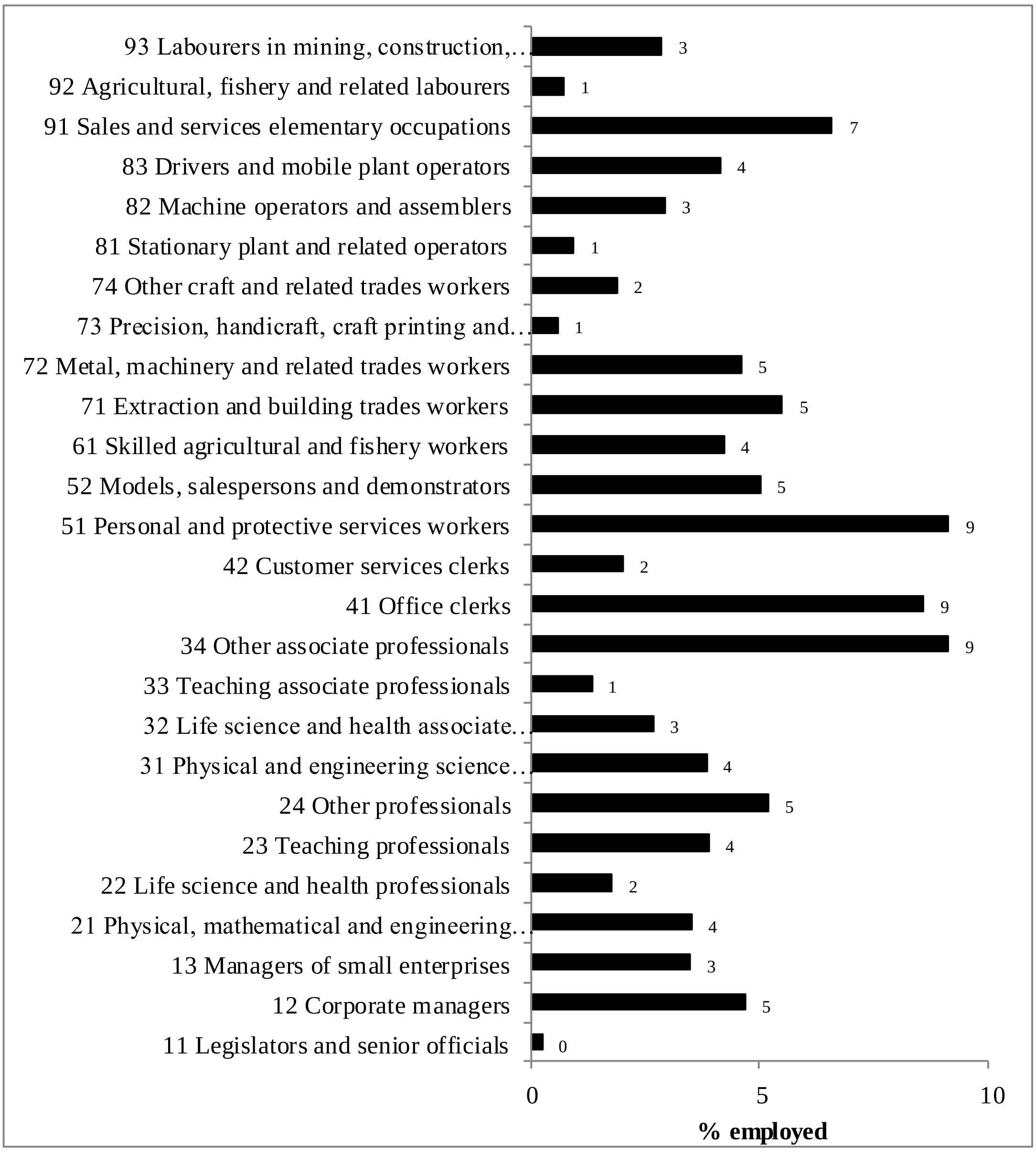


Figure 3.2: Current Occupational Structure of EU27+NO+CH, 2010 (ISCO 2 digit)



Projected occupational change to 2020 under the baseline scenario

The overall direction of change in the occupational structure of employment across the EU (and observable in most countries and other regions within it too) is towards an increase in the number of both relatively high skilled and low skilled jobs. This trend is observable in the projections of occupational change. It is notable that under the Baseline Scenario the general trend in the occupational structure of employment is towards a bifurcation in occupational structure. Growth is projected for many relatively high skilled occupations but also for a number of jobs which require relatively fewer skills (e.g. elementary occupations and sales and service workers). Jobs which historically have required intermediate level skills, such as skilled trades jobs, are projected to show a decline in many instances (see Figure 3.3 and Figure 3.4). This long-run trend in the occupational structure has been reported elsewhere (e.g. CEDEFOP, 2010; Wilson et al, 2011).

The projections of occupational change indicate relatively substantial growth in professional and associate professional occupations and, to a slightly lesser extent, corporate managers. These are jobs which are typically associated with high level skills and qualifications and, in some countries, are associated with skill shortages sometimes, as a consequence of the pace of occupational change taking place (e.g. in the UK – see IFF, 2009).

The projections of change in employment levels in various occupations (so-called expansion demands) do not incorporate replacement demands. Replacement demands take into account of the number of people who are expected to exit an occupation for various reasons (such as retirement, family formation, etc.). Taking replacement needs into account suggests a substantial growth in the number of people required to fill jobs in all occupations over the next decade. Figure 3.3 and Figure 3.4 indicate the direction of change in the Baseline, which results in a large part from projected changes in the sectoral composition of employment. For most occupations these are positive but for others such as clerks, skilled agricultural workers and crafts and related trades they are negative, indicating declining employment levels. The figure also shows the scale of replacement needs, which are large and always positive.

Data is available at a national level in Appendix C.

Figure 3.3: Occupational Change 2010-20, Baseline Scenario, EU27+NO+CH (ISCO 1-digit)

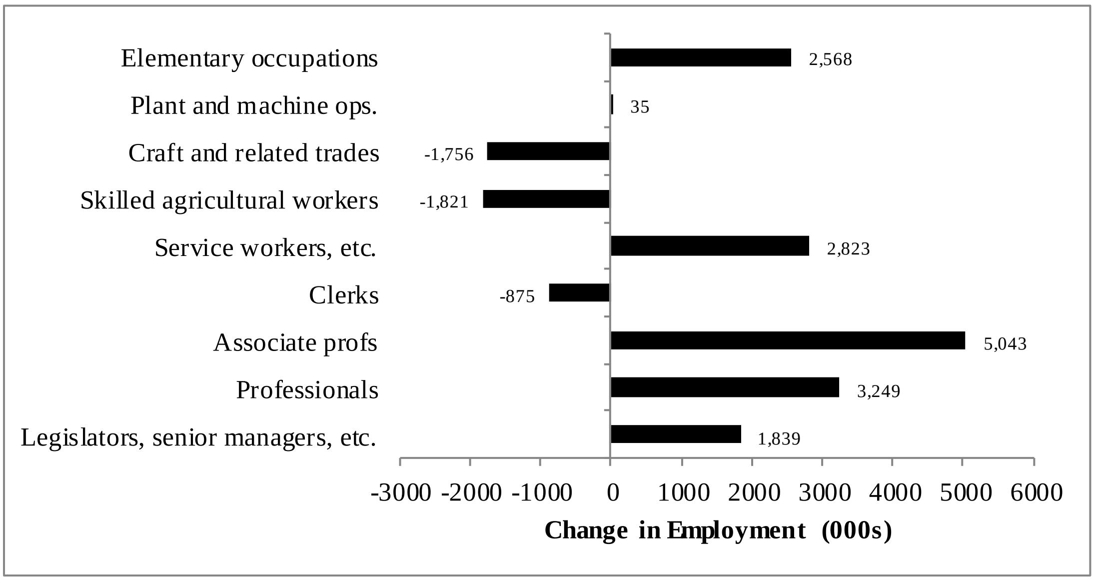
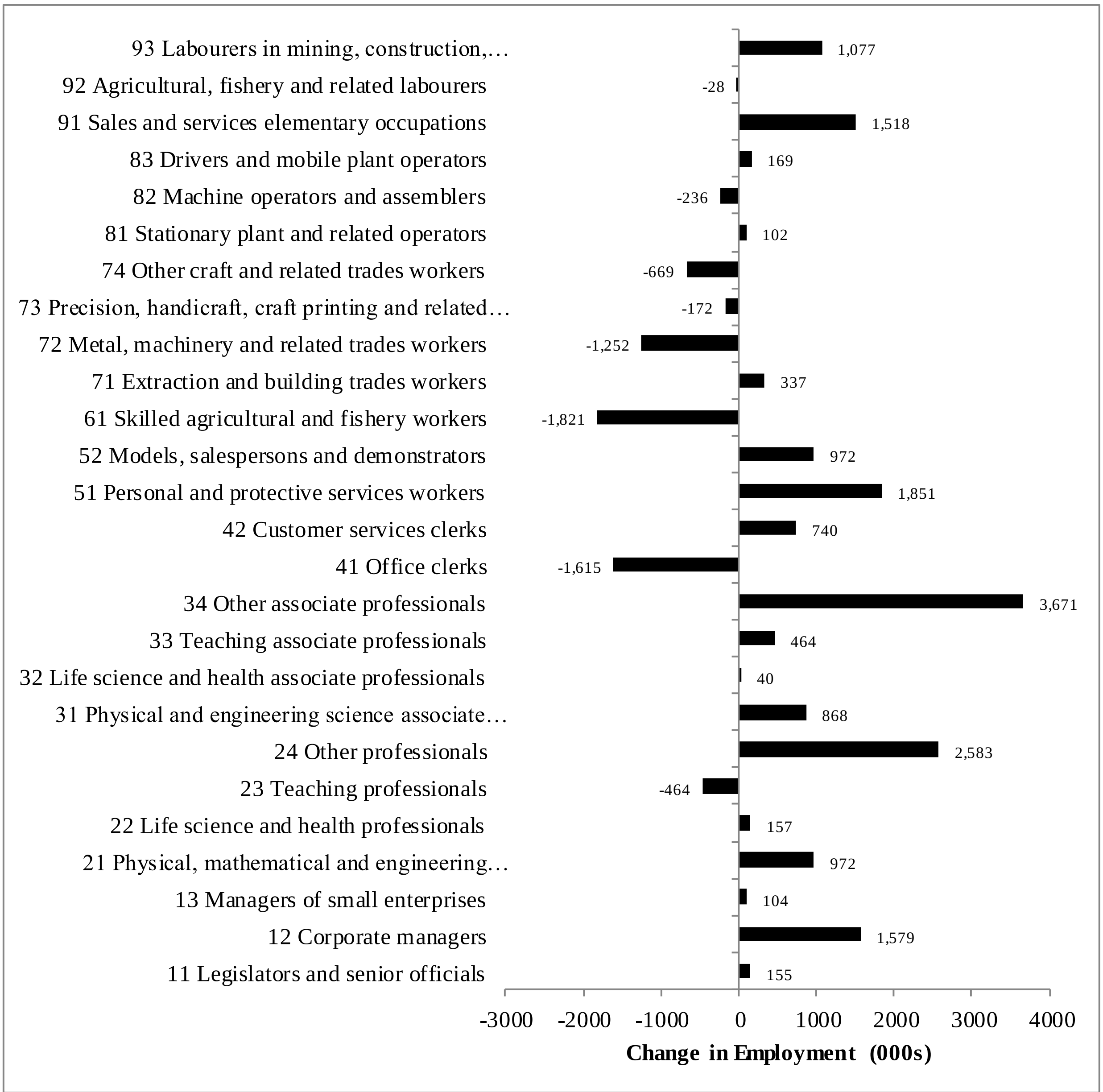


Figure 3.4: Occupational Change 2010-20, Baseline Scenario, EU27+NO+CH (ISCO 2-digit)



3.3 Modelling scenarios

The first group of scenarios focuses on addressing the EU 2020 targets[23] which contain the following components:

- a reduction in EU greenhouse gas emissions of at least 20% below 1990 levels
- 20% of EU energy consumption to come from renewable resources

In one of the scenarios we also consider the objective for a 20% improvement in energy efficiency.

The second set of scenarios, described towards the end of this section, consider the possible use of revenues from market-based instruments, and what might happen if skills mismatches occur.

Finally, key sensitivities are assessed.

Reference scenario

In the first scenario, hereafter referred to as the Reference scenario, policies from the 2010 PRIMES Reference case (European Commission, 2010) were introduced. This scenario is based on the same macroeconomic assumptions, energy import prices, technology and policy assumptions as the 2010 PRIMES Baseline (see Section 3.2). In addition, the Reference scenario also includes the agreed legally binding targets on greenhouse gas emissions and renewables (but not the objective for energy efficiency).

It would be possible to calibrate E3ME to the PRIMES projections directly, using the procedure described in Section 3.2. However this would not give us an estimate of labour market impacts of implementing the additional policies. Therefore each of the policy assumptions, as well as the legally binding targets, in the Reference scenario that was additional to the Baseline was translated into an input to the model.

Table 3.2 summarises these policies.

[23] A 20% cut in emissions of greenhouse gases by 2020 compared to 1990 levels (increasing to 30% if other countries make similar commitments), a 20% increase in the share of renewable energy and the objective of a 20% cut in energy consumption.

Table 3.2: Policies Included in the 2010 PRIMES Reference Scenario

POLICIES INCLUDED IN THE 2010 PRIMES REFERENCE SCENARIO

Measure	How the measure is reflected in PRIMES
TVs (+labelling) Regulation 2009/642/EC Electric motors Regulation 2009/640/EC Circulators Regulation 2009/641/EC Freezers/refrigerators (+labelling) Regulation 2009/643/EC	Adaptation of modelling parameters for different product groups for eco-design and decrease of perceived costs by consumers for labelling (which reflects transparency and the effectiveness of price signals for consumer decisions). As requirements and labelling concern only new products, the effect will be gradual (marginal in 2010; rather small in 2015 up to full effect by 2030). The potential envisaged in the eco-design supporting studies and the relationship between cost and efficiency improvements in the model's database were cross-checked.
Recast of the EPBD 2010/31/EU9	New building requirements are reflected in technical parameters of the model, in particular through better thermal integrity of buildings and requirements for new buildings after 2020.
Labelling regulation for tyres 2009/1222/EC	Decrease of perceived costs by consumers for labelling (which reflects transparency and the effectiveness of price signals for consumer decisions).
Regulation Euro VI for heavy duty vehicles 2009/595/EC	Emissions limits introduced for new heavy duty vehicles.
RES directive 2009/28/EC	Legally binding national targets for RES share in gross final energy consumption are achieved in 2020; 10% target for RES in transport is achieved for EU27, as biofuels can easily be traded among Member States; sustainability criteria for biomass and biofuels are respected; cooperation mechanisms according to the RES directive are allowed and respect Member States indications on their 'seller' or 'buyer' positions.
GHG Effort Sharing Decision 2009/406/EC	National targets for non-ETS sectors are achieved in 2020, taking full account of the flexibility provisions such as transfers between Member States. After 2020, no strengthening of targets is assumed.

Note(s): Policy measures additional those in the PRIMES 2010 Baseline.
Source(s): European Commission (2010).

The Reference scenario policies were carefully translated into model inputs based on information available from European Commission (2010), as well as other sources. The policies are categorised into two types; regulations and market-based instruments (MBI). In addition, other assumptions such as the ETS price were also introduced to the modelling so that the E3ME environmental results mimic the PRIMES Reference scenario projections. Table 3.3 describes how the Reference scenario policies were modelled in more detail.

Table 3.3: How the Policies get Translated into E3ME Inputs

HOW THE POLICIES GET TRANSLATED INTO E3ME INPUTS	
Policy measure	**How the measure is reflected in E3ME**
Regulations	
TVs (+labeling) Regulation 2009/642/EC Freezers/refrigerators (+labeling) Regulation 2009/643/EC Circulators Regulation 2009/641/EC Recast of the EPBD 2010/31/EU9	- improvement in energy efficiency through exogenous reduction in household and commerce demand for energy (source: PRIMES Reference scenario projection compared to the Baseline) - assumed labeling costs do not lead to price increases (source: EC press release RAPID) - assumed slight increase in average price estimated in construction industry to reflect higher costs, derived from an estimate of £100 per energy performance certificate (source: UK Government)
Labelling regulation for tyres 2009/1222/EC	- a small exogenous reduction in middle distillates demand from road transport (source: PRIMES Reference scenario projection compared to the Baseline)
Electric motors Regulation 2009/640/EC	- not modelled
Regulation Euro VI for heavy duty vehicles 2009/595/EC	- not modelled
GHG Effort Sharing Decision 2009/406/EC*	- additional regulation costs to the non-ETS sectors to meet the target (half of the reduction target met by regulation the other half by MBIs) - emissions targets calculated from PRIMES Reference scenario projections compared to the Baseline
RES directive 2009/28/EC (Power Generation)	- additional renewable investment made by electricity sector (investment figures come from PRIMES Reference scenario) - RES in power generation targets are met nationally (information from PRIMES Reference scenario) - the price of electricity increases to finance

HOW THE POLICIES GET TRANSLATED INTO E3ME INPUTS

Policy measure	How the measure is reflected in E3ME
	investment in renewables
RES directive 2009/28/EC (Transport)	- exogenous shift in transport fuel demand from middle distillates to biofuels[24] (source: PRIMES Reference scenario projection compared to the Baseline) - a 1% increase in average fuel price for road transport to reflect higher costs of biofuels (source: CE, DECC, 2010[25])
MBIs	
EU-ETS	- full ETS implementation (roughly half of the allowances are auctioned[26])
GHG Effort Sharing Decision 2009/406/EC*	- introduction of carbon pricing to the non-ETS sectors to meet the target (half of the reduction target through MBIs, the other half through regulation) - emissions targets calculated from PRIMES Reference scenario projections compared to the Baseline
Other inputs	
ETS price	- adjusted to meet the ETS emission targets in the Reference case - ETS price assumption in the Baseline case from PRIMES
Revenue recycling	
Revenues from MBI	- recycled through reductions in income tax (at national level) - half of ETS revenues get recycled through reductions in income tax (at national level)
Energy efficiency	
No policy measures	- not modelled - energy efficiency increase is 9.4% in the Reference scenario (compared to 7.4% in the PRIMES 2009 Baseline)
Other assumptions	
Emissions from non-energy use	- get included in effort-sharing
Non-GHG emissions	- assumed to fall in line with CO_2

Source(s): PRIMES Reference scenario projections (European Commission, 2010) and Cambridge Econometrics' own interpretation.

[24] It is noted that this directive also includes other fuels such as green electricity and hydrogen, but this is generally not reflected in the PRIMES scenario and we adopt a similar assumption.

[25] UK data show that bioenergy is around 10% more expensive per unit of energy, therefore an increase in its contribution to 10% of total fuel would yield a maximum price increase of 10%*10%=1%.

[26] DG Climate: 15 Mar 2011 EU ETS phase 3 allowance auctions: Statement by Jos Delbeke, Director-General for Climate Action. This represents the share used by power generation.

The Reference scenario is the most difficult scenario in terms of interpretation, due to its complex mix of policies. The remaining environmental policy scenarios are more straight forward and can be grouped into three broad categories:

- scenarios where the targets are the same but met in different ways
- scenarios with different targets
- sensitivity analysis

Scenarios where the targets are met in different ways

In the Reference scenario, the 20% renewable and GHG reduction targets are assumed to be met through a combination of policies, including both regulation and MBIs. Two scenarios were set up to investigate the impacts on labour markets when the targets are met by different means.

Regulation

The first scenario assumes that the Reference scenario's GHG and renewables targets are met by regulation only, apart from existing policy (e.g. the ETS). Under the Regulation scenario it is assumed that there are costs associated with these regulations and the emitters will have to bear the cost increases (or pass on through their prices). Since there are no MBIs under the Regulation scenario, there are no revenues collected and therefore there is no revenue recycling.

MBIs

In this case, the environmental outcomes are also the same as in the Reference scenario, but the means of achieving the targets is purely 'market-based', beyond existing regulatory policy. The simplest way of doing this (and economically most efficient in terms of effort-sharing) was to assume a single carbon trading scheme within Europe covering all sectors and all Member States. This means that individual Member States may not meet their targets, but Europe as a whole does. As in the Reference scenario, all revenues generated from MBIs are recycled via income tax reductions (at national level).

Scenarios with different targets

The second group of environmental policy scenarios investigates the impacts of having different and/or additional environmental targets to those adopted in the Reference scenario, while still using similar policy measures. There are two scenarios within this group: the 30% GHG target and a case where the 20% energy-efficiency objective is met.

30% target

This scenario moves the 20% GHG target to a 30% reduction. The new targets are assumed to be achieved through a mixture of MBIs and regulation, essentially (where it makes sense to do so) scaling up the policies in the Reference scenario.

Information regarding the split between reductions in emissions from the ETS and non-ETS sectors comes from the EC Communication (European Commission, 2010b). The 30% target reductions are represented as (compared to 2005 levels):

- 34% for ETS sectors
- 16% for non-ETS

This is compared to 21% and 10% reductions in the Reference scenario (compared to 2005 rather than 1990 levels). We assume that all the reduction in emissions is domestic.

Energy-efficiency objective

In this scenario, the energy-efficiency objective is also met, through a series of additional regulatory and market-based measures. The target is defined as a reduction in final energy demand and the target of 20% is defined as a 20% final energy demand reduction in 2020 compared to PRIMES 2006 Baseline projection reference.

An estimate of the additional investment required to achieve these reductions in energy consumption is added to this scenario. The calculation is based on the findings from the *World Energy Outlook 2010* (IEA, 2010) which suggests that for every 1% reduction in energy consumption, the EU buildings sector must invest €31.4bn a year. This is a fairly crude calculation with quite strong assumptions but it does give a rough indication of the scale of investment required[27].

Revenue recycling scenarios

One of the benefits of several of the scenarios, but particularly the MBI case, is that they generate revenues for national authorities. A further set of scenarios assesses ways in which these revenues could be used, either to provide additional benefits or to offset some of the costs of environmental policy. The options that were considered were variants of the MBI case (to show the largest effect) and are:

- all revenues offset by income tax reductions
- one quarter invested in transport, three quarters in income tax reductions
- one quarter invested in machinery, three quarters in income tax reductions
- one quarter invested in buildings, three quarters in income tax reductions
- one quarter invested in renewables, three quarters in income tax reductions
- all revenues used for investment in transport, machinery, buildings and renewables (one quarter each)
- all revenues paid out through higher benefits rates
- all revenues offset through employers' social security reductions

The results from these scenarios are presented in Section 3.9.

Imbalance scenario

The imbalance scenario addresses the issue that there may be skills bottlenecks that constrain economic activity, but at too detailed a level to be picked up in the E3ME model (as discussed in Chapter 5).

In this scenario we define an imbalance as a reduction in participation in the labour force due to skills mismatches. An arbitrary figure of -0.5% by 2020 was chosen; this is very likely to be a high estimate but will give an indication of possible impacts at the macroeconomic level. This scenario is presented as a worst-case scenario in which no measures are taken to correct the possible imbalances.

The results from this scenario are also presented in Section 3.9.

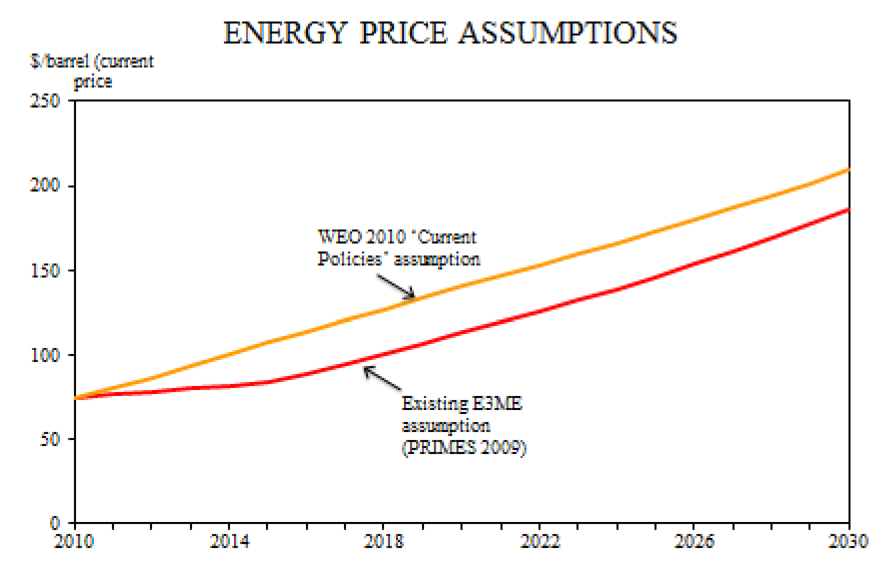
Sensitivity scenarios

One of the main uncertainties in the modelling is the level of future energy prices. This is important because it determines the amount of work that must be done by policy to meet the fixed targets (e.g. the relative price of renewables is affected), but it also has some sectoral effects that could impact on specific employment groups, and direct social effects from household energy consumption. We therefore implemented sensitivity scenarios in which different energy prices apply. It should be noted that in the sensitivity scenarios we did not then adjust the policies to meet the same target as in the main scenario; instead we simply show the additional impacts that follow from a higher energy price.

[27] This reflects a calculation that was used in the ongoing assessment being carried out for DG Energy. The assumptions underlying the calculation must be noted, for example that the ratio of investment to energy reduction is the same in all countries. In the WEO, the energy reduction also includes the effects of a carbon price but it is not possible to separate this from the investment effects. Nevertheless, the result gives a rough indication of the level of investment required.

Figure 3.5 shows the energy price assumptions that were used in the main scenarios and the high energy price assumption from the IEA's *World Energy Outlook 2010* (IEA, 2010) 'Current Policies' that was used in the sensitivity analysis.

Figure 3.5: Energy Price Assumptions



Source(s): European Commission (2010), IEA (2010).

Baseline sensitivity The first sensitivity scenario considers the impacts of higher oil prices on the Baseline. The results from this sensitivity testing allow for direct differentiation of the oil price effects.

Reference scenario sensitivity The second sensitivity scenario investigates the impacts of higher oil prices on the Reference scenario. The environmental targets in the Reference scenario are expected to reduce energy consumption, and therefore also exposure to energy price shocks, compared with the Baseline.

Rest of world action In this sensitivity scenario the rest of the world takes equivalent action to the EU, and this is represented by a similar increase in the prices of traded goods produced in non-EU countries (so that prices are equalised and there are no net competitiveness effects). No assumptions are made about revenue recycling in non-EU countries.

Table 3.4: Scenario Summary

SCENARIO SUMMARY	
Scenario	**Description**
Baseline and Reference case	
Baseline (ba)	PRIMES Dec 2009 Baseline.
Reference (ref/S2)	PRIMES April 2010 Reference scenario.
Scenarios where targets are met in different ways	
Regulation (S3)	Same targets as Reference case but achieved purely through regulation.
MBIs (S4)	Same targets as Reference case but achieved purely through MBIs.
Scenarios with different targets	
30% target (S5)	GHG reduction target of 30% instead of the 20% targets in the Reference case using the same mix of policies. ETS and non-ETS split information from DG CLIMA communication.
Energy-efficiency objective (S6)	Additional to the Reference scenario, the 20% energy-efficiency objective is met through a mixture of MBIs and regulation.
Revenue recycling scenarios	
Income tax reductions	All revenues offset by income tax reductions.
Investment in transport	25% invested in transport, 75% in income tax reductions.
Investment in machinery	25% invested in machinery, 75% in income tax reductions.
Investment in buildings	25% invested in buildings, 75% in income tax reductions.
Investment in renewables	25% invested in renewables, 75% in income tax reductions.
Broad investment package	All revenues used for investment in transport, machinery, buildings and renewables (25% each).
Social benefit rates	All revenues paid out through higher benefits rates.
Social security contributions	All revenues offset through employers' social security reductions.
Imbalances scenarios	
Skills mismatch	0.5% reduction in available labour supply.
Sensitivity scenarios	
Rest of the world action (Ss1)	Reference case run with rest of the world taking similar environmental actions to the EU (reflected in increase in extra-EU import prices).
Baseline with high oil price (Ss21)	Baseline run with a higher oil price assumption (WEO 2010 figures).
Reference case with high oil price (Ss22)	Reference case run with a higher oil price assumption (WEO 2010 figures).

Note(s): Code in parentheses represents the short name for each scenario.
Source(s): Cambridge Econometrics.

3.4 Environmental impacts in the policy scenarios

Figure 3.6 shows the impacts of the scenario inputs on CO_2 emissions. In the Reference case and Scenarios 3 and 4, the 20% GHG targets are met (this translates into a 7% reduction compared to the Baseline). In Scenario 5, this target becomes 30% so the corresponding fall in CO_2 emissions is larger. Scenario 6 does not have a fixed emissions target; the fall in energy consumption translates into lower emissions levels (including lower direct emissions and indirect emissions from electricity generation). These reductions are also substantial in size.

Most of the effects are seen after the end of ETS Phase II in 2012. Much of the effort to reach the 20% targets happens after 2015, when more renewable capacity comes on stream.

Carbon prices

The carbon prices required to meet the emissions targets are higher in the Reference case and Scenarios 3 and 4 than in the Baseline case. The targets have been calculated to match the reduction in energy emissions from the PRIMES projections; non-energy and other GHG emission are assumed to fall by similar amounts as in those model runs.

Although in the Reference case there is a large share of renewables, the model results suggest that this alone is not enough to meet the 20% emission target and a higher carbon price is therefore also necessary. In all cases the emission reductions are domestic; the use of CDMs would result in a lower carbon price.

As one would expect, a higher carbon price is required to meet the 30% target, although in reality this could be reduced considerably by the use of CDMs which have not been incorporated here. Expectations of higher prices are added to the model in this scenario to limit the construction of new coal-fired electricity plants. Even so, the model results suggest a much higher carbon price for the ETS sectors than for the non-ETS sectors. However, this is partly due to data classification issues so should not regarded as a prediction of future prices; a much more comprehensive analysis is required, which is not the subject of this report.

The carbon price in Scenario 6 is zero, because the reductions in energy use alone are enough to meet the 20% emissions target.

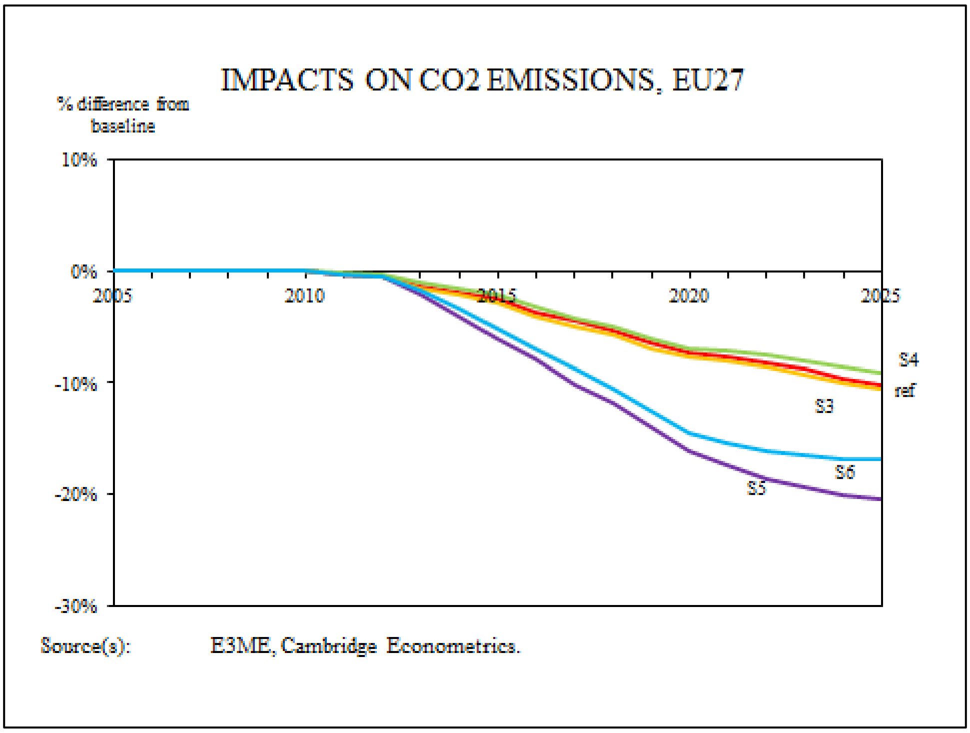
Table 3.5: Carbon prices (08 €/tCO_2) in 2020

CARBON OR SHADOW CARBON PRICES (08 €/tCO_2) IN 2020

	ETS	Non-ETS
Base	25.0	0.0
Ref	58.4	2.9
S3	58.1	Varies by country
S4	50.4	16.2
S5	94.8	35.5

Note(s): The carbon prices shown in the table are the cost in the MBI or the costs of meeting regulations. See main text for assumptions. toe is thousands of tonnes of oil equivalent.
Source(s): E3ME, Cambridge Econometrics.

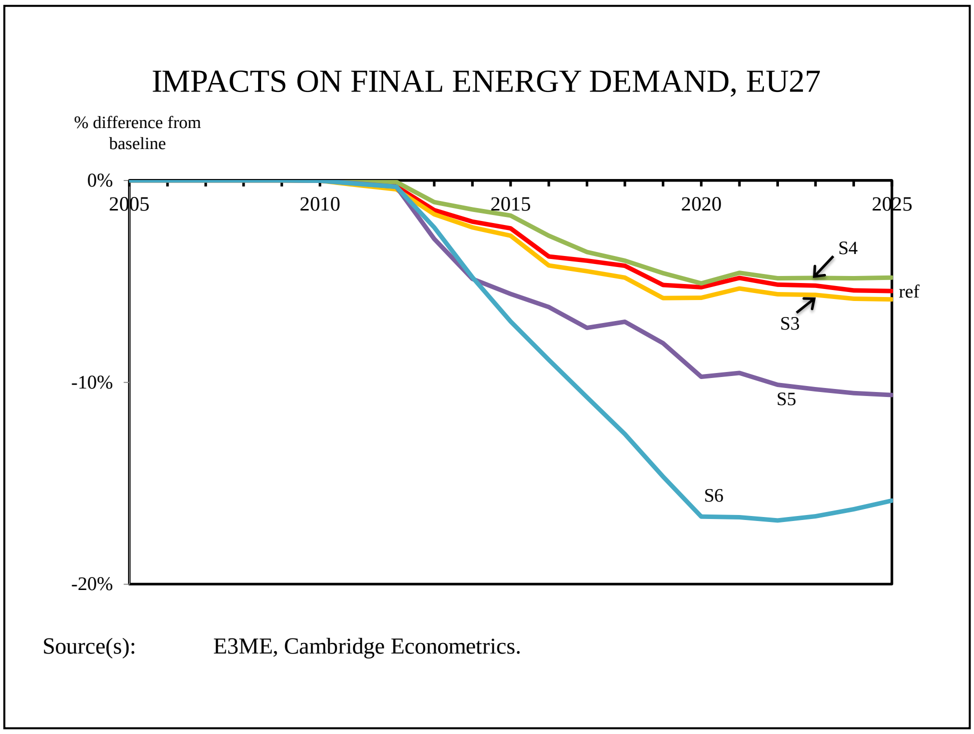
Figure 3.6: Impacts on CO_2 Emissions, EU27



Energy consumption

The scenarios also result in reductions in energy demand (see Figure 3.7). The chart shows final energy demand for each of the scenarios. In the Reference case, Regulation case (S3) and MBI case (S4), energy consumption falls in line with the emissions targets. In Scenarios 5 and 6 there is a much larger reduction in energy consumption reflecting the tougher targets. As S6 focuses explicitly on energy consumption, its reduction is proportionally larger.

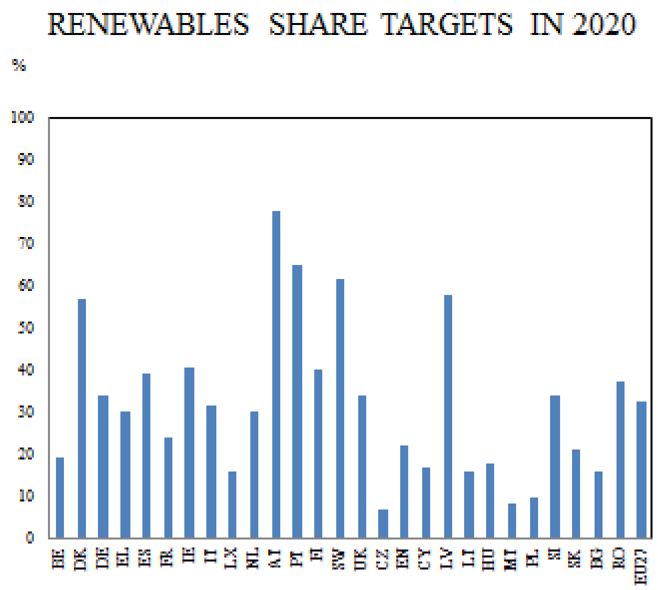
Figure 3.7: Impacts on Final Energy Demand, EU27



Renewable shares

The renewable shares are defined by the targets (see Figure 3.8). These are met in the Reference case, and there are only minor deviations in the Regulation case. In the MBI case a European target, rather than a set of national targets, is met so there is some shift between countries compared with the targets shown in Figure 3.8. The share of renewables increases slightly further in Scenario 5 due to the more stringent emission targets.

Figure 3.8: Renewables Share Targets in 2020



Source(s): PRIMES reference case, European Commission, 2010.

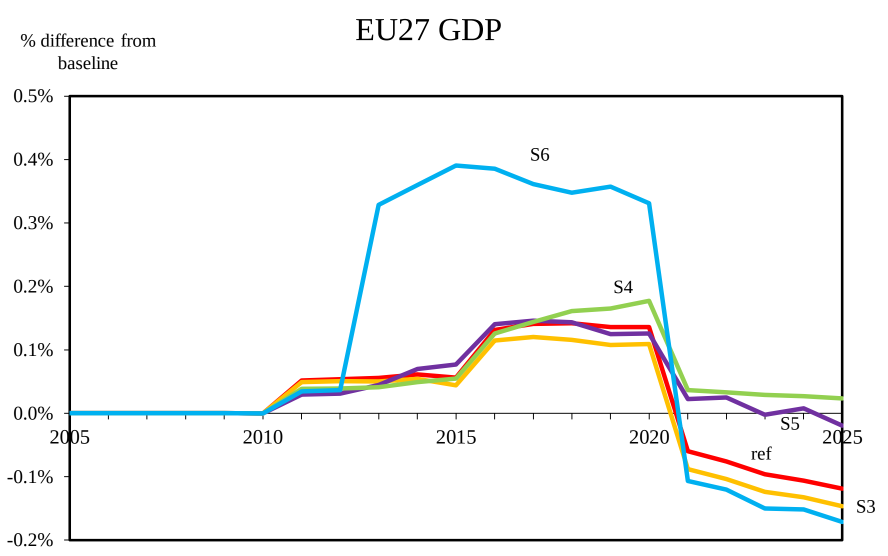
3.5 Economic impacts

GDP impacts

Overall the impacts of the environmental policies on GDP are small (<+/- 0.4%) and positive up to 2020, (see Figure 3.9). The main driver for the positive results is the multiplier impacts from investment in electricity infrastructure to meet the renewables target and the energy-efficiency objective (this is financed by borrowing and recovered over the lifetime of the assets in the form of higher electricity or energy prices).

In 2020, the result for the MBI case (S4) is slightly more positive while the result for the Regulation case (S3) is slightly more negative than the Reference case as the revenues from MBIs are used to reduce direct taxes, resulting in higher disposable income for households and therefore higher consumption. In all scenarios there are also gains in GDP from reduced imports of fossil fuels.

Figure 3.9: Impacts on EU27 GDP



Source(s): E3ME, Cambridge Econometrics.

In the Reference, Regulation and MBI cases the slope of the (differences from Baseline) GDP curve reflects the assumptions for the timing and scale of the investment in renewables. This is particularly strong over 2015-20, but less so after the 2020 target has been met and investment is reduced. At an aggregate level, outcomes for the 30% case (S5) are similar.

There are stronger positive impacts on GDP (although still modest), in the energy-efficiency scenario (S6). These reflect the greater scale of investment required to achieve the more stringent targets in this period. The switch to an almost-zero GDP impact after 2020 reflects the assumption that investment falls back.

In summary, the renewables targets have a positive impact on GDP up to 2020 because of the additional investment. This is only partly offset by increases in the prices of energy goods because these recover the cost of the investment over a longer period. The investment required to meet the energy-efficiency objective has the same effect. Although carbon and energy prices are high in the scenarios where the targets are increased, the benefits from revenue recycling through lowering direct tax leads to higher disposable income, household spending and GDP at European level.

Results by country

The impacts on GDP in 2020 by country are shown in Table 3.6. Again the results for the Reference, Regulation, and MBI cases are dominated by the investment assumptions for renewable energy (based on the results from the PRIMES projections) and energy efficiency.

Three of the countries that have the largest impacts are also the ones with the largest investment costs to meet the renewable targets. In Portugal and Latvia, this leads to a positive impact on GDP. In Bulgaria, however, the higher investment is countered by higher energy prices and an erosion of real incomes, leading to an overall reduction in GDP compared to base. Although all Member States have a similar trade-off, which may be positive or negative, it is the scale of the investment required in these countries that makes the results stand out. There are also clear sectoral implications in these countries: sectors that produce investment goods are typically creating more jobs in the scenarios, while those that produce consumer goods see a fall in employment when the real income erosion effect is strong.

In all countries, these scenarios show a shift from consumption to investment, with the aggregate GDP effects partly dependent on the relative magnitudes of the two changes. Although there are negative international competitiveness effects in some energy-intensive sectors (as domestic products become more expensive compared to imports), at the level of aggregation considered in these results the impacts are outweighed by the investment effects and (at macro level) reductions in fossil fuel imports. However, as discussed in Section 5.2, this does not mean that particular sectors and firms would not be particularly affected by the policies.

In the MBI scenario (S4), impacts on GDP for some countries are slightly more positive while some are slightly worse off than in the Reference case, even though overall GDP increases. This is because under the MBI scenario there is a single, European target rather than a set of country targets. Therefore some countries will end up paying a higher, EU-average, carbon price as a result of the EU target than the price that would be paid if the target were met domestically. The positive impacts from revenue recycling are also reflected in the S4 results.

In most countries, the GDP impacts in the energy-efficiency scenario (S6) and in the 30% target scenario (S5) are more positive than the Reference, Regulations and MBI cases up to 2020. This is due to the higher rates of investment, revenue recycling and reductions in imports of fossil fuels. In the energy-efficiency case (S6), countries also benefit from the additional investment that is required to achieve the necessary energy reduction.

However, the positive impacts from investment and revenue recycling in S5 and S6 fail to counter the negative impacts on GDP from higher carbon or energy costs in some countries. These are typically the more energy and emission-intensive economies such as Greece and Bulgaria, which suffer a greater loss of competitiveness from higher energy prices.

Table 3.6: GDP Impacts in 2020, % Difference from Baseline

GDP IMPACTS IN 2020, % DIFFERENCE FROM BASELINE

	ref	**S3**	**S4**	**S5**	**S6**
Portugal	0.7	0.7	0.7	1.1	1.9
Latvia	0.6	0.4	0.4	0.6	1.1
Belgium	0.5	0.4	0.3	0.6	0.4
Ireland	0.4	0.4	0.5	0.5	1.1
Czech Republic	0.4	0.4	0.4	0.4	2.0
Lithuania	0.4	0.4	0.5	0.6	2.6
Hungary	0.4	0.3	0.4	0.4	1.2
Poland	0.4	0.3	0.4	0.5	0.9
Slovenia	0.4	0.3	0.4	0.5	1.3
Slovakia	0.4	0.4	0.3	0.5	1.4
Luxembourg	0.3	0.3	0.1	0.2	0.6
Netherlands	0.3	0.2	0.2	0.0	-0.3
Sweden	0.3	0.3	0.3	0.3	0.7
Spain	0.2	0.1	0.5	0.3	0.7
Estonia	0.2	0.2	0.1	0.2	1.5
Denmark	0.1	0.1	0.2	0.2	0.7
Germany	0.1	0.1	0.2	0.1	0.3
Italy	0.1	0.1	0.1	0.2	0.6
Austria	0.1	0.1	0.2	0.3	0.2
United Kingdom	0.1	0.0	0.1	0.0	0.0
Romania	0.1	0.1	0.1	0.0	0.3
France	0.0	0.0	0.1	0.0	0.3
Finland	0.0	0.0	0.1	0.1	0.7
Greece	-0.1	-0.2	0.0	-0.3	-1.1
Cyprus	-0.1	-0.3	-0.1	-0.1	-0.4
Bulgaria	-0.2	-0.3	-0.5	-1.7	-1.3
Malta	-0.3	-0.3	-0.2	-0.3	0.2
EU27	0.1	0.1	0.2	0.1	0.4

Note(s): Countries are ordered by scale of impact in the Reference case.
Source(s): E3ME, Cambridge Econometrics.

3.6 Impacts on employment demand

Expectations

Table 3.7 summarises the effects in these scenarios that we expect to see, on the basis of theory. Since the overall level of economic activity is a key driver of employment, the impacts on the aggregate level of employment are expected to follow the broad pattern of the GDP results (although the timing may be different if there is a lag in employment effects). Impacts are not expected to be uniform across sectors, depending on the policy measures in each scenario. In each case the table also provides a broad qualitative estimate of the scale of the effects. As there are synergies and complementarities between the different effects it is not always possible to give an unambiguous estimate of the likely net impact of these effects.

Table 3.7: Factors that are Expected to have Impacts on Employment

FACTORS THAT ARE EXPECTED TO HAVE IMPACTS ON EMPLOYMENT		
Factors (policy measure)	**Possible impacts on employment**	**Expected magnitude**
Investment in new power generation technologies (RES)	Higher demand for workers in construction, engineering, electricity, chemicals and other related services.	Large initially but smaller over time
Increase in electricity price to fund the investment (RES)	Reduction in real incomes, affecting retail and other consumer sectors.	Potentially large
Increased demand for biofuels (RES)	Higher demand for agriculture workers who grow bio-crops, overall demand for agriculture employment may stay the same as workers shift from traditional crops to bio-crops.	Inconclusive
Increased demand for biofuels (RES)	Lower demand for employment in traditional oil and gas extraction.	Medium
Reduction in energy demand (emissions reduction targets & energy-efficiency targets)	Reduction in mining, manufactured fuels, electricity and gas sectors (following reduction in energy demand).	Medium
Investment (e.g. in buildings) to achieve energy reduction (energy-efficiency targets)	Higher demand for workers in construction, engineering and other related services.	Large initially but smaller over time
Movement between sectors and countries – higher demand in areas where costs are lower (effort sharing)	Higher employment demand where energy/carbon costs are lower, lower demand where costs are higher.	Inconclusive
Higher ETS price to achieve emission targets	Lower employment demand for ETS sectors as industries become less competitive, although this is to some extent compensated by a switching from energy to labour within these sectors as labour becomes relatively cheaper.	Medium
Reduction in real disposable incomes due to higher price levels for non-energy goods.	Lower employment demand for consumer-related sectors (e.g. retail and distribution, hotels and catering and services sectors).	Potentially large
Reduction in income tax leading to higher consumer spending (ETS, MBI, and energy tax revenue recycling)	Higher employment demand for consumer-related sectors (e.g. retail and distribution, hotels and catering and services sectors) and secondary impacts on other sectors.	Large
Higher demand for printing and marketing (labelling regulations)	Higher employment demand in printing and marketing industries.	Small (not included in modelling)

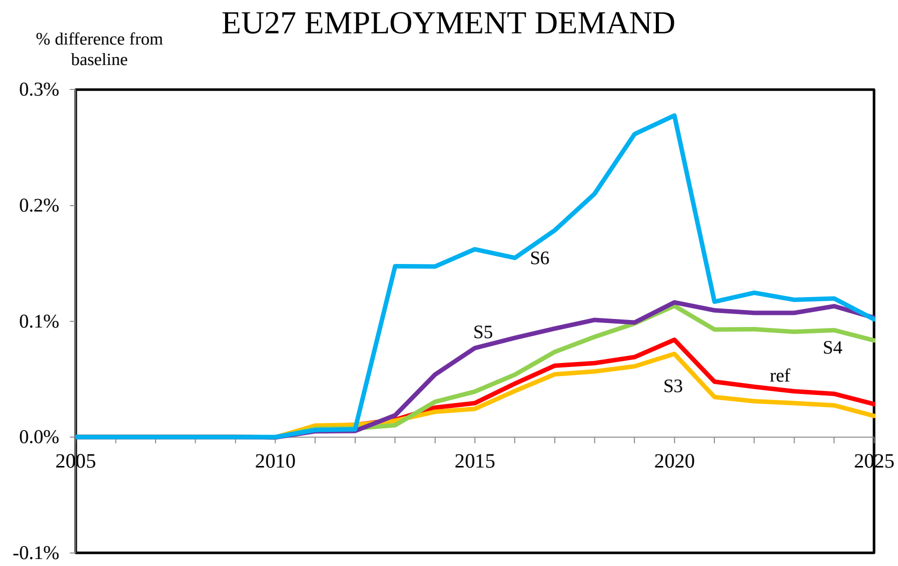
Source(s): Cambridge Econometrics.

Employment results

The whole-economy employment results shown in Figure 3.10 largely conform to these expectations. The trend in employment impacts follows the same pattern as that for GDP, albeit with smaller magnitude (< + 0.3%).

Employment in the Reference, Regulation (S3), and MBI (S4) scenarios is boosted by investment in new electricity technologies, as well as by secondary impacts arising from revenue recycling. By far the largest impacts in these scenarios come from the 20% renewables target. This requires large amounts of investment that would create jobs to build the new technologies (sectoral results are discussed below). Even so, the maximum boost to the net number of jobs created is just 0.1% or 168,000-265,000 jobs.

Figure 3.10: EU27 Employment Demand



Source(s): E3ME, Cambridge Econometrics.

In the MBI scenario (S4), quite a substantial amount of revenues (around €45bn measured at 2008 prices, in 2020) could be collected. In our scenario these have been used to reduce income taxes, boosting household spending and sectors such as retailing, consumer services and food. The employment impacts in S4 are therefore slightly higher than the Reference case and Regulation case, reflecting more jobs in these sectors. However, these revenues could instead be used directly to influence labour market outcomes; this is discussed further in Section 3.9.

The 30% target (S5), which has much bigger environmental effects, has some additional employment impacts, although at aggregate level these are very small. The main difference from the Reference case in S5 is the higher carbon price required to meet the 30% GHG reduction target. In this scenario, the impacts on employment are slightly positive as the larger revenues available for recycling which accrue from higher carbon prices result in higher consumer demand for products, stimulating jobs in the supplying sectors (the same sectors that benefit in the MBI case). The high carbon price also stimulates a substitution effect from energy to labour. The carbon price also plays a key role in the dynamics of employment after 2020. This is because investment ends once the 2020 targets are met, so the key driver of employment post 2020 is the degree of revenue recycling that occurs in each scenario, which in turn is determined by the carbon price. The higher carbon price in S5 compared to the reference case means that employment remains relatively stable in S5, whereas there is a substantial fall in the Reference case due to a lower carbon price.

There is further insight in comparing the 30% target (S5) with the Reference case in the years 2011-12, where employment in S5 is initially slightly lower. This is because the higher carbon price in S5 leads to a reduction in electricity demand, meaning that lower investment in renewable capacity is required in S5 than the Reference case. Consequently, lower investment results in a slightly lower initial level of employment in S5 until the effects of recycled revenues (which are larger in S5 due to a higher carbon price) become apparent from 2013 onwards.

The energy-efficiency scenario (S6) has larger labour market impacts (around 0.3%). In this scenario, the energy-efficiency objective is achieved through a mixture of MBIs and regulation. This means that there are some revenues to be recycled (which stimulate consumer spending) but at the same time firms have to bear the cost increases or pass them on to customers in higher prices, which has an offsetting effect on demand. Overall, however, there is a positive employment impact in this scenario due to the investment required to make the energy savings. After the investment is completed in 2020, the positive employment impacts fall back. This is due to the same reason as in the Reference case.

Disaggregating the results by cause

Due to the complex interactions involved it is quite difficult to separate the causes of the net changes in employment. The main driver is changes in economic output as a result of the carbon prices, regulation, investment and revenue recycling. However, there are also impacts from changes in real wage rates (higher energy costs lead to inflation, but nominal wage rates may not increase by as much) and the relative costs of energy and labour, leading to substitution effects.

The effects of technology on employment levels are even more difficult to determine. Rapid roll-out of new investment will embody technological progress, and this is reflected in higher productivity. The effects of this on employment are ambiguous, as higher productivity may lead to higher activity and an associated creation of jobs, or the boost to labour productivity may be larger than any boost to output so that there is a net loss of jobs.

Table 3.8: Employment Impacts in 2020, % Difference from Baseline

EMPLOYMENT IMPACTS IN 2020, % DIFFERENCE FROM BASELINE					
	ref	**S3**	**S4**	**S5**	**S6**
Portugal	0.6	0.6	0.6	0.8	1.9
Slovenia	0.4	0.3	0.5	0.7	2.1
Estonia	0.3	0.3	0.3	0.4	0.9
Poland	0.3	0.2	0.3	0.4	0.6
Sweden	0.2	0.2	0.1	0.2	0.5
Latvia	0.2	0.2	0.2	0.1	0.7
Belgium	0.1	0.1	0.1	0.2	0.3
Germany	0.1	0.1	0.1	0.1	0.1
Spain	0.1	0.1	0.2	0.2	0.4
Ireland	0.1	0.1	0.2	0.1	0.4
Luxembourg	0.1	0.0	0.0	0.0	0.2
Austria	0.1	0.1	0.1	0.2	0.3
Finland	0.1	0.1	0.1	0.1	0.5
Czech Republic	0.1	0.1	0.2	0.2	0.7
Cyprus	0.1	0.1	0.2	0.2	0.6
Lithuania	0.1	0.1	0.1	0.1	0.8
Hungary	0.1	0.1	0.1	0.1	0.4
Slovakia	0.1	0.1	0.1	0.2	0.7
Bulgaria	0.1	0.1	0.1	0.2	0.6
Romania	0.1	0.1	0.1	0.1	0.2
Denmark	0.0	0.0	0.1	0.1	0.2
Greece	0.0	0.0	0.0	0.0	-0.2
France	0.0	0.0	0.1	0.1	0.3
Italy	0.0	0.0	0.0	-0.1	0.0
Netherlands	0.0	0.0	0.1	0.0	0.2
United Kingdom	0.0	0.0	0.0	0.0	0.0
Malta	0.0	0.0	0.1	0.1	0.6
EU27	0.1	0.1	0.1	0.1	0.3

Note(s): Countries are ordered by scale of impact in the Reference case.
Source(s): E3ME, Cambridge Econometrics.

Employment results by country

Table 3.8 shows the whole-economy employment results by country. The ranking is similar to the previous table for GDP, and there is a general consistency in the country level results.

Portugal sees the largest increase in employment, mainly in the sectors that produce investment goods (including construction), to develop new renewable capacity. The other countries near the top of the table (e.g. Slovenia) are also ones that see fairly large increases in GDP. However, the employment results are not completely explained by GDP and investment increases; other factors include:

- sectoral composition
- responses of wage demands to higher prices

- substitution rates between energy and labour
- other local labour market conditions

No countries consistently see reductions in employment although there are a few cases where employment falls slightly. Again, these are mainly due to impacts on output in particular sectors, in most cases related to the negative aspect of falling real household incomes or loss of trade competitiveness.

Sectoral results

The sectoral results[28] (see Figure 3.11) generally follow the expectations set out in Table 3.7).

Sectors that produce investment goods

The greatest positive impacts on employment come from the 20% renewables target and investment in energy-efficient equipment. This requires substantial investment which creates jobs in construction and mechanical engineering, and their supply chains. The scale of the jobs that would last beyond 2020 (when the boost to investment is assumed to come to an end) is questionable; there will be jobs in maintenance and replacement, but far fewer than those stimulated during the period of heavy investment.

Within these sectors there may be very specific sub-sectors that suffer adverse effects. These could include energy-intensive production methods that have specific skills requirements. Some examples are considered in Chapter 5.

Sectors that produce consumer goods

There are some increases in employment levels in consumer-related sectors (e.g. hotels and catering) which benefit from higher household disposable income when revenue is recycled. These impacts are most apparent in scenarios where there are larger amounts of revenues to be recycled; the 30% target (S5), the energy-efficiency scenario (S6) and to some extent the MBI scenario (S4). The types of jobs that are created reflect the demand stimulated by the recycling of revenues into household spending; there is no strong environmental component.

Energy-intensive sectors

Employment in the energy-intensive industries increases slightly in the scenarios, which reflects the net impact of offsetting effects. Most of these sectors are affected by either higher carbon prices, energy prices or both. These higher energy costs are likely to be passed on to their final price and could lower demand for their products and in turn lower employment demand. In some specific cases where there is strong international competition these losses could perhaps be considerable.

However, in the period of heavy renewables investment (and energy-saving investment in S6), these industries can also be among the main suppliers of products for which demand has been stimulated. Consequently, employment demands can increase.

In all the scenarios there is also some substitution between energy and labour, which has the effect that employment can increase even if the sector's output does not.

Agriculture

The agriculture results can be interpreted as movement within the sector from traditional to bio-crops. This is why the impacts on agriculture are not as high in the Reference case as one would expect as a result of increases in bio-crops demand. The issue of movements within, rather than between, sectors is discussed further in Chapter 5.

[28] Sectoral employment results in absolute levels are shown in Appendix C.

Sectors with an exogenous treatment in the modelling

Employment in energy extraction sectors (E3ME sectors 2 & 3) is unaffected, because our assumption is that mines and gas fields always operate at full capacity and any reduction in demand is simply reflected in reduced imports. However, if measures were adopted at a global level, then there could be some reduction in demand and employment levels in these sectors.

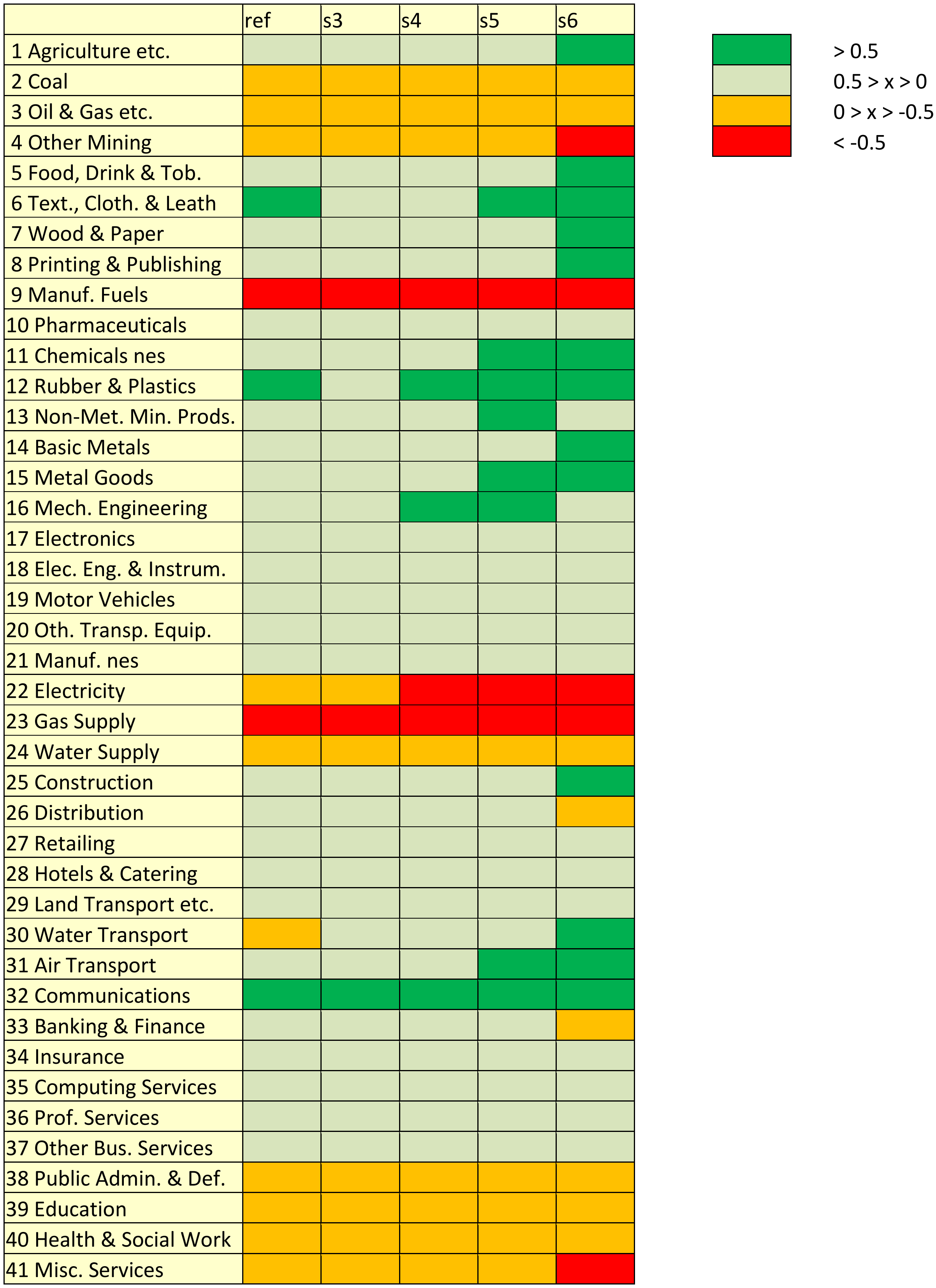
Employment in energy transformation and supply sectors, such as manufactured fuels and gas distribution, falls in the scenarios in line with reduced demand for energy, especially in the scenarios with stricter environmental targets (S5 and S6). These sectors are among the ones described in more detail in Section 5.2.

Public sector employment is treated as exogenous in the model as we assume the employment decisions in these sectors are determined by policy decisions which are not changed in the scenarios. While there may be some small impact on the types of jobs in the public sector (e.g. relating to green procurement) it seems unlikely that there would be an overall change in the level of employment.

Long-term outcomes

It should be noted that over the long term there is some tendency in labour markets to adjust to changes in demand; if demand for labour within one particular sector rises or falls, over time average wages respond, affecting employment in other sectors. For example, if there is a large increase in employment in the renewable sectors, some of these jobs will come at the expense of other sectors. Thus the difference between gross and net changes in employment goes beyond simple shifts between sectors (such as fossil fuels to renewables) and net changes cannot be fully estimated unless the whole economy is taken into account.

Figure 3.11: EU27 Sectoral Employment in 2020, % Difference from Baseline



3.7 Results by occupation and qualification

Overview

The projections of employment by sector drive the occupational and qualifications projections. Projections of occupational and qualification structure are mapped into E3ME's sectoral employment forecasts in order to obtain detailed sectoral employment projections by occupations and qualifications. For occupations this is a recursive process with no feedback from the skills (occupations) employed to sectoral employment prospects.

In the case of qualifications there is a further step, which reconciles the implications for employment patterns with expected developments on the supply side. The supply of people with formal qualifications is modelled independently of demand, and is essentially unchanged between scenarios apart from a scale effect linked to the overall labour supply projections from E3ME[29].

Demand for and supply of qualifications is then brought into balance by a 'constraining' algorithm, which reallocates people with qualifications into employment and specific occupations in a hierarchical fashion. This reflects the link between the probability of obtaining and retaining employment, and the highest qualification held[30].

Model results

Figure 3.12 to Figure 3.14 illustrate how employment projections, by occupation, vary across the scenarios[31], at a pan-European level (EU27). Figure 3.12 and Figure 3.13 show the occupational structure of employment, across all industries, for 2010 and 2020 respectively. At this broad level of aggregation, the occupational composition of employment does not show much difference between scenarios. In general, the disparities are very small for both the base (2010) and target year (2020). Looking at the projected change of occupational employment over 2010-20 some minor differences can be distinguished, but their magnitude is very small. In general those differences that do arise reflect differences in the macroeconomic levels of employment across scenarios, and the different sectoral structures, but because the sectoral changes are not large, their impact on the breakdown by occupations is similarly modest.

The more positive scenarios show the largest positive and the smallest negative changes. This pattern is common across all occupations, with the exception of employment of plant and machine operators and assemblers, which is projected to decline only in the Baseline sensitivity and Reference sensitivity scenarios and to increase in all others. Even at the more detailed level of analysis of occupational structure, the two-digit level, employment patterns do not vary much across the different scenarios.

[29] The focus is on the highest qualification held.

[30] The constraining process does not affect the occupational results. The structure of employment by occupation is the same after the constraining process.

[31] Results for the sensitivity scenarios are also included in these charts. They are described in Section 3.10.

Figure 3.12: Occupational Shares in the Various Scenarios, 2010, EU27

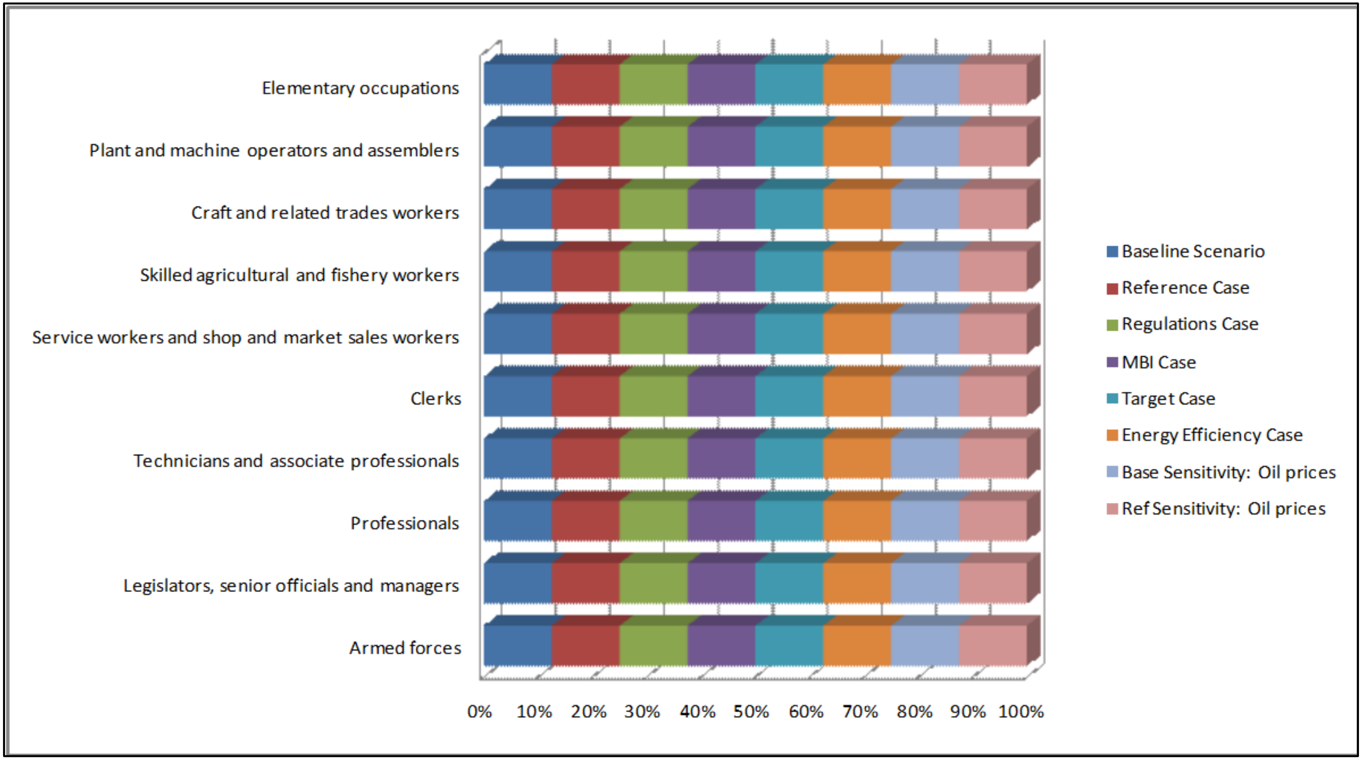


Figure 3.13: Occupational Shares in the Various Scenarios, 2020, EU27

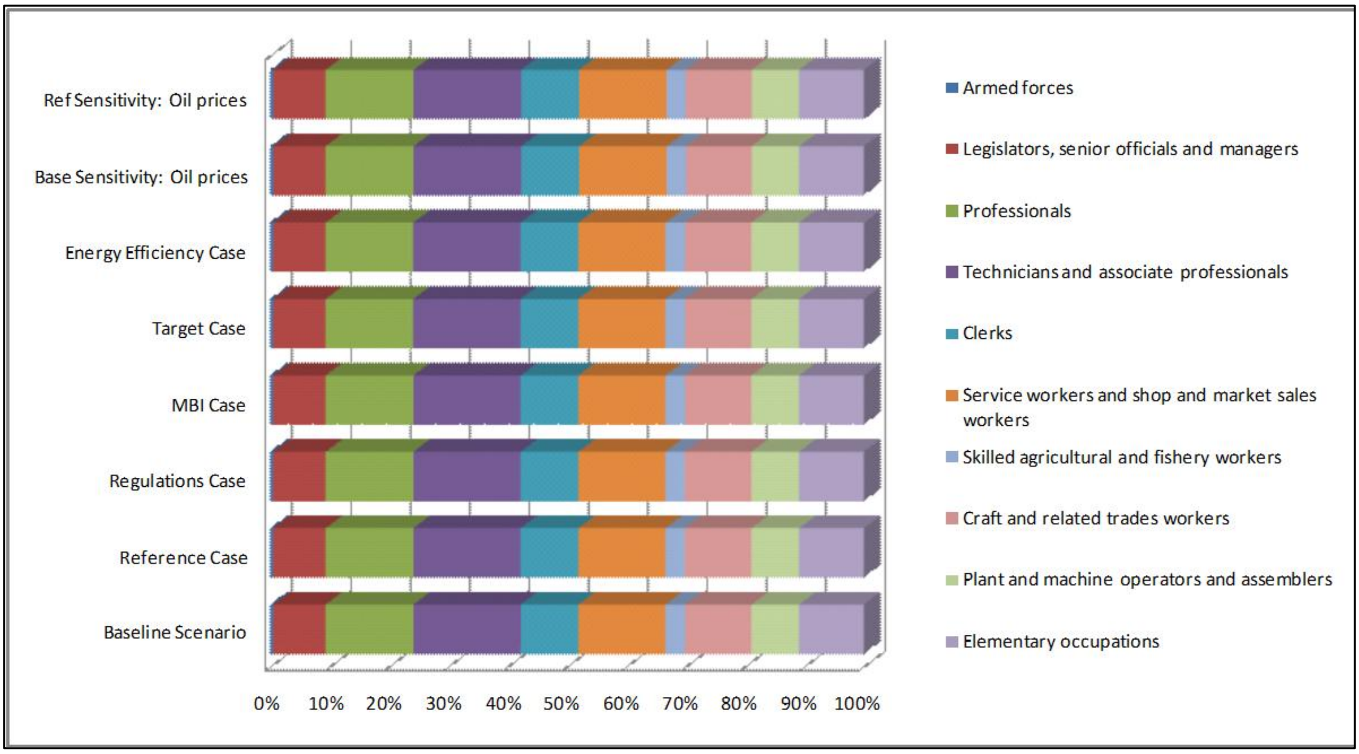


Figure 3.14: Occupational Shares in the Various Scenarios, 2020, EU27

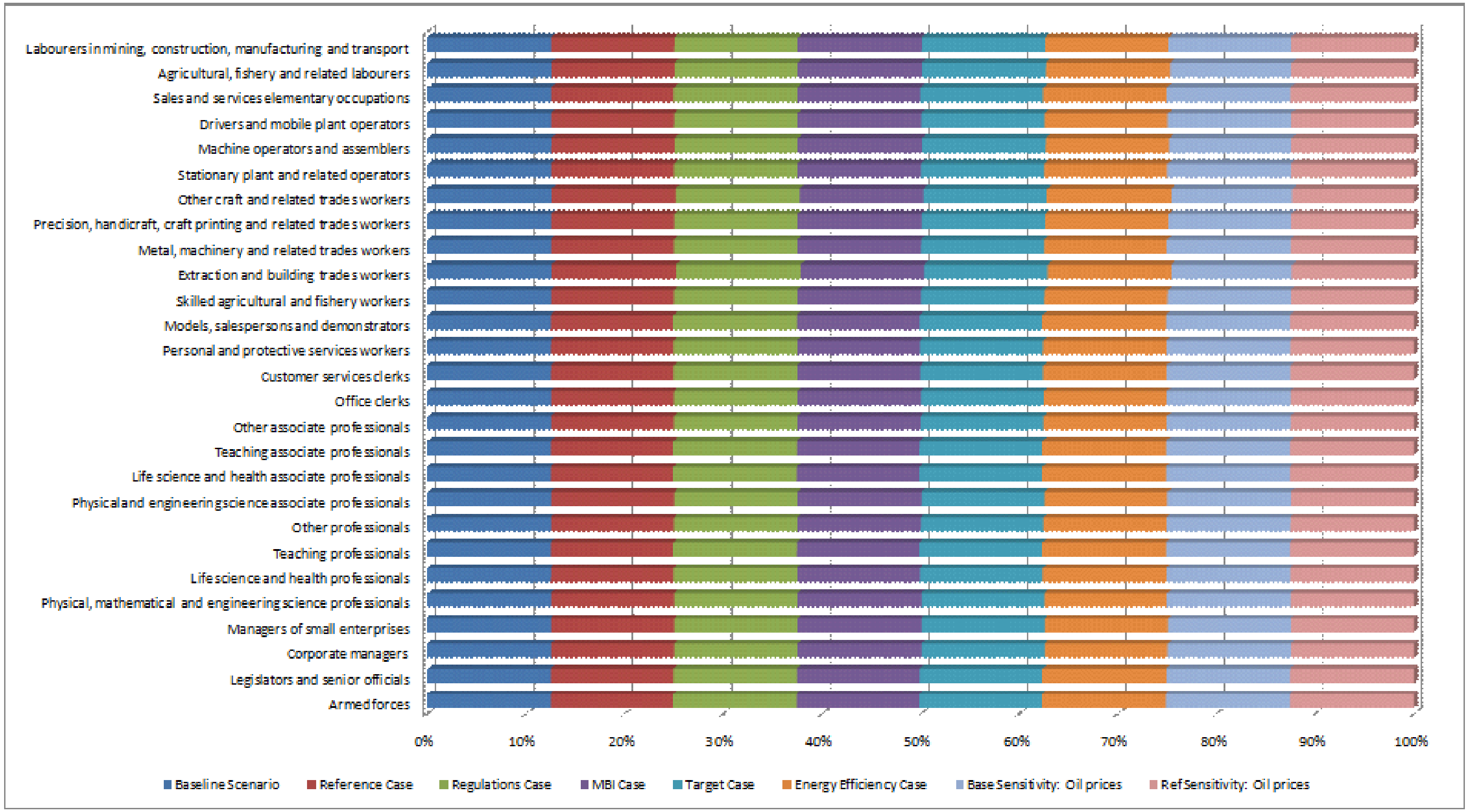


Figure 3.15 and Figure 3.16 illustrate how the qualifications structure of employment and the levels of employment vary across the scenarios. As is the case for occupational employment, the impact is negligible apart from scale effects. These figures refer to projections before the constraining process is conducted. Once this is taken into account the qualifications results are further modified to reflect the patterns of available supply, which is essentially common to all the scenarios. The magnitude of the changes after this is even smaller.

Figure 3.15 and Figure 3.16 show the qualifications structure of employment, across all occupations, for 2010 and 2020 respectively. Overall, the qualifications composition of employment is barely affected by the different scenarios. The employment change over the period 2010-20 confirms that the net impact of the scenarios on employment by qualifications is tiny.

The main discernible impact is again the result of scale effects. The impact of the environmental policies on employment by qualification can be explored further by looking into the qualifications structure across occupational categories, but these show little or no change. The qualifications structure of employment remains largely unaltered across scenarios.

Overall conclusions

The key message from this analysis of modelling results is that, at this level of aggregation, any shifts in occupational and qualifications structure in the different scenarios are very modest in their net effect. Of course it is possible that at a more micro level there will be more significant effects, both in terms of positive demand for certain types of skill associated with green technologies and more general impacts on jobs in sectors that are hardest hit by the impact of environmental mitigation policies (see Chapter 5 for examples). However such effects barely register at the NACE 2-digit level where other factors predominate. This is broadly consistent with the findings from Chapter 2.

It is clear that Member States have responded in different ways to the Green agenda and this is reflected by the skills needs emerging in those countries within specific sectors (see CEDEFOP (2010a) for an examination of these issues). This is also reflected in the baseline case used, which includes the effects of existing environmental policy, such as the EU ETS, and structural changes to the workforce that are related to the environment but not the direct result of policy.

Figure 3.15: Qualifications' Shares in the Various Scenarios, EU27, 2010

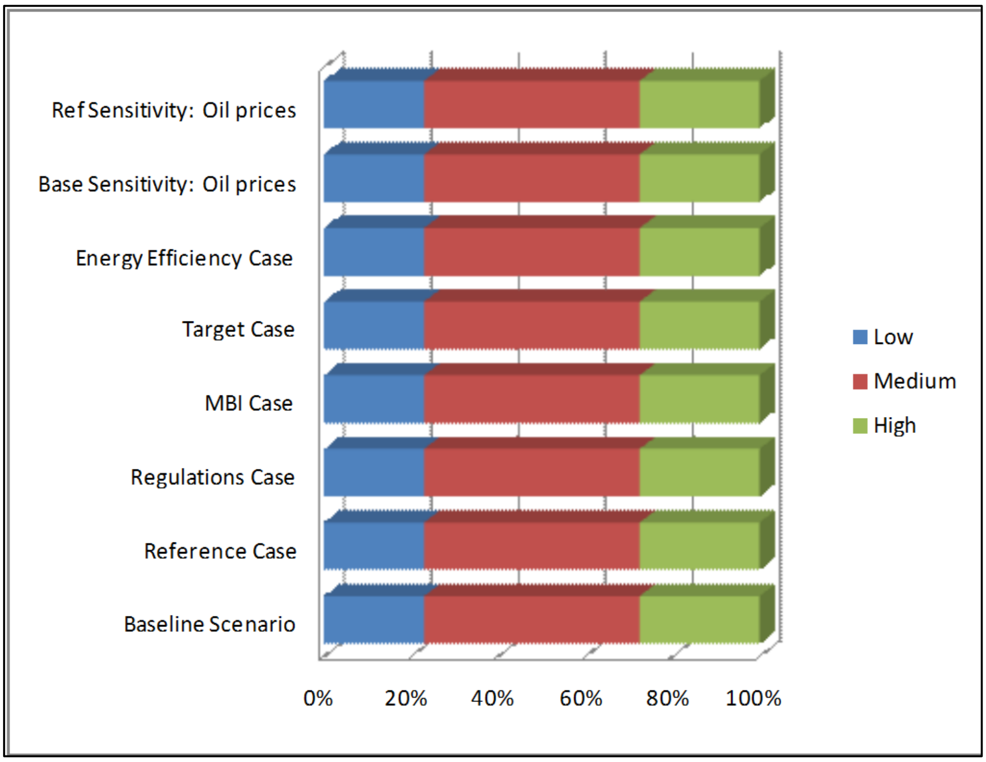
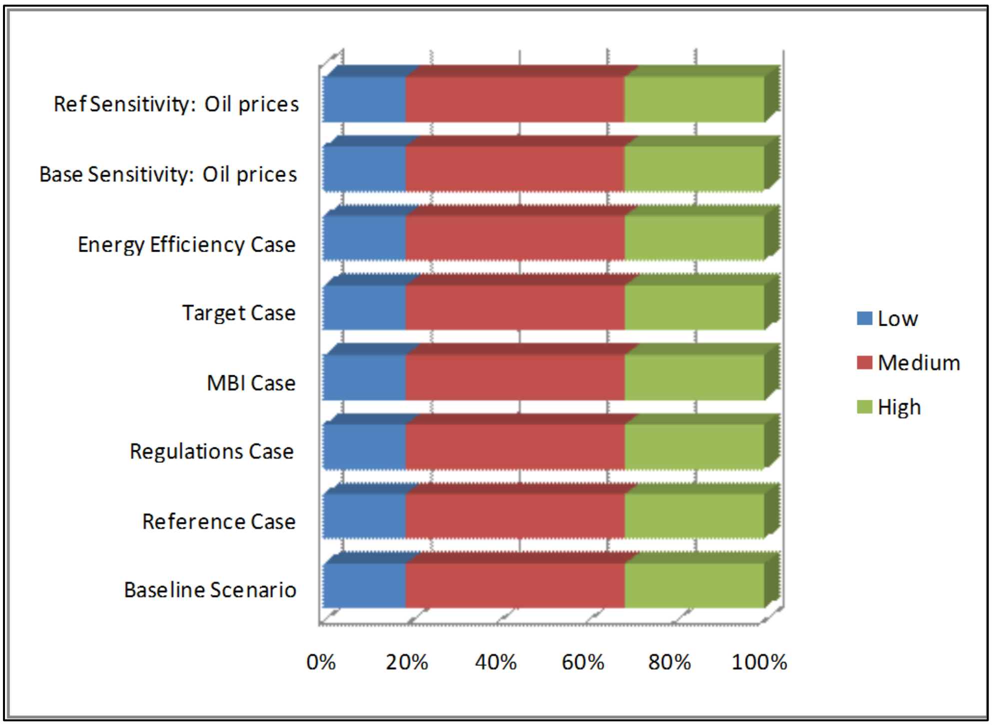


Figure 3.16: Qualifications' Shares in the Various Scenarios, EU27, 2020



3.8 Impacts on labour supply

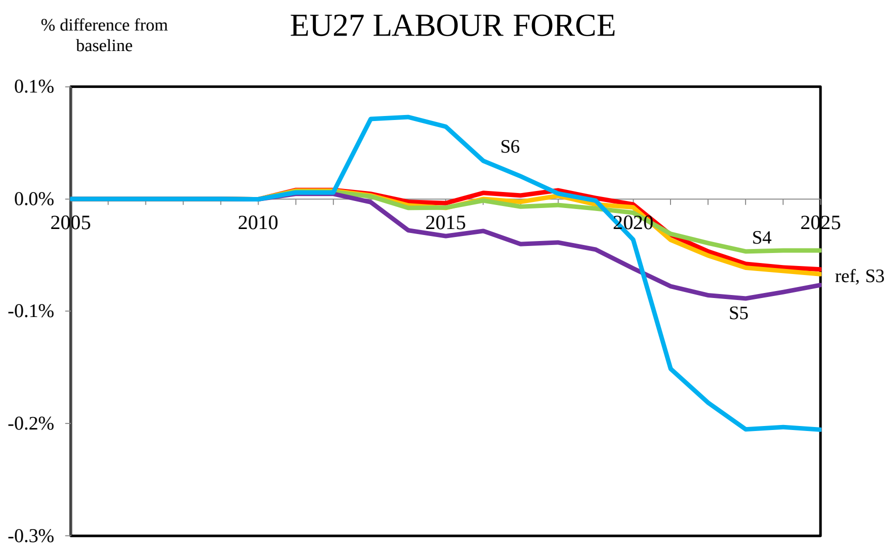
Labour force results in E3ME are modelled by estimating participation rates and then applying these to Eurostat population forecast assumptions. The results show that participation rates decrease slightly by 2020 in all the policy scenarios, although again the impacts are quite small (< +/- 0.2%). Despite higher levels of economic activity in the scenarios, participation rates fall marginally because higher inflation erodes real wage rates and hence the incentive to work. Figure 3.20 shows the aggregate trends in each scenario. Detailed results are given in Appendix C.

Labour supply by country

Labour supply increases by the most (in relative terms) in the countries that see the largest increases in employment, and in most cases GDP (Portugal, Estonia, Latvia, Sweden). The main factors underlying this increase are therefore lower unemployment rates and higher economic growth rates; i.e. greater opportunity. In some other countries, notably Germany, real wage rates fall. This leads to the lower participation rates at the aggregate EU level.

There are no specific inputs to these scenarios designed to affect participation directly.

Figure 3.17: Impacts on EU27 Labour Force



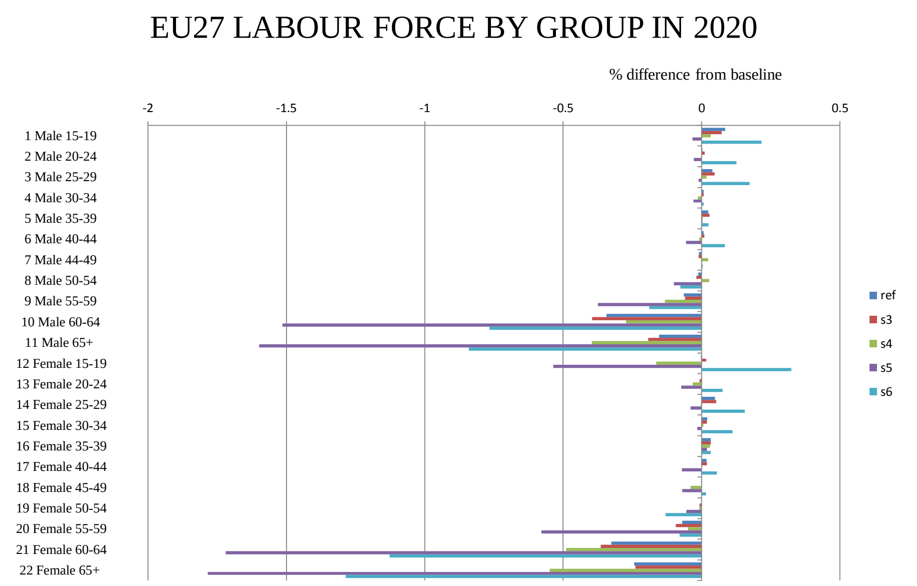
Source(s): E3ME, Cambridge Econometrics.

Labour supply by group

The skills module generates implications for supply by level of highest qualification held. However, these patterns do not change significantly between the scenarios. Detailed results by labour group (see Figure 3.18) show that older age groups (50+) are more responsive than other groups, deciding to leave the labour force sooner (i.e. to retire early) in response to lower real wage rates. Participation rates among younger labour groups (15-19) are also fairly sensitive to economic conditions, as individuals can choose to stay in education for longer. These groups are therefore more flexible to move in and out of the labour force than the middle-aged groups. The results therefore show only small differences for these age groups in the scenarios.

The labour force results also show similar patterns between male and female groups. One possible explanation is that the scenarios were not designed to target a particular gender. Other factors that have impacts on participation rates in E3ME include benefit and pension rates, average working hours, and other structural indicators; these were also broadly unchanged in the scenarios.

Figure 3.18: EU27 Labour Force by Group in 2020



Source(s): E3ME, Cambridge Econometrics.

3.9 The revenue recycling and imbalances scenarios

Overview

This section provides results for a set of additional model runs that was carried out. These scenarios are not determined by environmental policy but reflect the outcomes of the scenarios described in previous sections in this chapter.

The first set of scenarios focuses on the revenues that are gathered from the use of MBIs in meeting the 2020 targets. The results from these scenarios are compared with those from the MBI case described previously, where there are the most revenues available to recycle. The scenarios look at various investment and taxation/expenditure options. They are:

- all revenues offset by income tax reductions
- one quarter invested in transport, three quarters in income tax reductions
- one quarter invested in machinery, three quarters in income tax reductions
- one quarter invested in buildings, three quarters in income tax reductions
- one quarter invested in renewables, three quarters in income tax reductions
- all revenues used for investment in transport, machinery, buildings and renewables (one quarter each)
- all revenues paid out through higher benefits rates
- all revenues offset through employers' social security reductions

The final scenario focuses on possible labour market imbalances that may arise from meeting the targets. Although these were not evident from the previous model results, this illustrates what could happen if there are in fact bottlenecks but at a level that is too detailed to be picked up in the modelling (see Section 5.4). The scenario considers an exogenous reduction in labour participation as a result of skills mismatches, by 0.5% in 2020. For ease of interpretation we have assumed that all age and gender groups are affected equally but it is easy to imagine variation between age groups, for example with older workers lacking the skills base to adapt to new technologies.

Economic impacts

The economic impacts of this group of scenarios are described in the paragraphs below.

Revenue recycling scenarios

Table 3.9 shows the economic impacts of the different types of revenue recycling on GDP in the EU; the figures given are compared to the MBI case (S4) so show the impact of changing the recycling method. The impacts can be summarised as:

- Reducing income taxes benefits all salary earners and is the benchmark to which we compare the other results. Lower tax rates provide an incentive to work. Some groups, however, do not benefit, such as retired individuals, unemployed or economically inactive (see Section 5.6).

- Investment in machinery, vehicles and buildings benefits the engineering and construction sectors and also lowers the carbon prices required to meet the 2020 targets. It thus has positive economic benefits with a focus on particular sectors, which can be considerable when spent domestically (e.g. by the construction sector which has limited international competition).

- Investment in renewables has a smaller economic impact because this displaces the investment that would have taken place anyway (to meet the 20% target). This effectively becomes a subsidy for energy companies which leads to lower prices but encourages the use of imported fuels.

- Higher benefit rates target the revenues at vulnerable groups in society and could help to ease the transition to a low-carbon or energy-efficient economy. However, high benefit rates may offer a disincentive to work.
- Reducing employers' social security contributions directly lowers the cost of labour and leads to a higher increase in employment (and reduction in unemployment) and competitiveness gains for industry. It also leads to a higher increase in company profits but usually a smaller increase in GDP.

Generally these trends are apparent in the table below. The impacts on GDP range from -0.2% when revenue is recycled via a reduction in employer's social security rates to 0.75% when investment is spread across transport, machinery, buildings and renewables.

The differences between countries reflect a range of different factors, of which the main ones are:

- Trade ratios – When the revenues are used for investment the sectors that produce capital goods benefit. Although construction is by definition domestic, machinery and equipment may be imported. Imports can also be found further down the supply chain, for example of basic metals. The share of the funding that flows out of the country can be an important factor in determining changes in GDP.
- Labour markets – For the recycling to have a positive impact there must be available capacity, including in labour markets. If unemployment is low, the main impact of higher demand will be an increase in wages rather than employment levels. This can serve to push up inflation and reduce competitiveness in traded sectors. This is particularly relevant in the case where revenues are used to reduce employers' social security contributions (i.e. labour costs). The supply of labour is also important in the case where social benefits are increased. Higher benefit rates provide income to the poorest groups in society but may also create a disincentive to work; these effects also vary across countries.

The second of these points is highlighted when considering the results for the social benefits case. The real transaction (of income from government to households) is the same as reducing income taxes but this provides different incentives. In the short term, reducing labour supply can have a small positive effect (as wages increase faster than prices) but this result does not hold in the long term, as prices catch up and competitiveness suffers. As the carbon price increases up to 2020, most, but not all, Member States see the short-term benefit in 2020 itself, but this decreases over time.

Table 3.9 GDP (% difference from S4) in Revenue Recycling Scenarios

GDP (% DIFF. FROM S4) IN REVENUE RECYCLING SCENARIOS

	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp'rs Soc Sec
Belgium	0.1	0.1	0.0	0.0	0.1	-0.2	-0.2
Denmark	0.4	0.2	0.1	0.0	0.8	0.0	-0.3
Germany	0.3	0.3	0.1	0.1	0.8	0.5	-0.3
Greece	0.9	0.3	0.0	0.0	1.3	0.7	-0.4
Spain	0.9	0.4	0.1	-0.1	1.4	0.2	-0.2
France	0.1	0.0	0.0	0.0	0.1	0.0	-0.1
Ireland	0.1	0.1	0.1	-0.1	0.1	0.2	-0.2
Italy	0.3	0.3	0.1	0.0	0.7	0.3	-0.4
Luxembourg	2.0	0.5	0.2	0.1	2.8	1.0	-0.4
Netherlands	0.7	1.1	0.2	0.1	2.1	0.4	-0.4
Austria	0.2	0.5	0.1	0.1	0.8	0.4	-0.2
Portugal	0.3	0.2	0.1	-0.1	0.5	0.1	-0.3
Finland	0.1	0.1	0.1	0.1	0.6	0.2	-0.3
Sweden	0.2	0.3	0.1	0.1	0.6	0.1	-0.2
United Kingdom	0.1	0.1	0.1	0.1	0.4	0.1	-0.2
Czech Republic	1.0	1.8	0.2	0.3	3.3	0.6	-0.7
Estonia	0.7	0.7	0.3	0.2	2.0	0.2	-0.4
Cyprus	1.0	0.3	0.3	0.1	1.8	-0.1	-0.1
Latvia	1.2	0.3	0.2	-0.1	1.5	0.4	-0.3
Lithuania	0.3	0.6	0.1	0.1	1.1	0.2	-0.4
Hungary	0.4	0.4	0.2	0.1	1.1	0.2	-0.1
Malta	0.0	0.1	0.0	0.2	0.2	0.3	-0.6
Poland	0.3	0.4	0.2	0.0	1.0	-0.2	-0.4
Slovenia	0.2	0.2	0.1	0.0	0.5	0.3	-0.3
Slovakia	0.5	1.7	0.4	0.3	2.6	0.2	-0.2
Bulgaria	0.8	0.8	1.0	0.3	3.2	0.1	-0.1
Romania	0.2	0.3	0.1	0.1	0.7	0.7	-0.3
EU27	0.3	0.3	0.1	0.0	0.7	0.2	-0.2

Note(s): Figures show the impacts of changing revenue recycling method from income tax reductions.
Source(s): E3ME, Cambridge Econometrics.

Skills mismatch scenario

The skills mismatch scenario results in a small reduction in GDP in most countries, on average 0.1% in 2020 for the EU (see Table 3.10). This is because a reduction in the available pool of labour pushes up wage rates, reduces employment demand (see below) and leads to a small loss of competitiveness. The effects vary between Member States. In some countries the effects are positive due to the relative changes that are occurring within Europe. For example, a country with a tight labour market will be hit harder by a fall in available labour so some countries see relative gains in competitiveness relative to others in the EU.

As we have not made a judgment about in which sectors the skills shortages occur the sectoral results do not yield much insight, except that the impacts are slightly larger in sectors that are exposed to international competition.

Table 3.10 GDP (% difference from Baseline) in Skills Mismatch Scenario

GDP (% DIFFERENCE FROM BASELINE) IN SKILLS MISMATCH SCENARIO

Belgium	-0.3	United Kingdom	0.0
Denmark	-0.1	Czech Rep.	0.0
Germany	0.0	Estonia	-0.1
Greece	-0.2	Cyprus	-0.2
Spain	0.0	Latvia	0.0
France	-0.3	Lithuania	0.0
Ireland	0.1	Hungary	-0.4
Italy	-0.1	Malta	-0.2
Luxembourg	-0.8	Poland	-0.2
Netherlands	0.0	Slovenia	0.0
Austria	0.0	Slovakia	0.0
Portugal	-0.1	Bulgaria	0.0
Finland	0.0	Romania	-0.1
Sweden	-0.3	**EU27**	-0.1

Source(s): E3ME, Cambridge Econometrics.

Labour market impacts

The labour market impacts of the revenue recycling scenarios are not necessarily trivial as they are using large amounts of revenues (up to €45bn at EU level). They are discussed in detail in the paragraphs below.

Employment demand

In most of the revenue recycling scenarios there is an increase in employment in line with the slightly higher GDP growth. As expected we observe an increase in employment in the scenario where the revenues are used to reduce labour costs directly (through employers' social contributions, see Table 3.11) although it is notable that this is not as high as when spending is directed at investment in labour-intensive sectors. The scenario with the increase in benefits tends to have the lowest level of employment growth due to the disincentive effects.

The differences between countries are due to the GDP impacts but also the reactions of wages to the changing tax and benefit rates and within the sectors where the investment is directed to.

Table 3.11 Employment (% difference from S4) in Revenue Recycling Scenarios

EMPLOYMENT (% DIFFERENCE FROM S4) IN REVENUE RECYCLING SCENARIOS	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp'rs Soc Sec
Belgium	0.0	0.0	0.0	0.0	0.1	-0.4	0.1
Denmark	0.2	0.1	0.1	0.0	0.5	0.0	0.1
Germany	0.1	0.1	0.1	0.0	0.2	-0.1	0.0
Greece	0.1	0.0	0.0	0.0	0.1	-0.2	0.0
Spain	0.3	0.1	0.0	0.0	0.4	-0.1	0.2
France	0.0	0.0	0.0	0.0	0.0	-0.1	0.1
Ireland	0.0	0.0	0.0	-0.1	0.0	-0.1	0.0
Italy	0.2	0.3	0.1	0.0	0.6	-0.1	-0.1
Luxembourg	0.0	0.0	-0.1	0.0	-0.1	-0.4	0.2
Netherlands	0.5	0.4	0.2	0.1	1.2	0.2	0.2
Austria	0.0	0.1	0.0	0.0	0.1	-0.2	0.0
Portugal	0.2	0.1	0.1	0.0	0.4	-0.2	0.0
Finland	0.1	0.2	0.0	0.0	0.5	-0.2	-0.1
Sweden	0.1	0.1	0.1	0.0	0.3	-0.1	0.0
United Kingdom	0.0	0.0	0.0	0.0	0.0	-0.3	0.0
Czech Rep.	0.2	0.3	0.1	0.0	0.5	-1.2	0.4
Estonia	-0.1	0.5	-0.1	-0.1	0.4	-1.1	0.1
Cyprus	0.2	-0.1	0.3	0.1	0.5	-0.4	0.3
Latvia	0.1	0.0	0.0	0.0	0.1	-0.2	0.2
Lithuania	0.2	0.1	0.2	0.1	0.5	-0.1	0.2
Hungary	0.2	0.2	0.1	0.1	0.6	-0.3	0.2
Malta	0.0	-0.2	0.1	0.1	0.0	-0.4	0.1
Poland	-0.1	0.1	0.0	-0.1	-0.1	-1.2	0.4
Slovenia	0.1	0.1	0.2	0.0	0.4	-0.1	0.5
Slovakia	0.1	-0.1	0.1	0.0	0.1	-0.5	0.2
Bulgaria	0.3	0.3	0.4	0.0	1.1	-0.7	0.4
Romania	0.1	0.1	0.1	0.0	0.2	-0.4	0.1
EU27	0.1	0.1	0.1	0.0	0.3	-0.3	0.1

Note(s): Figures show the impacts of changing revenue recycling method from income tax reductions.
Source(s): E3ME, Cambridge Econometrics.

Employment demand falls in the skills mismatch scenario by around 0.05% in 2020 in the EU (see Table 3.12). This is because a shortage of available labour pushes up wage rates and labour costs. However, it should be noted that the remaining workers receive slightly higher wages. The pattern is fairly similar to the economic results with some variation between countries, although there are no countries where employment levels increase.

The model results show a slight decrease in unemployment but this is because the workers that have been affected by the skills mismatches are assumed to withdraw from the labour market rather than claim benefits.

Table 3.12 Employment (% difference from Baseline) in Skills Mismatch Scenario

EMPLOYMENT (% DIFFERENCE FROM BASELINE) IN SKILLS MISMATCH SCENARIO

	s32a		s32a
Belgium	-0.1	United Kingdom	-0.1
Denmark	0.0	Czech Rep.	-0.1
Germany	0.0	Estonia	-0.1
Greece	-0.1	Cyprus	0.0
Spain	0.0	Latvia	0.0
France	-0.1	Lithuania	0.0
Ireland	0.0	Hungary	-0.1
Italy	-0.1	Malta	0.0
Luxembourg	-0.1	Poland	-0.1
Netherlands	0.0	Slovenia	0.0
Austria	0.0	Slovakia	-0.1
Portugal	-0.1	Bulgaria	-0.1
Finland	-0.1	Romania	-0.1
Sweden	-0.1	**EU27**	-0.1

Source(s): E3ME, Cambridge Econometrics.

Occupational demand

Figure 3.19 shows how the structure of employment in terms of occupation is projected to change under the Baseline and each of the revenue recycling scenarios.

The key driver of change is sectoral employment patterns, as described above, which are affected by the different patterns of demands for goods and services assumed in the different scenarios. The patterns of skill demands within sectors are assumed fixed. In practice these might also be expected to vary between scenarios but there is no robust evidence upon which to base such variations

At the broad level of aggregation used in Figure 3.19 the occupational composition of employment varies little across the scenarios. Looking at the projected change of occupational employment over the period 2010-20, it is clear that there are some significant changes to the patterns of skill demands happening, but these are common to all the scenarios. These Baseline changes include the impacts from environmental policy that has already been implemented.

Figure 3.20 focuses on the differences in the changes between the scenarios. In general the direction of change under each of the scenarios is more or less the same. There is relatively little difference between the investment in broad technologies scenario, which is the most positive scenario regarding overall employment growth, and the increase in social benefits scenario, which is associated with the weakest level of employment growth.

Figure 3.19: Occupational Structures under Various Scenarios, 2020, EU27+NO+CH

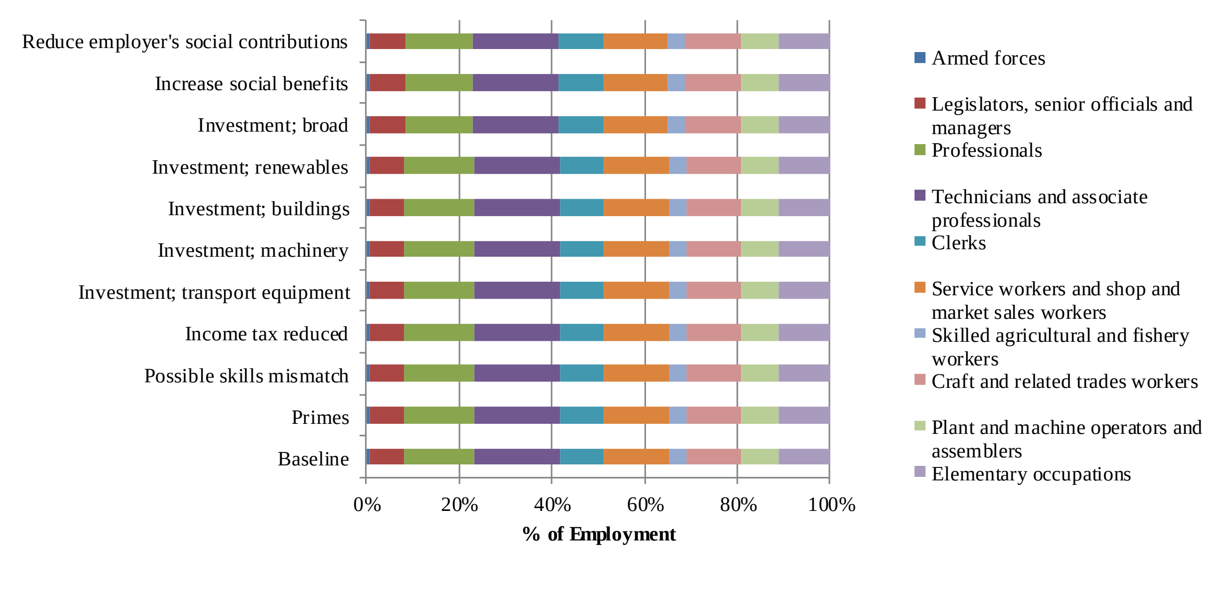


Figure 3.20 shows the net change by occupation, in thousands, for each of the scenarios based on 2-digit ISCO (International Standard Classifications of Occupations). If one looks in detail at the information included in Table 3.11 it reveals that there are some differences between scenarios in some critical occupations. Under the Baseline scenario an estimated 11m additional jobs are projected to be created by 2020; each of the scenarios differs only marginally from this overall total. But there is evidence that some of the scenarios which anticipate increased investments in technologies of one kind or another result in relatively high increases for employment in professional, associate professional, and craft jobs (i.e. occupations which are generally associated with high levels of skills) as indicated in Table 3.12.

Overall there is indicative evidence that the more a scenario requires investment in the development of new technologies and processes, the more this is likely to be reflected in a slightly increased demand for key skills (reflected in an added demand for people to work in particular types of professional and associate professional occupations).

The differences between the scenarios are modest but, as noted above, the types of occupation affected are often ones which experience skill shortages. These often arise as a consequence of the pace of technical change being such that the supply side is unable to keep up with demand. Relatively small differences in the scale of demand can be of importance in such a context.

Figure 3.20: Occupational Change in 000s in the Various Scenarios, 2010-20, EU27+NO+CH

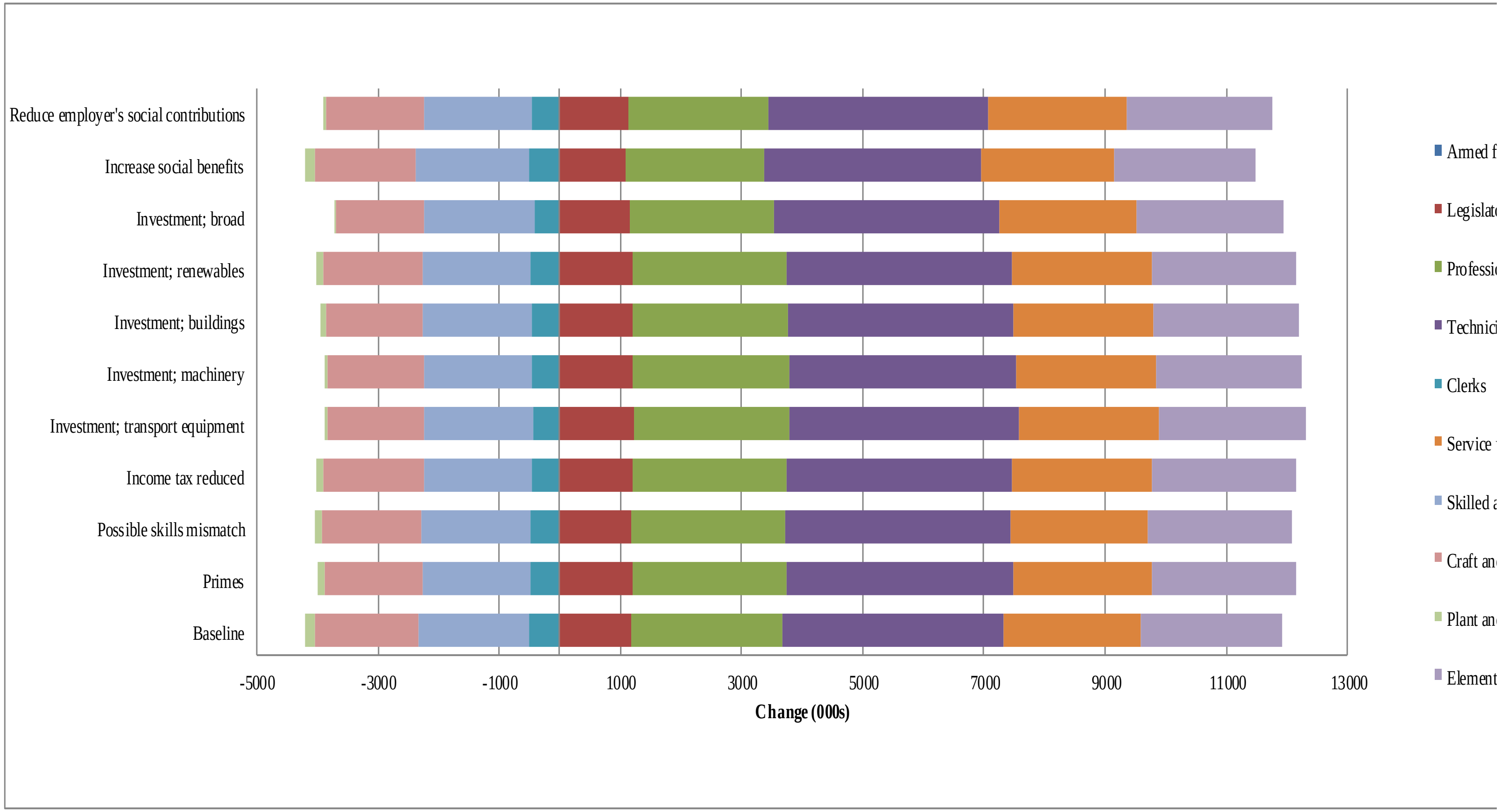


Table 3.13: Change in Occupational Employment (000s) by Scenario in the EU27+NO+CH, 2010-20

CHANGE IN OCCUPATIONAL EMPLOYMENT (000s) BY SCENARIO IN THE EU27+NO+CH, 2010-20											
	Baseline	**Primes Ref**	**Skills mismatch**	**Income tax**	**Invest Tran**	**Invest Mach**	**Invest Build**	**Invest Renew**	**Invest All**	**Social Benefits**	**Emp'rs Soc Sec**
01 Armed Forces	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40	-40
11 Legislators and senior officials	155	156	156	156	156	156	156	156	156	155	156
12 Corporate managers	1,579	1,605	1,594	1,601	1,616	1,611	1,608	1,601	1,635	1,578	1,610
13 Managers of small enterprises	104	123	116	119	129	125	124	119	142	106	129
21 Physical, mathematical and engineering science professionals	972	993	987	989	1,013	1,003	997	991	1,038	985	994
22 Life science and health professionals	157	160	159	159	160	160	159	159	160	157	159
23 Teaching professionals	-464	-462	-463	-462	-462	-462	-462	-462	-462	-463	-462
24 Other professionals	2,583	2,614	2,606	2,612	2,624	2,621	2,615	2,610	2,639	2,586	2,615
31 Physical and engineering science associate professionals	868	894	886	892	919	911	899	892	948	880	893
32 Life science and health associate professionals	40	42	41	42	43	42	42	42	43	38	44
33 Teaching associate professionals	464	465	465	465	466	465	465	465	466	464	465
34 Other associate professionals	3,671	3,717	3,703	3,718	3,740	3,735	3,721	3,715	3,761	3,676	3,725
41 Office clerks	-1,615	-1,581	-1,594	-1,582	-1,565	-1,561	-1,576	-1,583	-1,537	-1,609	-1,575
42 Customer services clerks	740	749	746	751	757	753	751	750	758	740	754
51 Personal and protective services workers	1,851	1,876	1,864	1,881	1,879	1,878	1,877	1,876	1,869	1,836	1,898
52 Models, salespersons and demonstrators	972	979	974	975	993	979	978	977	1,002	966	984
61 Skilled agricultural and fishery workers	-1,821	-1,794	-1,803	-1,778	-1,787	-1,785	-1,790	-1,786	-1,814	-1,874	-1,767
71 Extraction and building trades	337	437	428	389	437	421	453	392	542	404	411

CHANGE IN OCCUPATIONAL EMPLOYMENT (000s) BY SCENARIO IN THE EU27+NO+CH, 2010-20

	Baseline	Primes Ref	Skills mismatch	Income tax	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp’rs Soc Sec
workers											
72 Metal, machinery and related trades workers	-1,252	-1,238	-1,245	-1,237	-1,217	-1,211	-1,232	-1,234	-1,182	-1,249	-1,228
73 Precision, handicraft, craft printing and related trades workers	-172	-169	-170	-168	-166	-164	-168	-168	-160	-172	-167
74 Other craft and related trades workers	-669	-681	-684	-680	-674	-674	-674	-676	-658	-683	-665
81 Stationary plant and related operators	102	106	104	107	117	115	107	107	124	99	109
82 Machine operators and assemblers	-236	-224	-230	-223	-202	-204	-220	-221	-179	-245	-213
83 Drivers and mobile plant operators	169	203	195	213	216	218	214	210	220	162	231
91 Sales and services elementary occupations	1,518	1,554	1,543	1,557	1,569	1,562	1,558	1,553	1,574	1,526	1,564
92 Agricultural, fishery and related labourers	-28	-24	-26	-23	-24	-23	-24	-24	-27	-33	-21
93 Labourers in mining, construction, manufacturing and transport	1,077	1,098	1,093	1,092	1,109	1,102	1,103	1,093	1,133	1,081	1,106
TOTAL	11,063	11,559	11,404	11,524	11,806	11,734	11,643	11,514	12,151	11,069	11,709

Source(s): IER, Cambridge Econometrics.

Table 3.14: Change in Occupational Employment (000s) by Scenario in EU27+NO+CH, 2010-20 (difference from Baseline)

CHANGE IN OCCUPATIONAL EMPLOYMENT (000s) BY SCENARIO IN EU27+NO+CH, 2010-20 (DIFFERENCE FROM BASELINE)

	Primes Ref	Skills mismatch	Income tax	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp’rs Soc Sec
01 Armed Forces	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	-0.1	0.1
11 Legislators and senior officials	0.5	0.3	0.5	0.7	0.6	0.5	0.5	0.8	-0.3	0.7
12 Corporate managers	25.7	14.6	21.6	36.3	32.1	28.4	22.1	55.7	-1.7	30.7
13 Managers of small enterprises	18.3	11.8	14.6	25.3	21.0	19.7	14.8	38.1	1.3	24.6
21 Physical, mathematical and engineering science professionals	21.6	14.9	17.5	41.0	31.7	25.5	18.8	66.4	13.0	21.8
22 Life science and health professionals	2.1	1.4	1.8	2.4	2.1	1.9	1.7	2.6	-0.2	1.7
23 Teaching professionals	1.5	1.0	1.5	1.9	1.6	1.5	1.4	2.1	0.3	1.6
24 Other professionals	31.4	22.6	28.5	41.1	38.2	32.4	26.9	55.5	3.4	31.8
31 Physical and engineering science associate professionals	26.5	18.3	23.8	51.2	43.6	31.0	24.2	80.1	12.4	25.7
32 Life science and health associate professionals	1.9	0.9	2.8	3.6	2.8	2.5	2.6	3.2	-1.2	4.6
33 Teaching associate professionals	1.6	0.8	1.6	1.9	1.7	1.6	1.4	2.1	0.5	1.4
34 Other associate professionals	45.6	31.7	46.3	68.5	63.1	49.9	43.6	89.9	4.7	53.6
41 Office clerks	34.0	21.3	33.3	50.7	54.1	39.6	32.3	78.3	6.2	40.1
42 Customer services clerks	9.4	6.6	11.0	16.8	12.7	10.7	10.3	18.1	-0.3	13.9
51 Personal and protective services workers	24.6	13.2	30.3	27.9	27.4	26.1	25.3	17.9	-15.5	47.0
52 Models, salespersons and demonstrators	7.2	1.8	2.6	20.8	6.8	6.1	5.4	29.5	-6.5	12.3
61 Skilled agricultural and fishery workers	26.5	18.0	43.2	33.7	35.9	30.6	34.4	6.6	-52.7	54.2
71 Extraction and building trades	100.6	91.5	51.7	100.3	84.2	116.0	55.4	205.4	66.9	74.0

CHANGE IN OCCUPATIONAL EMPLOYMENT (000s) BY SCENARIO IN EU27+NO+CH, 2010-20 (DIFFERENCE FROM BASELINE)

	Primes Ref	Skills mismatch	Income tax	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp’rs Soc Sec
workers										
72 Metal, machinery and related trades workers	13.5	7.1	14.3	34.3	41.0	20.0	17.4	69.9	2.7	23.6
73 Precision, handicraft, craft printing and related trades workers	3.8	2.5	4.0	5.9	8.9	4.7	4.3	12.0	0.7	5.2
74 Other craft and related trades workers	-11.5	-14.7	-10.5	-4.6	-4.6	-4.7	-7.0	11.0	-14.1	4.0
81 Stationary plant and related operators	4.3	2.1	5.5	14.9	13.0	5.2	5.4	21.8	-2.8	7.2
82 Machine operators and assemblers	12.4	6.0	13.3	34.2	31.7	16.3	14.6	57.3	-8.7	23.4
83 Drivers and mobile plant operators	34.4	25.7	44.0	47.5	49.2	45.0	41.0	51.0	-7.0	61.8
91 Sales and services elementary occupations	36.0	24.7	38.5	50.6	43.5	39.3	34.4	55.2	7.2	45.4
92 Agricultural, fishery and related labourers	3.5	2.0	5.4	4.4	4.5	4.1	4.3	1.4	-5.5	7.0
93 Labourers in mining, construction, manufacturing and transport	20.9	15.5	14.4	31.5	24.7	25.9	15.7	56.1	3.9	28.9
TOTAL	**496**	**342**	**462**	**743**	**672**	**580**	**451**	**1,088**	**7**	**646**

Source(s): IER, Cambridge Econometrics.

Table 3.15: Change in Occupational Employment by Scenario in the EU27+NO+CH (% difference from Baseline 2010-20 Growth)

CHANGE IN OCCUPATIONAL EMPLOYMENT BY SCENARIO IN THE EU27+NO+CH (% DIFFERENCE FROM BASELINE 2010-20 GROWTH)										
	Primes Ref	**Skills mismatch**	**Income tax**	**Invest Tran**	**Invest Mach**	**Invest Build**	**Invest Renew**	**Invest All**	**Social Benefits**	**Emp’rs Soc Sec**
01 Armed Forces	-0.1	0.1	-0.1	-0.4	-0.1	-0.1	-0.1	-0.4	0.2	-0.2
11 Legislators and senior officials	0.3	0.2	0.3	0.4	0.4	0.3	0.3	0.5	-0.2	0.4
12 Corporate managers	1.6	0.9	1.4	2.3	2.0	1.8	1.4	3.5	-0.1	1.9
13 Managers of small enterprises	17.5	11.4	14.0	24.2	20.2	18.9	14.2	36.6	1.3	23.6
21 Physical, mathematical and engineering science professionals	2.2	1.5	1.8	4.2	3.3	2.6	1.9	6.8	1.3	2.2
22 Life science and health professionals	1.4	0.9	1.2	1.5	1.3	1.2	1.1	1.7	-0.1	1.1
23 Teaching professionals	-0.3	-0.2	-0.3	-0.4	-0.4	-0.3	-0.3	-0.4	-0.1	-0.4
24 Other professionals	1.2	0.9	1.1	1.6	1.5	1.3	1.0	2.2	0.1	1.2
31 Physical and engineering science associate professionals	3.1	2.1	2.7	5.9	5.0	3.6	2.8	9.2	1.4	23.0.
32 Life science and health associate professionals	4.9	2.2	7.0	9.1	7.0	6.4	6.6	8.1	-3.1	11.7
33 Teaching associate professionals	0.4	0.2	0.3	0.4	0.4	0.3	0.3	0.5	0.1	0.3
34 Other associate professionals	1.2	0.9	1.3	1.9	1.7	1.7	1.2	2.5	0.1	1.5
41 Office clerks	-2.1	-1.3	-2.1	-3.1	-3.4	-2.5	-2.0	-4.9	-0.4	-2.5
42 Customer services clerks	1.3	0.9	1.5	2.3	1.7	1.5	1.4	2.5	-0.0	1.9
51 Personal and protective services workers	1.3	0.7	1.6	1.5	1.5	1.4	1.4	1.0	-0.8	2.5
52 Models, salespersons and demonstrators	0.7	0.2	0.3	2.1	0.7	0.6	0.6	3.0	-0.7	1.3
61 Skilled agricultural and fishery workers	-1.5	-1.0	-2.4	-1.9	-2.0	-1.7	-1.9	-0.4	2.9	-3.0
71 Extraction and building trades	29.9	27.2	15.3	29.8	25.0	34.4	16.4	61.0	19.9	22.0

CHANGE IN OCCUPATIONAL EMPLOYMENT BY SCENARIO IN THE EU27+NO+CH (% DIFFERENCE FROM BASELINE 2010-20 GROWTH)

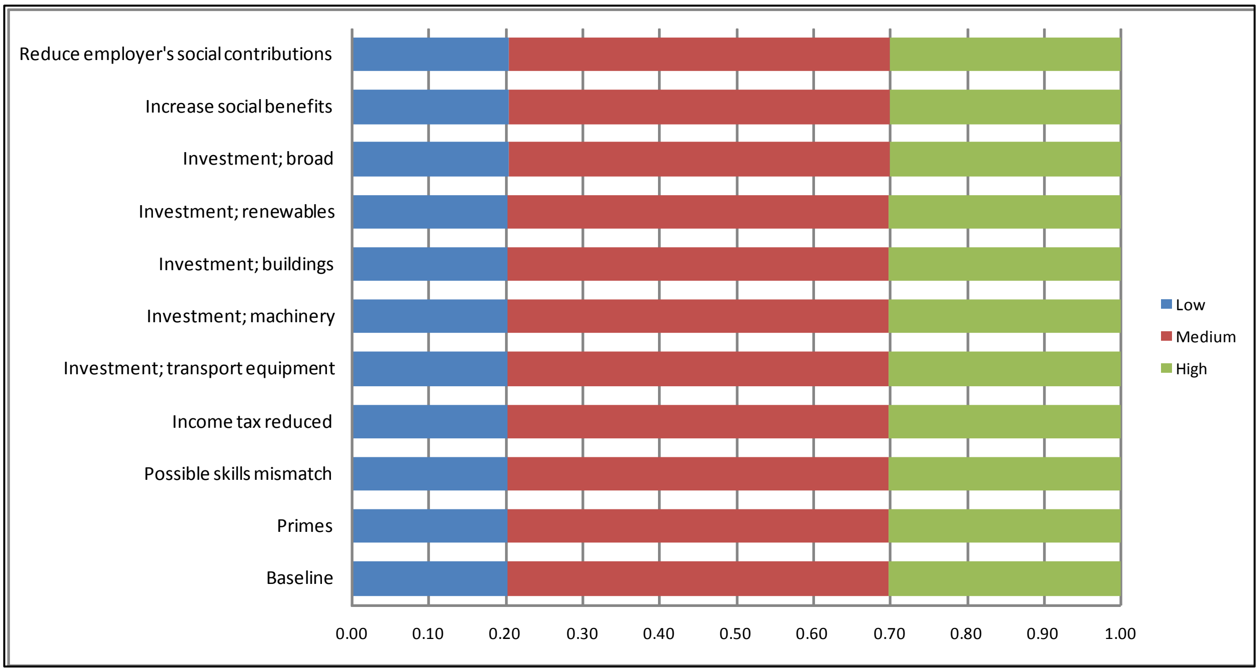
	Primes Ref	Skills mismatch	Income tax	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp'rs Soc Sec
workers										
72 Metal, machinery and related trades workers	-1.1	-0.6	-1.2	-2.7	-3.3	-1.6	-1.4	-5.6	-0.2	-1.9
73 Precision, handicraft, craft printing and related trades workers	-2.2	-1.5	-2.3	-3.5	-5.2	-2.7	-2.5	-6.9	-0.4	-3.0
74 Other craft and related trades workers	1.7	2.2	1.6	0.7	0.7	0.7	1.1	-1.6	2.1	-0.6
81 Stationary plant and related operators	4.3	2.1	5.5	14.6	12.8	5.2	5.3	21.5	-2.7	7.1
82 Machine operators and assemblers	-5.2	-2.6	-5.6	-14.5	-13.4	-6.9	-6.2	-24.3	3.7	-9.9
83 Drivers and mobile plant operators	20.4	15.2	26.1	28.1	29.1	26.7	24.3	30.2	-4.1	36.6
91 Sales and services elementary occupations	2.4	1.6	2.5	3.3	2.9	2.6	2.3	3.6	0.5	3.0
92 Agricultural, fishery and related labourers	-12.7	-7.1	-19.3	-15.7	-16.1	-14.7	-15.3	-5.0	19.9	-25.0
93 Labourers in mining, construction, manufacturing and transport	1.9	1.4	1.3	2.9	2.3	2.4	1.5	5.2	0.4	2.7
TOTAL	**4.5**	**3.1**	**4.2**	**6.7**	**6.1**	**5.2**	**4.1**	**9.8**	**0.1**	**5.8**

Source(s): IER, Cambridge Econometrics.

Qualification changes

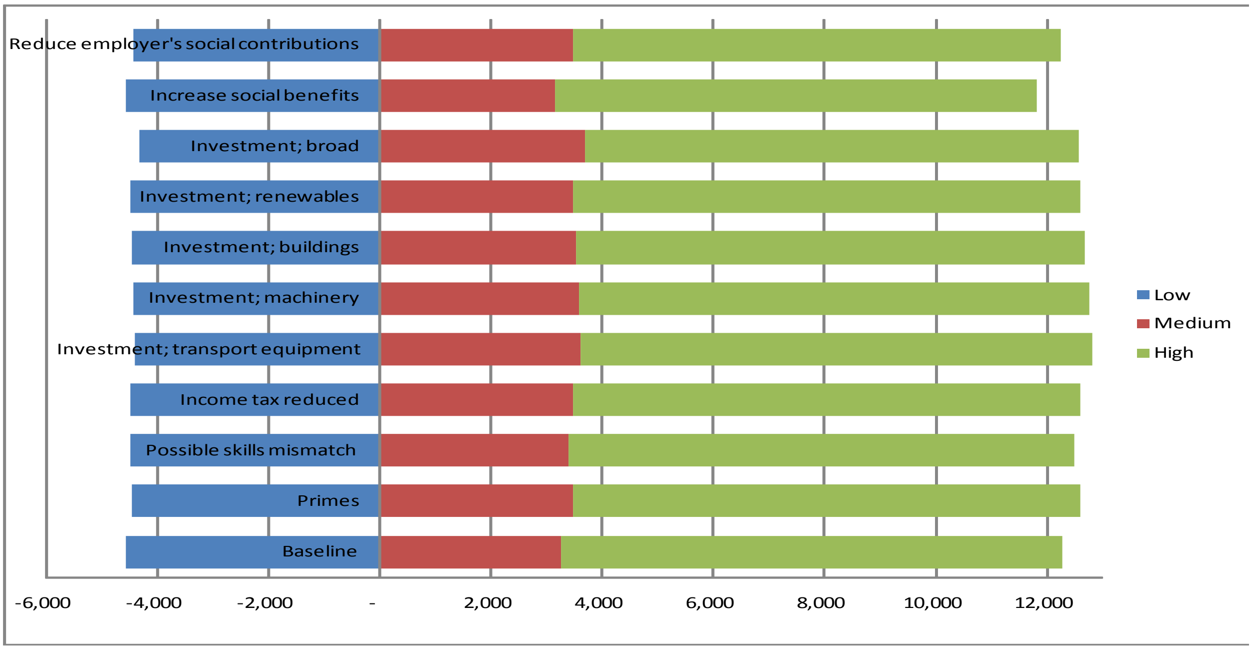
As well as measuring skills with respect to occupation it also possible to do so with respect to qualification. The qualification variable used in the projections is defined with respect to: high level qualifications (degree level qualifications, etc.); intermediate level qualifications (apprenticeship and equivalent) and; low level qualifications (including no qualifications). Figure 3.21 shows the projected qualifications structure of the labour force by 2020 under each scenario. As can be seen there is relatively little difference in the qualifications structure of the workforce across any of the scenarios. This is in part because the results reflect both supply as well as demand changes and the model sorts the available work force by qualification into whatever jobs are available.

Figure 3.21: Qualifications' Shares in the Various Scenarios, EU29, 2020



A clearer picture of the impact of the scenarios can be seen from the level of change which is expected to take place over the 2010 to 2020 period under each of the scenarios (see Figure 3.22). The main discernible impact is again the result of scale effects. The investment in broad technology scenario suggests one of the smallest declines for low and largest increases for medium and high levels of education. The impact of scenarios on qualifications employment can be explored further by looking into the qualifications structure across occupational categories, but these show little change. Accordingly, the main conclusion is that the qualifications structure of those in employment remains largely unaltered across scenarios.

Figure 3.22: Qualifications Employment Change (in 000s) in Various Scenarios, 2010-20



Summary of trends

The message that the modelling suggests is that, at this level of aggregation, any shifts in occupational and qualifications structures under the different scenarios are modest. Of course it is likely that at a more micro level there will be more significant effects, both in terms of positive demand for certain types of skill associated with green technologies, as well as more general impacts on jobs in sectors that are hardest hit by the impact of environmental mitigation policies. What is most apparent is that the Baseline scenario will result in a continuation of the trend observed across the EU of relatively strong growth in the number of people employed in higher level occupations (possibly including the impacts of existing environmental legislation).

The scenarios which assume a greater level of investment in technologies of one sort or another will result in a slight increase in the number of people employed, both overall and in higher level occupations, but these gains are relatively small. There are clearly stronger determinants of employment growth overall, and skilled jobs in particular, across Europe which account for the employment trends observed in the various scenarios described above than the particular assumptions – *qua* potential policy levers - contained in the scenarios.

3.10 Sensitivity scenario results

GDP

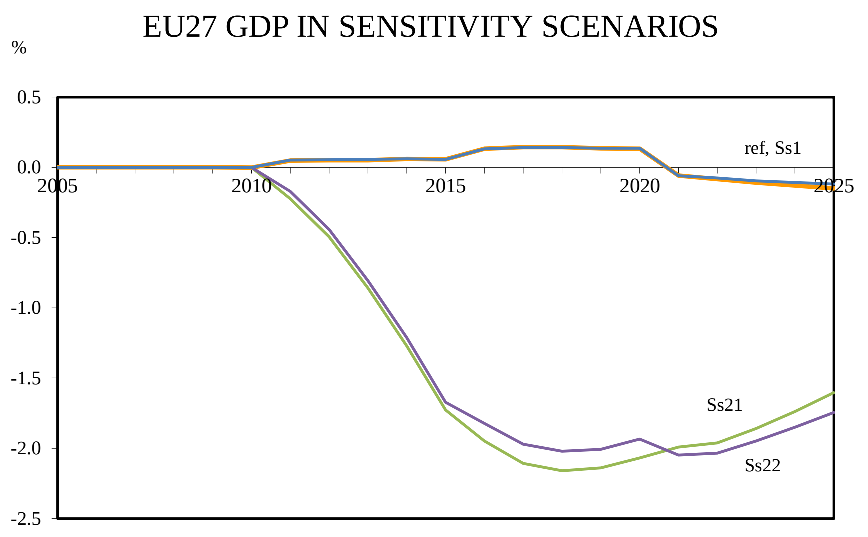
Figure 3.23 shows results from the sensitivity analysis (scenarios Ss1, Ss21 and Ss22, as defined in Table 3.4).

GDP impacts in the sensitivity scenario where firms in the rest of the world increase their prices as a result of the implementation by governments of similar environmental actions (Ss1) are very similar to the results in the Reference case (also shown in Figure 3.23). Although, as expected, higher world prices mean that extra-EU imports fall and exports increase, the impacts from higher import prices means that real disposable income and consumption fall. The benefits to growth for the EU are therefore reduced by import price inflation. However, there are still some important sectoral effects behind this aggregate result; energy-intensive sectors benefit the most from improved competitiveness, while sectors dependent on household consumption (e.g. food, consumer services) lose out. The implication for jobs is thus a modest protection of (often manual) manufacturing jobs at the expense of those in the service sector.

GDP is reduced by approximately 2% from Baseline in 2020 as a result of a permanent 30% increase in international energy prices (Ss21 and Ss22). Higher energy prices tend also to be passed on through higher product prices, erode real incomes and reduce domestic expenditure. This result is similar in magnitude (given the oil price increase) to previous analysis with the E3ME model (see Pollitt and Chewpreecha, 2009). The impacts are larger in the more energy-intensive EU Member States and the energy-intensive sectors, such as basic metals, non-metallic mineral products and air transport, as well as the energy sectors themselves.

However, it should be noted that the investment effects from increasing the share of renewables are still positive, reflected in the fact that GDP in Ss22 is higher than in Ss21 in the period up to 2020.

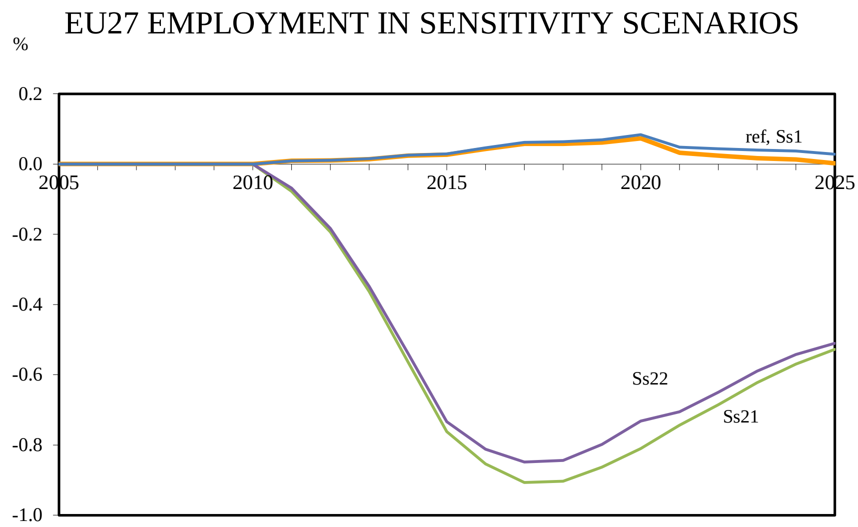
Figure 3.23: Impacts on EU27 GDP as a Result of High Oil Prices



Source(s): E3ME, Cambridge Econometrics.

Employment Employment results in the two high global energy price scenarios generally follow the pattern of the negative GDP results (see Figure 3.24). As in the main scenarios, the effects are roughly half in percentage terms of the GDP effects. There are, however, differences between sectors. The energy-intensive sectors will in general have the highest cost and price increases and loss of output, but in some cases they may be able to substitute labour for energy. This reduces the loss of employment that would be expected from the reduction in economic activity.

Figure 3.24: EU27 Employment in Sensitivity Scenarios



Source(s): E3ME, Cambridge Econometrics.

Emissions impacts Higher oil prices reduce energy demand and consequently reduce emissions. Because we did not adjust the carbon prices used, the emissions reductions in the sensitivity scenario exceed (i.e. emissions are lower than) the targets in the Reference scenario (even in ETS sectors). If we were to adjust the policies (e.g. lower the carbon price) in order to meet the same target under a higher oil price assumption, the economic and employment impacts would be less negative.

Labour supply In Ss1 there is very little difference in the outcome for labour supply compared with the Reference case, as the macroeconomic impacts are quite similar.

In the high oil price sensitivity scenarios there are reductions in labour supply, which in some countries are quite large. There are three reasons for this:

- economic activity falls, indicating less opportunity
- unemployment rates increase, so some people leave the labour force and fewer are likely to join
- higher inflation rates erode real incomes, reducing the incentive to work

The countries that are most affected are generally the ones that are more energy-intensive and therefore have the largest effects through all these channels. They include Greece, Romania and Spain.

4 The Impact on the Type and Quality of Green Jobs

4.1 Introduction

Building on the initial analysis presented in the second interim report, this chapter presents a fuller assessment of the impact of environmental policies on the quality of work and jobs.

In practice, there are limited data to allow a comprehensive analysis of job quality in relation to the sustainability agenda. This chapter sets out how best use has been made of the evidence available and reports on the key findings of the analysis.

4.2 The structure of the analysis

The role of technical change

The greening of the European economy- with its emphasis on energy saving, finding new forms of energy generation, and so on - can be regarded as part of the ongoing process of technical change in the economy. As such, it can be expected to have an impact on the skill content of jobs. There are various ways of measuring skills. The two most commonly used measures are occupation and qualification. Whilst these are imperfect measures of skill they have become the standard measures used in the analysis of skill trends. To date much research demonstrates that occupational change has been driven by the take up of new technologies which, with the ICT revolution from the late 1970s onwards, have transformed the content of many occupations (Wilson et al, 2007). If the skill content of jobs changes as a consequence of technical change then there are also likely to be distributional issues with respect to who obtains access to various jobs, and implications for the quality of employment (for example, if jobs come de-skilled or up-skilled). These are important issues with respect to the direction of change in the EU economy and the aim to generate high skilled, high value employment (c.f. New Skills for New Jobs). In general the consensus is that technical change has been biased in favour of high skills. This has been the general direction of change in employment patterns in recent years across most sectors, although there is some indication of polarisation of demand, with some growth in less skilled jobs too (Wilson et al, 2010).

The impact of the 'greening' of the economy

The extent to which the greening of the European economy over the medium term will have an impact on the occupational structure of employment and the content of employment is, in the light of the above, a pressing issue. Section 3.6 indicated how the various scenarios will impact upon output and employment levels by sector. Whilst the scenarios suggest relatively modest change in output and employment levels at an aggregate or sectoral level (compared to the changes already happening in the baseline), the nature of the change observed may nevertheless have some impact on:

- future skill demand (measured with reference to occupation and qualification)
- the quality of employment (measured with reference to a number of measures of job quality and job satisfaction)
- different groups in the labour market, especially groups which are considered to be vulnerable to shifts in the structure of employment

Each of these has been considered in turn. Section 3.7 presented analysis of the change in employment demand with respect to occupation and qualification. This gave an indication of the extent to which changes in skill demand are likely to take place in the period to 2020.

In this chapter:

- The occupational projections are considered with respect to how they relate to 'green jobs'. This is based on the O*NET classification of green jobs and provides an indication of the extent to which the Baseline Scenario will result in an increase in 'green jobs' of different types (i.e. ones which are in some way directly related to meeting environmental needs in the economy). This is not a replication of the O*NET classification but an interpretation and expansion of the classification to reflect what is known about the greening of jobs in the EU (see CEDEFOP, 2010a).
- Various dimensions of job quality are considered, including the extent to which these are associated with particular occupations (based on European Labour Force Survey and European Working Conditions Survey data). This information is then related to the Baseline Scenario to give an indication of the extent to which the 2020 Agenda might impact on job quality.
- Finally, consideration is given to the impact on vulnerable groups, and the extent to which projected occupational change is likely to have an adverse impact on particular groups in the labour market.

Overall the analysis provides an overview of how different dimensions of employment are likely to be affected over the medium term. It needs, however, to be borne in mind that the results are indicative of the direction of change both across the EU and in particular Member States. At all times the assumptions which have guided the analysis are made explicit, as are the limitations of the data. Notwithstanding these caveats, the study provides a detailed assessment of how climate change, and the policies introduced to mitigate any damage to the environment and economy, will have an impact on employment patterns.

4.3 Green jobs

Defining green jobs

The projections of occupational change (see Section 3.7) provide an indication of how the green agenda will affect the overall skill structure of employment, but provide relatively little information about the green content of jobs. In the USA, O*NET have developed a taxonomy of green occupations as outlined in Box 4.1. This provides a basis for devising a classification system for estimating the extent to which there is a green component to jobs in the EU. Inevitably there is a high degree of estimation required in producing a classification of green jobs. This requires not only the cross-classification of occupations codes used in O*NET's classification of occupations with those in ISCO, but also a degree of interpretation of what might constitute a 'green enhanced' or 'green increased demand' occupation within the context of the EU labour market. Accordingly, the estimates should be regarded as indicative, and treated with caution. However, they do give an indication of the way in which the greening of the European economy is likely to affect occupations and skill demand.

Before providing the results a brief description is provided of the O*NET classification in the boxes below (see Box 4.2 to Box 4.4).

Box 4.1: O*NET Classification of Green Occupations

Green Increased Demand Occupations. The impact of green economy activities and technologies is an increase in the employment demand for an existing occupation. However, this impact does not entail significant changes in the work and worker requirements of the occupation. The work context may change, but the tasks themselves do not. An example is the increased demand for electrical power line installers and repairers related to energy efficiency and infrastructure upgrades.

Green Enhanced Skills Occupations. The impact of green economy activities and technologies results in a significant change to the work and worker requirements of an existing occupation. This impact may or may not result in an increase in employment demand for the occupation. An example is the occupation 'architect', where greening has increased knowledge requirements pertaining to energy-efficient materials and construction, as well as skills associated with integrating green technology into the aesthetic design of buildings. For example, many architects have pursued Leadership in Energy and Environmental Design (LEED) certifications to ensure the proper application of U.S. Green Building Council principles to building designs. The essential purposes of the occupation remain the same but tasks, skills, knowledge, and external elements, such as credentials, may have been altered.

New and Emerging (N&E) Green Occupations. The impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements, resulting in the generation of a new occupation. This new occupation could be entirely novel or 'born' from an existing occupation. An example would be solar system technicians who must be able not only to install new technology, but also to determine how this technology can best be used on a specific site.

Source: Dierdorff et al (2009) p. 11/12

The O*NET classification, under each of its three main occupational categories, contains a mix of occupations from high skilled to more routine skills. For example, Green Increased Demand Occupations includes the following types of jobs (see Box 4.2).

Box 4.2: Examples of Green Increased Demand Occupations

First-Line Supervisors/Managers of Logging Workers
First-Line Supervisors/Managers of Mechanics, Installers, and Repairers
First-Line Supervisors/Managers of Production and Operating Workers
Fish and Game Wardens
Forest and Conservation Technicians
Forest and Conservation Workers
Helpers--Installation, Maintenance, and Repair Workers
Helpers--Carpenters
Hydrologists
Industrial Engineers
Industrial Machinery Mechanics
Industrial Production Managers
Industrial Safety and Health Engineers
Industrial Truck and Tractor Operators
Insulation Workers, Floor, Ceiling, and Wall
Labourers and Freight, Stock, and Material Movers, Hand
Locomotive Engineers
Materials Scientists

Similarly, Green Enhanced Skills also includes a variety of occupations with reference to skill levels (see Box 4.3).

Box 4.3 Examples of Green Enhanced Occupations

Aerospace Engineers
Agricultural Technicians
Aircraft Structure, Surfaces, Rigging, and Systems Assemblers
Arbitrators, Mediators, and Conciliators
Architects, Except Landscape and Naval
Atmospheric and Space Scientists
Automotive Specialty Technicians
Civil Engineers
Construction and Building Inspectors
Construction Labourers
Construction Managers
Continuous Mining Machine Operators
Electrical Engineering Technicians
Electrical Engineers
Electro-Mechanical Technicians
Electronics Engineers, except Computer
Engineering Managers
Environmental Engineering Technicians
Environmental Engineers
Environmental Science and Protection Technicians, including Health
Farmers and Ranchers
Financial Analysts

Both green enhanced and green increased demand occupations are defined according to the O*NET Standard Occupational Classification (SOC). In contrast, New and Emerging (N&E) Green Occupations are not classified according to O*NET SOC, because of their recent emergence, and so less can be said about the quality of employment in these occupations (see Box 4.4). Arguably amongst this group of occupations there is more of a bias towards professional and associate professional occupations but this may simply reflect the development stage at which many green technologies have currently reached.

Box 4.4 Examples of N&E Green Occupations

Air Quality Control Specialists
Automotive Engineering Technicians
Automotive Engineers
Biochemical Engineers
Biofuels/Biodiesel Technology and Product Development Managers
Biofuels Production Managers
Biofuels Processing Technicians
Biomass Plant Engineers
Biomass Production Managers
Biomass Plant Technicians
Brownfield Redevelopment Specialists and Site Managers
Carbon Capture and Sequestration Systems Installers
Carbon Credit Traders
Carbon Trading Analysts

Current employment in green jobs

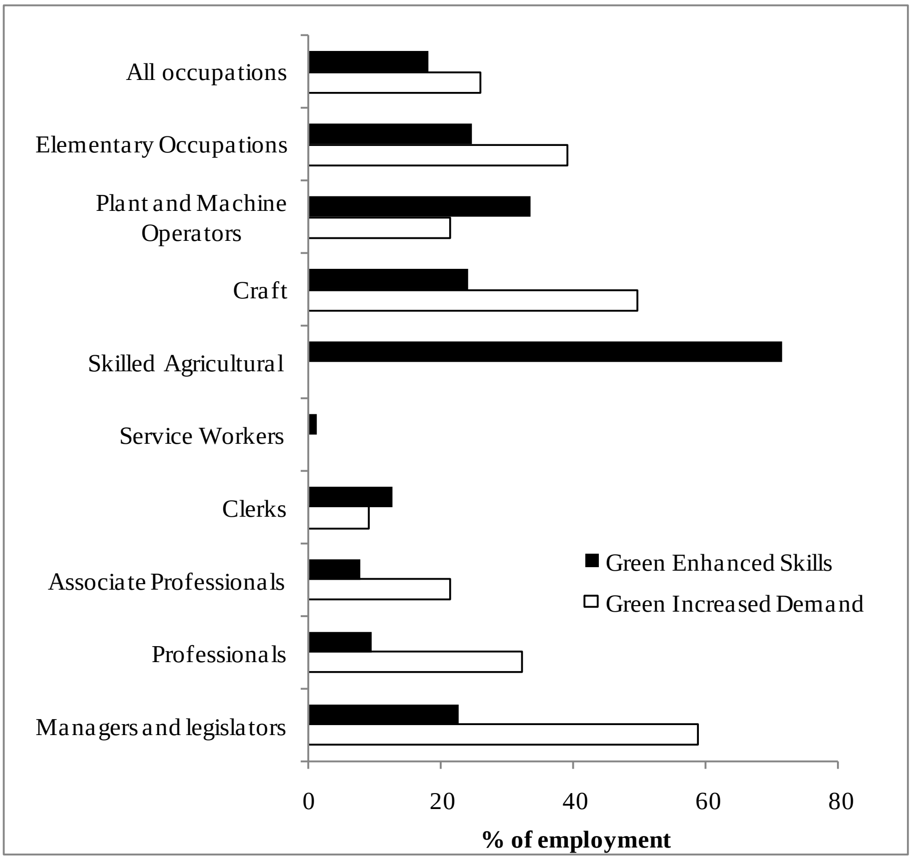
Given that existing occupational classification systems such as ISCO do not as yet encompass new and emerging green occupations, the analysis is limited to the 'green enhanced' and 'green increased demand' occupations respectively.

Based on 3-digit information contained in the European Labour Force Survey (EU-LFS) for 2009, occupations were allocated to (i) green increased-demand and (ii) green enhanced occupations. Some jobs were allocated to neither category. They are considered to be ‘non-green’.

An initial best estimate of the extent to which jobs are regarded as green is provided in Figure 4.1. This shows the percentage of all jobs that fall into the Green Enhanced Skills or Green Increased Demand categories. The data show the current distribution of green jobs across occupations, and indicate that a relatively high share of jobs have a green element to them. This is not to say that they are green jobs per se - evidence from the USA reveals that the number of people employed in what might be termed wholly green jobs is relatively small – rather the evidence points to existing jobs having a green element encompassed within them.

Overall the analysis suggests that around a quarter of all jobs in the EU fall under the category Green Increased Demand and around a fifth under the category Green Enhanced Skills. To some extent the O*NET classification is based on the extent to which there is potential for occupations to be affected by the greening of the economy. This might not reflect the current situation but the potential for jobs to become greener in the future. As Figure 4.1 indicates there is considerable scope for this to occur given the current occupational structure of the EU. It is also apparent from Figure 4.1 that there is considerable variation by occupation with, in particular, many skilled occupations such as managers and professionals being susceptible to change in demand because of green issues (green increased demand). On the other hand it is skilled agricultural workers that are expected to see the biggest change regarding the need for green enhanced skills within their existing jobs. These results have implications for the interpretation of the projections of employment, which are considered in the next section.

Figure 4.1: Indication of the Extent to which Occupations are Considered Green



Source: Estimates based on EU-LFS and O*NET classification of occupations

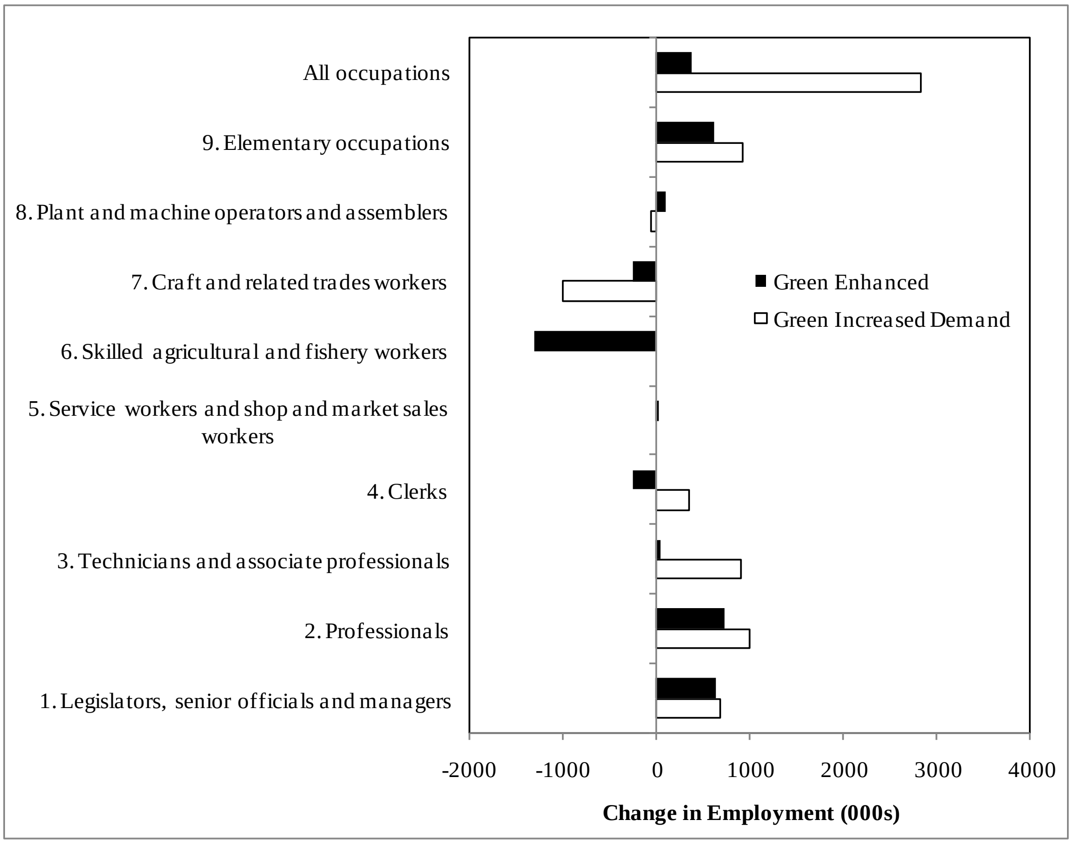
Projected change in green jobs to 2020 (based on Baseline scenario)

Using these results it is possible to provide an indication of the extent to which different jobs will be affected by 'greening' (see Figure 4.2). If one assumes that the percentage of people employed in each occupation according to whether they are working in Green Increased Demand or Green Enhanced Skills jobs remains fixed in the future, then an indication can be provided about the extent to which the number of people employed in each of these types of job will change. These estimates should be regarded as indicative of the extent to which there will be growth in the number of people employed in each type of green job in the future.

Figure 4.2 shows the numbers of people by occupation that fall into the Green Increased Demand or Green Enhanced Skills categories, assuming constant shares in the future as calculated from Figure 4.1. There is no attempt to differentiate potential future changes in the shares of Green Increased Demand, Green Enhanced Skills or non-green skills.

The results indicate that under the Baseline Scenario there will be an increased demand for green skills in the period 2010 to 2020, with around an additional 2.5m jobs falling into the Green Increased Demand category and around 300,000 into the Green Enhanced Skills occupations. This is over and above the current number of green jobs in the economy.

Figure 4.2: Future Demand for Green In-Demand and Green Enhanced Skills



Note(s): Based on applying the % shares from Figure 4.1 to the net changes in Figure 3.3.

Table 4.1 shows the changes in the projected number of green jobs under the Baseline Scenario. It also compares this with two other scenarios which assume relatively high and low overall employment growth respectively. As can be seen there is relatively little difference between the scenarios, except the level of reduced job growth in occupations classified as green enhanced skills under the increased social benefits scenario.

What can be said, from a more qualitative perspective, is that those scenarios which emphasise greater investment in new technologies related to the 2020 Agenda are likely to increase the demand for those skilled occupations which are already relatively green. In other words, under these scenarios the demand for professional and associate professionals, and for skilled craft workers, is likely to increase for both Green Increased Demand (GID) or Green Enhanced Skills (GHS) occupations.

In many respects the sustainability agenda can be considered in the context of technical change. There is already a substantial literature on the skills bias which is inherent in technical change. The projections of future employment growth suggest that those policies which are likely to result in increased technical change will drive up the demand for green skills of one kind or another over and above the already substantial increase that is likely to occur under the Baseline Scenario.

Table 4.1: Future Demand for Green In-Demand and Green Enhanced Skills under Selected Scenarios (000s), 2010-20

FUTURE DEMAND FOR GREEN IN-DEMAND AND GREEN ENHANCED SKILLS UNDER SELECTED SCENARIOS (000s), 2010-20															
	Baseline									2010- 2020 Difference Compared to Baseline Scenario					
	Green Increased Demand			Green Enhanced Skills			Non-Green			Investment: Broad			Increase in Social Benefits		
	2010	2020	Change	2010	2020	Change	2010	2020	Change	GID	GHS	NG	GID	GHS	NG
01 Armed Forces	0	0	0	0	0	0	1,231	1,191	-40	0.0	0.0	0.2	0.0	0.0	-0.1
11 Legislators and senior officials	0	0	0	73	93	20	502	638	135	0.0	0.1	0.7	0.0	0.0	-0.3
12 Corporate managers	4,061	4,663	603	4,177	4,797	620	2,400	2,757	356	21.2	21.9	12.6	-0.6	-0.7	-0.4
13 Managers of small enterprises	7,100	7,194	93	0	0	0	819	830	11	34.2	0.0	3.9	1.2	0.0	0.1
21 Physical, mathematical and engineering science professionals	7,260	8,144	884	0	0	0	723	811	88	60.4	0.0	6.0	11.8	0.0	1.2
22 Life science and health professionals	2,875	2,986	112	0	0	0	1,177	1,223	46	1.9	0.0	0.8	-0.1	0.0	0.0
23 Teaching professionals	0	0	0	0	0	0	8,830	8,366	-464	0.0	0.0	2.1	0.0	0.0	0.3
24 Other professionals	0	0	0	3,316	4,044	727	8,462	10,318	1,856	0.0	15.6	39.9	0.0	1.0	2.4
31 Physical and engineering	5,635	6,196	561	268	295	27	2,815	3,095	280	51.8	2.5	25.9	8.0	0.4	4.0

FUTURE DEMAND FOR GREEN IN-DEMAND AND GREEN ENHANCED SKILLS UNDER SELECTED SCENARIOS (000s), 2010-20

	Green Increased Demand			Baseline Green Enhanced Skills			Non-Green			2010- 2020 Difference Compared to Baseline Scenario Investment: Broad			Increase in Social Benefits		
	2010	2020	Change	2010	2020	Change	2010	2020	Change	GID	GHS	NG	GID	GHS	NG
science associate professionals															
32 Life science and health associate professionals	551	555	4	2,526	2,542	16	3,013	3,033	20	0.3	1.3	1.6	-0.1	-0.5	-0.6
33 Teaching associate professionals	0	0	0	0	0	0	3,036	3,499	464	0.0	0.0	2.1	0.0	0.0	0.5
34 Other associate professionals	1,909	2,248	339	0	0	0	18,778	22,111	3,333	8.3	0.0	81.6	0.4	0.0	4.3
41 Office clerks	0	0	0	3,050	2,796	-253	16,407	15,045	-1,362	0.0	12.3	66.0	0.0	1.0	5.3
42 Customer services clerks	2,193	2,545	353	0	0	0	2,407	2,794	387	8.6	0.0	9.5	-0.1	0.0	-0.2
51 Personal and protective services workers	0	0	0	357	389	32	20,363	22,182	1,819	0.0	0.3	17.6	0.0	-0.3	-15.2
52 Models, salespersons and demonstrators	0	0	0	0	0	0	11,387	12,359	972	0.0	0.0	29.5	0.0	0.0	-6.5
61 Skilled agricultural and	0	0	0	6,859	5,556	-1,303	2,728	2,210	-518	0.0	4.7	1.9	0.0	-37.7	-15.0

FUTURE DEMAND FOR GREEN IN-DEMAND AND GREEN ENHANCED SKILLS UNDER SELECTED SCENARIOS (000s), 2010-20

	Baseline									2010- 2020 Difference Compared to Baseline Scenario					
	Green Increased Demand			Green Enhanced Skills			Non-Green			Investment: Broad			Increase in Social Benefits		
	2010	2020	Change	2010	2020	Change	2010	2020	Change	GID	GHS	NG	GID	GHS	NG
fishery workers															
71 Extraction and building trades workers	4,774	4,903	129	4,510	4,631	122	3,218	3,305	87	78.5	74.1	52.9	25.5	24.1	17.2
72 Metal, machinery and related trades workers	9,335	8,218	-1,117	0	0	0	1,122	988	-134	62.4	0.0	7.5	2.4	0.0	0.3
73 Precision, handicraft, craft printing and related trades workers	0	0	0	0	0	0	1,375	1,203	-172	0.0	0.0	12.0	0.0	0.0	0.7
74 Other craft and related trades workers	0	0	0	2,342	1,977	-365	1,956	1,651	-305	0.0	6.0	5.0	0.0	-7.7	-6.4
81 Stationary plant and related operators	50	53	2	19	20	1	2,100	2,198	98	0.5	0.2	21.1	-0.1	0.0	-2.7
82 Machine operators and assemblers	2,382	2,298	-84	0	0	0	4,297	4,145	-152	20.4	0.0	36.9	-3.1	0.0	-5.6
83 Drivers and mobile plant operators	1,549	1,577	28	6,065	6,174	109	1,795	1,827	32	8.4	32.9	9.7	-1.1	-4.5	-1.3

FUTURE DEMAND FOR GREEN IN-DEMAND AND GREEN ENHANCED SKILLS UNDER SELECTED SCENARIOS (000s), 2010-20

	Baseline									**2010- 2020 Difference Compared to Baseline Scenario**					
	Green Increased Demand			**Green Enhanced Skills**			**Non-Green**			**Investment: Broad**			**Increase in Social Benefits**		
	2010	**2020**	**Change**	**2010**	**2020**	**Change**	**2010**	**2020**	**Change**	**GID**	**GHS**	**NG**	**GID**	**GHS**	**NG**
91 Sales and services elementary occupations	9,122	10,048	925	552	608	56	5,295	5,833	537	33.6	2.0	19.5	4.4	0.3	2.5
92 Agricultural, fishery and related labourers	0	0	0	1,511	1,486	-25	176	173	-3	0.0	1.2	0.1	0.0	-5.0	-0.6
93 Labourers in mining, construction, manufacturing and transport	0	0	0	3,571	4,161	590	2,949	3,437	487	0.0	30.7	25.4	0.0	2.1	1.7
TOTAL	**58,796**	**61,626**	**2,830**	**39,197**	**39,570**	**374**	**129,363**	**137,221**	**7,858**	**390.5**	**205.9**	**491.9**	**48.5**	**-27.5**	**-14.2**

Source: Estimates based on CE projections, EU-LFS and O*NET classification of occupations.

The demand for green jobs

To date, policy has often been focused largely on the need to reduce carbon footprints in order to meet a number of policy obligations and, in so doing, bring about the creation of new jobs. Much less attention has been given to qualitative changes in the nature of work which the green agenda might bring about though some trade unions, such as those in Sweden, recognise that the changes that the green agenda might bring about could result in some reduction in job quality if employment declines are accelerated in sectors of the economy which have been traditionally regulated through collective bargaining. Evidence suggests that the green agenda could accelerate job losses in some energy-intensive sectors of the economy. The ETUC, for example, points to a decline in employment in the steel industry (ETUC, 2007).

The one qualitative aspect of work which has received some attention from both a policy and research perspective is that of green skills. GHK's study of companies sensitive to climate change suggests that the greatest impact will be upon skills rather than the number of jobs (GHK, 2007). The study goes on to point out that relatively little is known about the impact on skills of the various green policies being pursued in Member States:

'...policies at the community, national and international level to mitigate and adapt to climate change will directly affect the level and structure of employment and skill needs worldwide. Unfortunately, there is little information on the exact magnitude of the changes that are likely to occur. Nevertheless, it is clear that skills development will be important if mitigation and adaptation policies are to be effective and efficient.'

(GHK, 2007, p. 35/36)

One review of skills needs resulting from the green agenda also points to the absence of data, but concludes that the general direction of change is towards skill levels being raised as a consequence of policies introduced by companies to manage climate change (Slingenberg, 2009). Given the level of structural change expected to occur as a consequence of policies introduced to manage climate change, there is every reason to expect that there will be some change in the quality of work. The extent and direction of this change is ultimately dependent upon the extent of structural change and the degree to which it leads to the creation of jobs in new sectors. On the basis of evidence presented above the general direction of change would appear to be towards jobs requiring higher levels of skill, but this conclusion tends to be reached by looking mainly at the new functional requirements which arise in firms and sectors as they adapt to climate change policies with less emphasis given to any loss of skills or skills obsolescence which might occur.

From a more qualitative perspective, Table 4.2 indicates how the demand for green skills is developing across sectors.

Table 4.2: The Greening of the Economy and Green Skills

THE GREENING OF THE ECONOMY AND GREEN SKILLS			
	Existing sectors with a moderate carbon footprint	**Existing sectors with a large carbon footprint**	**New, green sectors of activity (the eco-sector)**
Adaption of existing occupations to greening of economy (Green In Demand / Green Enhanced Occupations)	New skills required in existing jobs to deal with green regulations (e.g. design of products to eliminate waste)	New skills to manage carbon footprints in relation to green policy, but also potential loss if green policy results in consumption switching to alternative products	
New and emerging green skills		New jobs / occupations created to meet demands of green policy – e.g. designing processes to eliminate waste, energy auditors, etc.	New occupations created in new sectors of activity – environmental consultancy, renewable energy production, etc.

4.4 Job quality and green employment

Possibly as a consequence of rising real incomes across the EU during the 2000s, attention has been increasingly been focused on both the quality of life (c.f. the Stiglitz Report, 2010) and on the quality of working life (c.f. the European Commission’s 2020 agenda). Conceptually, the quality of employment has been considered in a number of different ways (see Bosworth et al, 2011). The first is subjective well-being, where individuals are asked to consider and rate for themselves either their overall satisfaction with their life or various elements of it. Secondly, there has been an approach based on Maslow’s hierarchy of needs (Maslow, 1970). This suggests that once individuals have secured their basic physiological and security needs, they want to realise higher order needs, such as self-actualisation related to the development and expression of their creative and intellectual interests. The inability to obtain lower order needs inhibits or prevents the realisation of the higher order ones. The third approach, identified in the Stiglitz Report, is the idea of the notion of fair allocations, which assesses people’s preferences with respect to the quality of their working life and their current position with respect to those preferences. The latter two concepts are not readily measured, though there has been increasing interest in how to define the quality of employment and, more generally, the quality of life (see European Parliament, 2009).

This section makes best use of the available evidence to assess the quality of green jobs.

Table 4.3: Job Characteristics by Type of Green Job (Column Percentages)

JOB CHARACTERISTICS BY TYPE OF GREEN JOB (COLUMN PERCENTAGES)

	Green Increased Demand	Green Enhanced Skills	Non - Green
Qualification level			
High	26%	17%	28%
Medium	47%	46%	52%
Low	27%	36%	19%
Industry			
Primary Sector	3%	27%	3%
Manufacturing	22%	13%	14%
Electricity and Water	2%	2%	1%
Construction	14%	13%	3%
Distribution	18%	23%	19%
Hospitality	8%	2%	8%
Finance	3%	2%	3%
Business Services	12%	7%	10%
Public Services	13%	11%	25%
Other	4%	1%	4%
Gender			
Male	67%	71%	41%
Female	33%	29%	59%
Age			
15-25	7%	8%	10%
26-45	48%	45%	48%
46-64	43%	43%	40%
65+	2%	5%	2%
% part-time	13%	13%	20%
% temporary	8%	8%	11%
Received Training Over Last Four Weeks	9%	8%	13%

Note(s): The sample used for this table includes employed individuals from EU27 (except Malta) plus Norway.
Source(s): EU – LFS 2009.

Current levels of job quality and job satisfaction

Using EU-LFS data to measure the quality of green jobs

Building on the preceding analysis of Green Increased Demand and Green Enhanced Skills occupations, the O*NET classification of jobs has been applied to the occupational categories used in the EU-LFS at a detailed level in order to produce an estimate of the number of EU27 jobs which have a green dimension to them (note that the respective occupational classifications for Europe and the USA are quite different and a degree of judgment is required in reading across from one classification to the other). In Table 4.3 these figures have been aggregated by the characteristics of individual workers (e.g. age, gender, qualification) and jobs to provide some indicative evidence of the distribution of green jobs across different characteristics of job. A number of observations can be made about green jobs compared to non-green jobs:

- both Green Increased Demand (GID) and Green Enhanced Skills (GHS) jobs are less likely to be in the public services than non-green jobs
- GID jobs are much more likely to be in manufacturing and construction
- both GID and GHS tend to employ men rather than women compared to non-green jobs
- green jobs are much less likely to be part-time and slightly less likely to be temporary jobs

The European Foundation's classification of job quality is based around four groups of indicators (Eurofound, 2002):

- **career and employment security**
  - employment status
  - income
  - social protection
  - workers' rights
- **health and well being**
  - health problems
  - risk exposure
  - work organisation
- **reconciliation of working and non-working life**
  - social infrastructures
  - working / non-working time
- **skills development**
  - qualifications
  - training
  - learning organisation
  - career development

These have been used as the basis to develop a measure of job quality in this report. However they are only available at the 1-digit level of ISCO. In order to examine things at a more detailed 2-digit level the European Labour Force Survey (EU-LFS) has been used. The limitation here is that the analysis is restricted to the measures available in the EU-LFS. The variables used are:

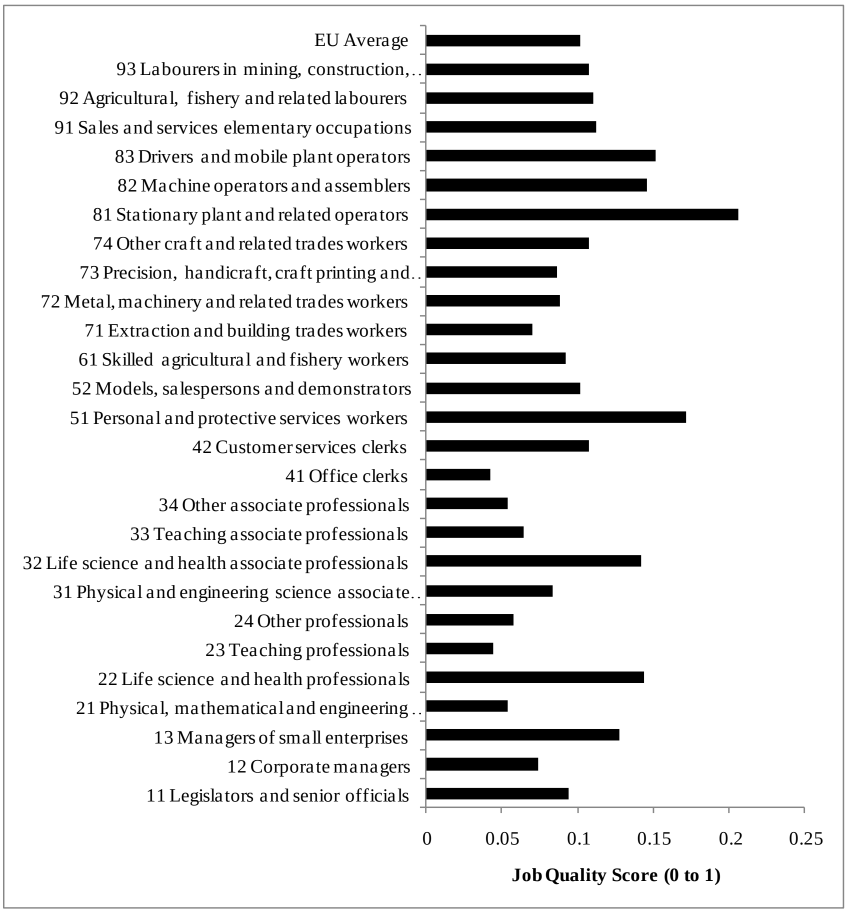
- have a temporary or fixed-term contract of employment
- in part-time employment (involuntary)
- relatively low income (in lowest three deciles of income distribution)
- working long hours (working more than 48 hours per week)
- received no training over the past four weeks
- have atypical work patterns (e.g. working permanent night shifts)

These provide only a partial measure of job quality. Not least they do not include any measure of stress. Nevertheless they provide some indication of aspects of job quality.

A score was derived by giving an individual a score of 1 if they experienced any of the above, and a score of 0 if they did not. The score was then standardised to be within the range 0 (good job quality) and 1 (relatively poor job quality). The issue of job satisfaction, based on summary data available in the European Working Conditions Survey, is analysed separately.

Figure 4.3 shows current levels of job quality based on the summative measure of job quality derived from the EU-LFS described above. The figure shows that, generally, those occupations which are associated with relatively high levels of skill are more likely to experience higher levels of job quality. There are, however, anomalies where people in relatively high skilled occupations report relatively lower levels of job quality. These are, in some instances, in occupations which are forecast to grow, to different degrees, under nearly all of the scenarios.

Figure 4.3: Indicative Measure of Job Quality by Occupation



Source(s): Estimates derived from EU Labour Force Survey, 2009.

The above is based on fairly 'objective' based measures of job quality. There is also a need to look at more subjective based measures which record individuals' attitudes towards their jobs as recorded by their reports of job satisfaction.

Job satisfaction

Figure 4.4 records job satisfaction levels by occupation in 2009. It is based on a scale where respondents are given a score of -2 if they are very dissatisfied with their job, -1 if fairly dissatisfied, +1 if fairly satisfied, and +2 if very satisfied. A score of 0 suggests they are neither satisfied nor dissatisfied with their job. The figure reveals that people working in higher level occupations were more likely to report relatively high levels of job satisfaction.

Figure 4.4: Levels of Job Satisfaction by Occupation, 2009

Source(s): Estimates derived from European Working Conditions Survey, 2009.

Exposure to physical risk factors

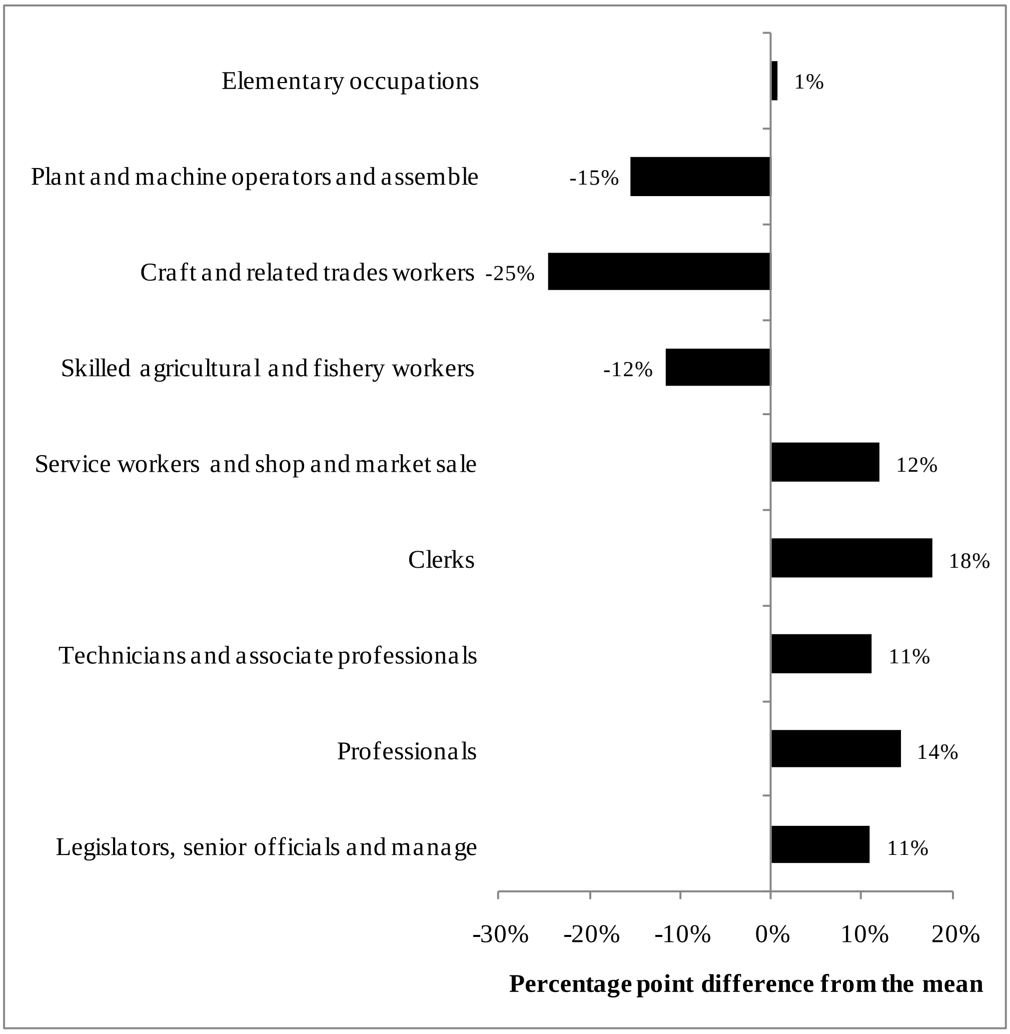
The European Working Conditions Survey (EWCS) also provides information about the extent to which people are exposed to physical risk factors. This includes: ergonomic risks associated with exposure to painful/tiring positions, vibrations, lifting or moving people, etc; biological/chemical and radiation risks including exposure to breathing in smoke, fumes, powder or dust, etc; and combined exposure to noise, high temperatures and low temperatures. The general picture to emerge from the these data is that it is blue collar jobs and jobs in the primary and production sectors which are most associated with physical risks of one kind or another and so have increased exposure to the risks set out above[32]. In many cases these are in sectors likely to be seeing job losses as a consequence of mitigation measures (heavy manufacturing industries and traditional energy production and related activities).

Figure 4.5 is based on a composite measure of whether a person reports that they are never or hardly ever exposed whilst working to: vibration; loud noise; high temperatures; breathing in fumes; or working in a tiring or uncomfortable position. The figure shows the percentage point difference from the EU-31 average of 63% of workers reporting that, on average, they are never or nearly never exposed to these

[32] http://www.eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf, p.31.

risks. For example, the table shows that professionals are less likely to be exposed to these types of risk by 14 percentage points compared to the EU average.

Figure 4.5: Additional Measures of Job Quality by Occupation: % of Workers not Exposed to Certain Risks While Working



Source(s): Estimates derived from ECWS, 2005.

The information in Figure 4.5 can be related to the occupational projections. In general, the Baseline Scenario and some of the investment based scenarios see a general trend towards the creation of relatively highly skilled and qualified employment which is associated with relatively high job quality as indicated in Figure 4.5. But under some scenarios there is also a modest boost to skilled craft work which is associated with lower job quality[33]. These jobs, however, are slightly better remunerated compared with clerks, plant and machine operatives, service workers, and elementary occupations. So the direction of the green policy is not exclusively towards creating higher quality jobs.

Job quality and green jobs

The above discussion has presented evidence about current levels of job quality and job satisfaction, for example the extent to which job satisfaction differs across

[33] http://www.eurofound.europa.eu/pubdocs/2006/98/en/2/ef0698en.pdf

different occupational groups. This provides little information about the extent to which the green skills agenda will influence future levels of job quality. There are two means of addressing this: (a) by looking at how the distribution of relatively good and bad quality jobs are distributed across the green skills typology; and (b) by looking at how occupational change under the various scenarios is likely to affect the distribution of job quality. This section first summarises the current relationship between green jobs and job quality before, in the next section, looking at the how distribution of job quality is likely to change in the future under the different scenarios.

Table 4.4 compares the distribution of green jobs according to the levels of job satisfaction reported for each occupation. It can be seen that in the upper left part of the table it is the higher level occupations, categorised as green in demand, which represent both a substantial share of overall employment and are associated with relatively high levels of job quality. It tends to be the relatively less skilled jobs – plant and machine operatives and elementary occupations – which are associated with relatively high levels of green intensity but relatively low levels of job quality.

Table 4.4: Job Quality and the Distribution of Green Jobs

JOB QUALITY AND THE DISTRIBUTION OF GREEN JOBS

Occupation	**Green In Demand**		**Green Enhanced**	
	% of jobs green in demand	% of jobs associated with high quality employment	% of jobs green enhanced skills	% of jobs associated with high quality employment
Legislators, senior officials and managers	High	High	Low	High
Professionals	High	High	Low	High
Technicians and associate professionals	High	High	Low	High
Clerks	Low	High	Low	High
Service workers and shop and market sale	Low	Medium to Low	Low	Medium to Low
Skilled agricultural and fishery workers	Low	Low	High	Low
Craft and related trades workers	Medium to High	Medium to High	Medium to High	Medium to High
Plant and machine operators and assemble	Medium to High	Low	Medium to High	Low
Elementary occupations	Medium to High	Medium to Low	Medium to High	Medium to Low

It needs to be borne in mind that where green jobs bring about a change in the skill composition of that job it is often at the margin. This is especially the case in relation to green enhanced skills where, by definition, the acquisition of green skills enhances rather than changes the existing skill set. The job content is not being substantially altered. Hence, at least over the short term, the greening of the economy is unlikely to have a dramatic impact on the various dimensions of job quality, either as encompassed in the measures used in the tables above, or the wider set of measures referred to in the literature. The employment relationship in most cases is not substantively altered. CEDEFOP's analysis of green skills tends to support this view insofar as it tended to show that the nature of skill change resulting from the greening of the economy, whilst significant, was not of a profound type, with the content of jobs being not comprehensively overhauled in most cases (CEDEFOP, 2010a).

Table 4.5: Projected Change in Job Quality, 2010-20, under the Baseline Scenario, 000s

PROJECTED CHANGE IN JOB QUALITY, 2010-20, UNDER THE BASELINE SCENARIO, 000S									
	2010 Level			2020 Level			2020-2010 Change		
	High Quality	Poor Quality	Very Poor Quality	High Quality	Poor Quality	Very Poor Quality	High Quality	Poor Quality	Very Poor Quality
01 Armed Forces	453	719	59	438	696	57	-15	-23	-2
11 Legislators and senior officials	378	190	7	481	242	9	103	52	2
12 Corporate managers	7,348	3,249	45	8,477	3,749	52	1,129	499	7
13 Managers of small enterprises	3,705	4,208	10	3,771	4,283	10	67	76	0
21 Physical, mathematical and engineering science professionals	6,136	1,837	18	6,933	2,075	20	797	239	2
22 Life science and health professionals	2,202	1,697	154	2,289	1,764	160	87	67	6
23 Teaching professionals	7,182	1,635	13	6,806	1,550	12	-375	-86	-1
24 Other professionals	8,982	2,764	36	10,994	3,383	44	2,012	619	8
31 Physical and engineering science associate professionals	6,122	2,492	111	6,787	2,763	123	665	271	12
32 Life science and health associate professionals	3,336	2,605	149	3,360	2,624	150	24	18	1
33 Teaching associate professionals	2,232	791	13	2,574	913	15	342	121	2
34 Other associate professionals									

PROJECTED CHANGE IN JOB QUALITY, 2010-20, UNDER THE BASELINE SCENARIO, 000S

	2010 Level			2020 Level			2020-2010 Change		
	High Quality	Poor Quality	Very Poor Quality	High Quality	Poor Quality	Very Poor Quality	High Quality	Poor Quality	Very Poor Quality
	16,155	4,443	95	19,091	5,251	112	2,936	808	17
41 Office clerks	16,195	3,182	87	14,916	2,931	80	-1,279	-251	-7
42 Customer services clerks	2,870	1,613	117	3,343	1,879	136	473	266	19
51 Personal and protective services workers	9,329	10,406	985	10,171	11,345	1,074	841	939	89
52 Models, salespersons and demonstrators	6,767	4,487	130	7,363	4,882	142	595	395	11
61 Skilled agricultural and fishery workers	5,879	3,692	15	4,766	2,993	12	-1,113	-699	-3
71 Extraction and building trades workers	8,804	3,686	47	9,184	3,846	49	381	159	2
72 Metal, machinery and related trades workers	7,049	3,332	95	6,254	2,956	84	-795	-376	-11
73 Precision, handicraft, craft printing and related trades workers	943	419	14	833	370	12	-110	-49	-2
74 Other craft and related trades workers	2,579	1,652	68	2,184	1,399	58	-395	-253	-10
81 Stationary plant and related operators	857	1,231	84	905	1,301	88	49	70	5
82 Machine operators and assemblers	3,489	3,028	170	3,395	2,947	166	-93	-81	-5
83 Drivers and mobile plant operators									

PROJECTED CHANGE IN JOB QUALITY, 2010-20, UNDER THE BASELINE SCENARIO, 000S

	2010 Level			2020 Level			2020-2010 Change		
	High Quality	**Poor Quality**	**Very Poor Quality**	**High Quality**	**Poor Quality**	**Very Poor Quality**	**High Quality**	**Poor Quality**	**Very Poor Quality**
	4,631	4,500	283	4,739	4,605	290	108	105	7
91 Sales and services elementary occupations	8,782	5,917	275	9,705	6,539	304	923	622	29
92 Agricultural, fishery and related labourers	912	764	11	898	752	11	-14	-12	0
93 Labourers in mining, construction, manufacturing and transport	4,012	2,394	123	4,708	2,809	144	696	416	21
TOTAL	**147,329**	**76,935**	**3,212**	**155,368**	**80,846**	**3,413**	**8,039**	**3,911**	**201**

Projected change in job quality (based on Baseline Scenario)

Based on what is known about the occupational distribution of job quality this can be related to the Baseline Scenario to indicate how the green agenda might influence job quality in the future (see Table 4.5).

Table 4.5 has been estimated by giving a score of 1 where a person reports that they work under one of the conditions listed below:

- have a temporary or fixed-term contract of employment
- in part-time employment (involuntary)
- relatively low income (in lowest three deciles of income distribution)
- working long hours (working more than 48 hours week)
- received no training over the past four weeks
- have atypical work patterns (e.g. working permanent night shifts)

If they score 0, this is referred to as a higher quality job, if they score 1 or 2, this is a medium quality job, and if they score more than 2, this is considered a lower quality job. The measure is somewhat arbitrary but gives an indication of job quality. The projections are produced by applying the proportions observed in the EU-LFS (for 2009) to the occupational totals produced under the Baseline Scenario.

Shares in the three categories are then assumed to be fixed within each occupational group to generate results for 2020.

The general direction of change is towards more high quality jobs being created but there are occupations which are associated with relatively high quality employment which are likely to contract. In particular, there is projected to be a relatively high number of relatively high quality jobs lost amongst office clerks and skilled agricultural and fishery workers. Offsetting these losses will be the growth in relatively high quality jobs in professional and associate professional occupations.

4.5 Vulnerable groups and green employment

Occupational characteristics of vulnerable groups

Defining vulnerable groups in the labour market can be done by reference to their risk of being out of work. There is a large research literature which addresses the characteristics of those people who are most likely to be in or out of work. For purposes of the analysis vulnerable groups have been classified as: where people are currently in the labour force and in employment but sick, relatively young or old, are from a minority ethnic group, or are currently unemployed. Since women often face disadvantage in the labour market they too have been included in the analysis.

Table 4.6 shows the current distribution of these groups according to their occupation (or previous occupation where currently unemployed). Using these proportions it is possible to assess the extent to which vulnerable groups might be affected by changes in the economy over the medium term under the Baseline Scenario. The general picture to emerge from Table 4.6 is that the employment of the selected groups is associated with less skilled occupations.

Table 4.6: Occupational Employment by Social and Demographic Groups, 2010 (Column Percentages)

OCCUPATIONAL EMPLOYMENT BY SOCIAL AND DEMOGRAPHIC GROUPS, 2010 (COLUMN PERCENTAGES)	Women	Below 22	Above 55	Active but Ill	Minority	Unemployed	All in Employment
01 Armed Forces	0.1	0.7	0.1	0.2	0.1	0.2	0.5
11 Legislators and senior officials	0.2	0.3	0.5	0.2	0.1	0.1	0.3
12 Corporate managers	3.1	0.9	4.6	2.6	1.8	1.5	4.1
13 Managers of small enterprises	2.8	0.9	6.0	1.8	3.7	1.7	4.0
21 Physical, mathematical and engineering science professionals	1.4	1.2	2.5	1.8	2.2	1.3	3.0
22 Life science and health professionals	2.7	0.5	2.7	1.6	3.3	0.3	2.0
23 Teaching professionals	6.7	1.5	5.1	3.7	0.9	1.4	4.4
24 Other professionals	5.2	1.8	4.7	3.5	1.5	1.9	4.5
31 Physical and engineering science associate professionals	1.6	3.1	3.2	3.0	1.1	2.3	3.7
32 Life science and health associate professionals	4.7	1.8	2.3	3.1	1.3	0.6	2.6
33 Teaching associate professionals	2.4	0.8	1.5	1.8	0.2	0.6	1.4
34 Other associate professionals	9.6	6.5	6.6	7.2	1.9	4.8	7.7
41 Office clerks	11.7	7.6	6.7	8.7	3.2	6.9	7.9
42 Customer services clerks	3.4	3.9	1.3	2.5	1.2	2.3	2.0
51 Personal and protective services workers	13.1	15.4	7.0	11.7	14.0	10.2	8.9
52 Models, salespersons and demonstrators	8.2	13.2	3.1	5.3	4.4	7.7	5.3
61 Skilled agricultural and fishery workers	5.2	3.9	13.1	7.0	1.6	2.0	5.9
71 Extraction and building trades workers	0.4	7.8	4.8	5.3	9.1	11.7	5.9
72 Metal, machinery and related trades workers	0.4	6.0	4.3	4.1	4.0	5.8	4.9
73 Precision, handicraft, craft printing and related trades workers	0.4	0.5	0.5	0.5	0.4	0.7	0.5
74 Other craft and related trades workers	2.1	2.5	1.6	1.8	3.6	3.6	2.2
81 Stationary plant and related operators	0.4	1.0	0.9	1.4	1.5	1.5	1.1
82 Machine operators and assemblers	3.0	3.5	2.1	4.6	4.5	6.3	3.2
83 Drivers and mobile plant operators	0.4	2.9	4.7	4.1	3.4	4.7	4.5

OCCUPATIONAL EMPLOYMENT BY SOCIAL AND DEMOGRAPHIC GROUPS, 2010 (COLUMN PERCENTAGES)

	Women	**Below 22**	**Above 55**	**Active but Ill**	**Minority**	**Unemployed**	**All in Employment**
91 Sales and services elementary occupations	8.8	6.3	7.3	9.3	24.0	9.5	6.0
92 Agricultural, fishery and related labourers	0.7	1.1	1.3	0.6	1.7	2.2	0.9
93 Labourers in mining, construction, manufacturing and transport	1.3	4.7	1.6	2.9	5.6	8.4	2.4
TOTAL	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Vulnerable groups' employment in green jobs

An estimate is provided below of the extent to which the various vulnerable groups identified above are employed in green or non-green occupations (see Table 4.7).

Table 4.7: Green Jobs by Social and Demographic Groups, 2010 (Column Percentage)

GREEN JOBS BY SOCIAL AND DEMOGRAPHIC GROUPS, 2010 (Column Percentage)

	Women	Below 22	Above 55	Active but Ill	Minority	Unemployed	All in employment
Green Increased Demand	19.0	22.3	27.2	24.4	39.3	28.0	26.8
Green Enhanced Skills	12.2	17.4	24.4	16.4	16.5	21.5	19.5
Non-Green	68.9	60.4	48.4	59.1	44.3	50.5	53.8
Total	100	100	100	100	100	100	100

The key finding is that women and young people are more likely to be employed in non-green occupations compared to all people in employment. Other things being equal, this suggests that these groups might be disadvantaged by any shift in employment towards a greater number of people employed in green occupations.

Future employment of vulnerable groups

Based on the occupational characteristics of vulnerable groups it is possible to infer something about their occupational prospects based on the projections in the Baseline Scenario. These projections assume that the age and gender and related structure of employment by indicator of disadvantage does not change between 2010 and 2020, (i.e. assuming that the shares of the various vulnerable groups within occupations remains fixed at base year levels). Accordingly, the projections are indicative of how employment for women, young, and older workers may change over the medium term. Table 4.8 indicates how employment for women, young, and older workers may change over the medium term.

Table 4.8: Implications of Projected Occupational Employment by Group, 000s

IMPLICATIONS OF PROJECTED OCCUPATIONAL EMPLOYMENT BY GROUP, 000s									
	Women			Below 22			Above 55		
	2010	2020	Change	2010	2020	Change	2010	2020	Change
01 Armed Forces	101	98	-3	148	143	-5	30	29	-1
11 Legislators and senior officials	153	194	41	39	49	10	136	173	37
12 Corporate managers	3,666	4,210	544	199	229	30	2,020	2,320	300
13 Managers of small enterprises	2,594	2,628	34	160	162	2	2,029	2,056	27
21 Physical, mathematical and engineering science professionals	1,677	1,881	204	270	303	33	1,137	1,275	138
22 Life science and health professionals	2,495	2,592	97	95	99	4	910	945	35
23 Teaching professionals	6,145	5,822	-323	256	243	-13	1,745	1,653	-92
24 Other professionals	6,345	7,736	1,391	410	500	90	2,127	2,593	466
31 Physical and engineering science associate professionals	1,702	1,871	169	638	701	63	1,290	1,418	128
32 Life science and health associate professionals	4,987	5,019	32	354	356	2	895	901	6
33 Teaching associate professionals	2,426	2,797	371	157	181	24	556	641	85
34 Other associate professionals	11,751	13,837	2,086	1,512	1,780	268	3,013	3,548	535
41 Office clerks	13,227	12,129	-1,098	1,640	1,504	-136	2,785	2,554	-231
42 Customer services clerks	3,545	4,115	570	778	903	125	488	567	79
51 Personal and protective services workers	13,982	15,231	1,249	3,129	3,409	280	2,797	3,047	250
52 Models, salespersons and demonstrators	8,033	8,719	686	2,467	2,678	211	1,128	1,224	96
61 Skilled agricultural and fishery workers	3,917	3,173	-744	560	454	-106	3,650	2,957	-693
71 Extraction and building trades workers	410	421	11	1,454	1,493	39	1,732	1,779	47
72 Metal, machinery and related trades workers	413	364	-49	1,122	988	-134	1,557	1,371	-186
73 Precision, handicraft, craft printing and related trades workers	442	387	-55	102	89	-13	233	204	-29
74 Other craft and related trades workers	1,883	1,590	-293	425	359	-66	538	454	-84
81 Stationary plant and related operators	381	399	18	163	171	8	287	300	13
82 Machine operators and assemblers	2,857	2,756	-101	636	614	-22	756	729	-27
83 Drivers and mobile plant operators	330	336	6	517	526	9	1,662	1,692	30
91 Sales and services elementary occupations	10,152	11,182	1,030	1,377	1,517	140	3,140	3,458	318

IMPLICATIONS OF PROJECTED OCCUPATIONAL EMPLOYMENT BY GROUP, 000s

	Women			Below 22			Above 55		
	2010	**2020**	**Change**	**2010**	**2020**	**Change**	**2010**	**2020**	**Change**
92 Agricultural, fishery and related labourers	669	658	-11	192	189	-3	433	426	-7
93 Labourers in mining, construction, manufacturing and transport	1,576	1,836	260	1,111	1,294	183	759	884	125
TOTAL	**105,857**	**111,979**	**6,122**	**19,912**	**20,933**	**1,021**	**37,832**	**39,198**	**1,366**

The projections suggest that women may be disadvantaged by the extent to which the jobs in which they are disproportionately employed are affected by the direction of change. Hence, women are particularly vulnerable to the contraction in jobs amongst office clerks. Similarly, women are less well represented amongst some professional and associate professional occupations. These are the occupations which are expected to grow over the medium term, especially so under those scenarios which assume a greater level of investment in technologies of one kind or another. It is possible, of course, that as demand for people to work in these occupations grows, women and other groups which have been historically under-represented in these occupations will be increasingly drawn into these occupations.

With respect to young people, they are relatively more likely to be employed in lower skill jobs. This often reflects their occupational position over the life cycle which tends to improve as they move into the prime age group, with some falling away in later years. The key issue is the extent to which, following the recent economic crisis which appears to have had a disproportionately adverse effect on young people, young people in 2010 are able to capture higher skill jobs in the future. It has not been possible to model this within the employment projections. There are concerns in some countries that young people may have missed the opportunity to access the labour market at their desired level – or that comparable to their counterparts in earlier years – which may affect their future progression through the labour market. The interesting issue is the extent to which it is possible to further stimulate the demand for skilled workers – as is evident under, for instance, the broad investment scenario – which will ensure that those young people who have entered the labour market at a lower than desired level are able to make up for lost time with the pick-up in demand for relatively highly skilled workers.

4.6 Conclusion and summary

The general direction of occupational change in the labour market is towards an increase in the number of relatively high and low skilled jobs (as revealed under the Baseline Scenario). The more investments are made in new technologies – many of which are likely to be energy saving or related to new forms of energy generation – the more demand there will be for people in higher skilled jobs (especially professional and associate professional ones). In this way, the greening of the economy can stimulate the demand for highly skilled (and high waged) workers, although the extent to which this will occur, even under the most optimistic of scenarios, is relatively modest when compared to the Baseline Scenario.

Insofar as the greening of the economy stimulates the demand for higher skilled jobs, it is likely to have a positive impact on job quality. In general, the higher the level of skill (or qualification) associated with an occupation, the higher the job quality. But it is also true that there are some lower skilled occupations which are associated with relatively high levels of job quality which will be adversely affected (such as office clerks). This is part of the general direction of occupational change across Europe, but it is also likely to be sensitive to changes in the economy which are likely to further stimulate the demand for the highest skilled jobs and weaken the demand for less skilled jobs. The Baseline can be compared with the scenarios which are associated with greater levels of investment in technology, which particularly favour high quality professional and associate professional jobs.

It is also apparent that a large number of jobs in the economy are likely to be transformed as a consequence of the economy becoming greener. Following the O*NET classification these have been designated Green Increased Demand and Green Enhanced Skills respectively. The former, in particular, is likely to show significant growth over the medium term. Many of these jobs are associated with relatively high quality employment, especially in relation to managerial, professional or associate professional occupations. But there is also evidence to suggest that some of the green jobs are in occupations which are associated with lower quality jobs. The growth in green employment is not necessarily synonymous with a growth in high quality employment.

Whilst the greening of the economy is associated with the expansion in employment of some high quality, high skilled jobs, some groups appear to have less access to green jobs than others. There is prima facie evidence that women and young people are less likely to be employed in green jobs. In other words, the evidence points to the greening of the economy reinforcing occupational trends which are less favourable in relation to women and young people. With respect to young people one may be observing nothing more than a life cycle effect in that the green enhanced and green in-demand jobs are relatively high skilled jobs which individuals are more likely to access as they get older and as they gain in experience and competence. With respect to women the issue is related more to the extent of gender segmentation in the occupational structure. Some green-enhanced and green in-demand jobs are more likely to be in occupations which have been, historically, disproportionately filled by men. This would suggest a need for policy to ensure that the impact of the green agenda on the distribution of occupational employment is closely monitored to ensure that men and women achieve, other things being equal, an equitable share of employment in those green jobs which are expected show growth in employment in the years ahead.

It needs reiterating that the data presented here are indicative given the methodological difficulties associated with defining green jobs. Nevertheless, on the basis of the evidence available, the greening of the economy would appear, at the margin, to have implications for the gender and age structure of employment.

5 Supplementary Analysis of Specific Issues

5.1 Introduction

In this chapter we present the findings from some supplementary analysis that explores a range of issues in greater detail than is possible with the modelling tools.

These issues are each considered in turn. Section 5.2 presents a qualitative analysis of the sectors that could lose out from the restructuring required to meet the targets, while Section 5.3 looks at sectors at the other end of the spectrum – those that may gain. In Section 5.4 we consider the bottlenecks that could occur in meeting the 2020 targets, and the causes of these. Section 5.5 looks at the rates of churn and turnover of employment in the sectors most affected by the restructuring. An overview of the social implications of the targets is provided in Section 5.6, including the impacts on unemployment and the distributional effects. Finally, Section 5.7 considers the impacts of restructuring at a more detailed regional level.

5.2 Focus on sectors: Sectors vulnerable to restructuring

Introduction Though our aggregate results suggest that environmental policies could create opportunities for employment and economic growth, it seems likely that some specific sectors will see a decline in activity and employment. At the very detailed level this may have implications for skills and training requirements. This section is intended to consider some sectors at the NACE 4-digit level that may see a decline in employment over the next decade (and beyond) due to environmental policy and also to highlight particular characteristics and issues that they may face that cannot be captured by a macroeconomic model.

The six industries that are considered are:

- coal
- manufacture of petrol and diesel
- fertilizer
- lime
- aluminium
- road haulage

Two of these sectors have large quantities of direct emissions, but also produce fossil fuels and may see loss of output due to policies aimed at discouraging the use of their products. The lime, aluminium and fertilizer sectors will be affected more by cost pressures on the inputs that they use. This also affects road haulage but there are some particular characteristics about this sector that make it interesting to consider.

The following paragraphs give a very short overview of the sectors, followed by a description of the main skills involved.

Coal In this section we define coal production as rev 2 NACE code 5.10, which is the mining of hard coal. The extraction of coal produces emissions, but this is minor compared to the emissions generated by coal combustion. Germany, Poland and the UK accounted for 58% of total emissions within the EU from hard coal (European

Parliament, 2010). In 2009, mining of coal and lignite and extraction of peat employed 327,000 people (Eurostat)[34].

At a European level, this sector has undergone continued restructuring and governments have had to find ways to adapt to its decline. During the second half of the 20th century direct employment in hard coal mining in Western Europe fell from around 1.8m to fewer than 100,000, with Belgium and the Netherlands cutting activity completely (Walker, 2001; Eurostat). Europe's coal sector has also received significant subsidies over time based on the grounds of sensitivity of subsidy removal to coal imports and also employment. There are examples, such as Germany during the 1990s, when subsidies exceeded the total wage bill for the sector (Radetzki, 1995).

The main users of coal (in particular electricity generation) are already included in the EU ETS, with all coal-fired combustion facilities with a capacity greater than 20 MWth forced to comply with the scheme since it began in 2005.

Changes expected in the coming decade

The coal mining sector, having already experienced a long-term decline in both activity and employment, is likely to see this trend continue, even in the absence of environmental regulation. This trend will be reinforced by environmental policies intended to reduce carbon (or other) emissions. However, Europe's resources of coal do provide the benefit of energy security, which could be important if nuclear capacity declines.

Most quantitative and qualitative forecasts agree that the coal industry is an industry that will lose out within the next ten years, due to a continuation of current trends and increasing regulation[35]. If subsidies were to be reduced or if global demand (outside the scope of E3ME) were to fall, jobs could be cut. Paroussos and Capros (2009) use the GEM-E3 model in assessing the effects on employment of an increase in energy efficiency by 15% in 2020 and 20% in 2030. Under varying assumptions about labour market flexibility the projected decrease in employment within the coal sector is 18-22%. It should be noted that if the focus was GHGs rather than energy efficiency, employment losses could be higher.

One important characteristic of the sector is that, due to coal mines and plants being large and in fixed rural locations, they account for a high proportion of employment in the areas within which they operate. This means there are local areas that stand to lose out substantially, both economically and socially, from the decline in employment within this sector. However, a European Commission (2007) study suggests that there are no examples of environmental policy causing concentrated job losses or regional difficulties. Nevertheless, a consideration for potential future difficulties underpins the European Commission's proposal in 2010 to phase out coal subsidies, rather than removing them immediately[36], to allow a smoother transition for areas with a high dependency on coal extraction.

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[34] EURACOAL state that in 2007, the coal industry employed 280,000 people.

[35] Although the E3ME model results suggest that employment in the energy extraction sectors will be unaffected by the enforcement of climate mitigation policies, this is by assumption.

[36] The EU executive presented a proposal for a new regulation that would allow Member States to grant operating aid to coal mines only if they present plans to close by 15 October 2014. The aim of the regulation is to bring to an end decades of repeatedly extended subsidy schemes to maintain uncompetitive mines, while mitigating the adverse social and economic impacts of immediate removal of state aid. See http://www.euractiv.com/en/energy/commission-proposes-phasing-out-coal-subsidies-news-496532 for more information.

A survey undertaken by New Energy Finance (2009) showed that the ETS has had a clear influence on the coal sector, impacting the capital investment decisions of power generating companies, and has resulted in the early closure of less efficient plants. It is anticipated that this incentive provided by the ETS would continue to have such effects in efforts to meet the 2020 targets.

There are factors, however, which could be expected to soften the negative impact of environmental policy on employment in the European coal sector. In 2008, the EU imported 50% of its energy needs and this figure is expected to increase to 65% by 2030 (Congressional Research Service, 2008). Issues of energy security within the European Union are therefore high on its agenda alongside climate change and, given that coal has a major share in (accounting for around one-third) of Europe's electricity production[37], securing Europe's energy supply with an emphasis on clean coal could protect the sector from heavy decline. Recent problems faced at Japan's nuclear reactors emphasise the risks associated with nuclear energy production, so a shift away from nuclear energy (for example in Germany) could require an increased contribution from coal.

One technological advance that would clearly benefit the coal sector is carbon capture and storage (CCS). This would allow users to burn coal without releasing most of the CO_2 emissions. Some prototype plants in Europe are being developed[38] and, although adoption by 2020 is highly unlikely, this technology is currently key to long-term demand for coal.

Manufacture of petrol and diesel

For this sector we focus on the manufacture of refined petroleum products, which falls under NACE code 19.20 and is represented by industry 9 in the E3ME model. In 2010 there were 104 refineries operating in the EU, producing 778m tonnes of fuel and accounting for 18% of global production[39]. Italy accounted for the largest share of total refineries within Europe in 2010 with 16, followed by Germany (13), France (12) and the UK (11). Cyprus, Estonia, Latvia, Luxembourg, Malta and Slovenia do not contain any refineries. According to the European Commission (2010d), Europe's refineries directly employed around 100,000 people.

The profile of demand for different petroleum products within the EU has changed over time, with the period of 1990 to 2008 seeing an increase in jet fuel and kerosene (5.5% to 9.4%) and gasoil (17.7% to 31% excluding heating oil), alongside a decrease in gasoline (22.7% to 16.1%) and heavy fuel oil (16.3% to 6.4%). Europe is a net importer of gasoil, amounting to 6.9% of total consumption in 2008 (European Commission, 2010d). Europe is a net exporter of gasoline, relying heavily on demand from the US market.

One notable development within the sector is that North Sea crude production (from Norway, UK and Denmark) decreased from 6.4 to 4.3m barrels per day over 2000-08. At the same time, imports of heavier, more sulphurous crude oil from Russia and Africa have been growing. This increase in the share of heavier crudes requires more complex and more costly refining processes to convert heavy crudes to light products, also resulting in higher CO_2 emissions. North-Western European (NWE) refineries are

[37] See European Commission website - http://ec.europa.eu/energy/coal/index_en.htm

[38] Initial plans to have twelve demonstration plants running by 2015 may not be realised due to funding issues – see http://www.endseurope.com/25467/ccs-demo-plants-may-not-be-ready-by-2015

[39] See the European Commission's website - http://ec.europa.eu/energy/observatory/oil/refining_processing_en.htm

particularly affected by this development as they previously used North Sea oil the most.

The economic crisis significantly reduced profit margins within the sector with margins for both simple and complex processing reaching 15 year low points in 2009. The profit margins for the sector at this time ranged from approximately -6 to 1$/bbl (European Commission, 2010d) with NWE refineries generally facing more favourable margins than Mediterranean refineries. It is expected that margins have since recovered due to the significant rise in prices.

There is also increasing competition within the sector, with Asia and the Middle East having added 2.2m bbl/day to their distillation capacity in 2009-10. This is reflected in recent purchases of European oil refineries by state-run firms from Asia, the Middle East and Latin America and also private equity firms (Economist, 2011). Although many refineries are found on the coast, the transportation costs faced by inland refineries place such refineries under a greater threat of closure[40].

Changes expected in the coming decade

The E3ME model predicts that in 2020, direct employment within the sector will be reduced by between 1,000 and 5,700 (based on the different scenario results) as a result of environmental policy in Europe, compared to a baseline value of 155,000. Additionally, a study by ETUC (2009) estimated that by 2020 there is a risk of approximately ten of the smaller refineries closing down. However, recent sales of oil refineries indicate that it may actually be the larger refineries that are ultimately forced to close down, as out of the twelve that were put up for sale, Royal Dutch Shell's two small, local market-orientated refineries were the first to be sold[41]. This is most likely to occur due to the impact of the recent recession on demand and margins[42], alongside the goals to reduce fuel consumption by vehicles. The report infers that such closures may lead to the loss of around 6,000 jobs (including direct and indirect jobs); broadly consistent with the E3ME results.

The impact of the ETS on the oil refining sector is likely to be intensified by the greater use of imported heavier crudes, requiring a more costly and energy-intensive refining process with greater levels of CO_2 emissions. The refining industry is expecting to have to buy about 25% of its allowances to maintain activity which, based on a carbon price of €30/ton, would cost the sector over €1bn per year. Increased requirements for fuel efficiency would be likely to compound the increase in costs faced by the sector. Improved fuel economy of vehicles is negatively impacting demand for gasoline in Europe and the US (Europe's key export market), and increasing fuel costs are also seeing diminishing driving distances per car. The Renewable Energy Directive has set a 10% target for the use of renewable energy in the transport sector by 2020, with a majority of this expected to come from biofuels. This is expected to reduce the need for conventional fossil fuels used in transport. A possible shift towards electric vehicles could result from increasing oil prices, with the process leading to a decline in the oil refining industry as demand for petroleum products decreases.

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[40] See http://www.glgroup.com/News/Threats-and-opportunities-for-the-European-refining-industry.-20730.html

[41] See http://uk.reuters.com/article/2010/09/13/uk-europe-oil-refineries-idUKLNE68C04620100913 for more information.

[42] FACTS Global Energy believe margins will stay poor indefinitely (http://www.economist.com/node/18529885?story_id=18529885)

In summary, the sector is facing two key challenges. On the one hand it is facing increased costs for its own CO_2 emissions as shifting inputs and a requirement to buy ETS allowances affect refineries. On the other hand falling demand for petrol and diesel due to environmental legislation (including biofuels) could lead to overcapacity and refineries closing. High oil prices and a possible long-term shift to electric vehicles are likely to negatively impact the sector further.

Fertilizer

For this section we consider the manufacture of fertilizers and nitrogen compounds, which comes under the NACE code of 20.15. The European fertilizer industry employs up to 30,000 people within the EU27 and there are 159 fertilizer manufacturing sites (EFMA, 2007). In the EU27, total consumption for 2006/07 of nitrogen, phosphate and potash for agricultural use (in million tons nutrient) are 10.5, 3.1 and 3.4 respectively. In 2008, the largest European producer of nitrogen, phosphate and potash was Germany, accounting for 27% of total production[43]. The industry is the single biggest user of natural gas in the European Union with natural gas representing 50-70% of the total cost of the production of nitrogen fertilizers.

Although nitrogen fertilizer production is energy intensive and produces CO_2 (due to process and energy emissions), it is claimed that efficient fertilization can have a positive effect on the greenhouse gas balance as a whole. Through efficient fertilization of biomass crops, six times more energy can be captured than is consumed in the production, transport and application of fertilizers (EFMA, 2009).

European fertilizer production to date has been declining within Europe. Although consumption increased in Eastern Europe, Western and Central Europe saw the largest decline of 22.9% of any global region for the period 2008-09 (EFMA, 2009). This can be attributed to a decrease in demand from agriculture, and also to a lack of natural gas within the EU and its high price from abroad. There are also increasing pressures from international competitors, particularly Brazil, Russia, India and China.

Changes expected in the coming decade

Although the most recent forecast from EFMA shows a slight increase in demand, the extra cost of ETS phase III, set to widen the auctioning of greenhouse gas emissions in 2013, is likely to cause the long-term decline in demand to continue. EFMA (2009) estimates that 95% of European fertilizer plants will have to buy emissions allowances from 2013, with an extra annual cost to the industry of more than €200m. Pressures on European competitiveness may imply a negative outlook for employment within the industry as a result of environmental policy measures.

According to the Pellervo Economic Research Institute, the nitrogen fertilizer industry producer prices will need to increase by between 20-30% to compensate for the increased manufacturing costs due to the ETS. One of the major concerns is that European ammonia and nitric acid plants are among the most efficient in the world, so the lost competitiveness would result in the expansion of capacity in parts of the world with less efficient plants and more polluting energy industries (EFMA, 2008), resulting in carbon leakage. These concerns are supplemented by the necessary role that the fertilizer industry is likely to play in food production within the context of a growing population.

Lime

In this section we define the sector as NACE code 23.52, which is the manufacture of lime and plaster. In 2007, EU27 countries produced an estimated 28m tonnes of lime and dolime from 210 production sites. This made up 12% of global production and

[43] Sourced from IFA statistics website.

contributed €2.5bn to Europe's GDP. EU27 employment is estimated at 11,000 people. Production costs in the EU27 in 2006 were roughly €60 per tonne (NERA, 2008), which is roughly €10-20 per tonne more expensive than non-European producers, but the difference in production costs are to a large extent outweighed by the relatively high transport costs. The EU lime industry is made up of several big producers that operate globally, thus giving them good access to best practice and the newest technology, as well as a wide range of markets.

The lime production process is highly energy intensive, with energy costs contributing roughly half of total costs (European Commission, 2010c). The industry is also characterised by two types of kiln that are used in the production of lime; a horizontal and vertical kiln. Horizontal kilns have certain benefits over vertical kilns, as they are less likely to become clogged up than vertical kilns when small-sized stones (which are abundant in many quarries) are used.

Production of lime results in CO_2 emissions (see below) and can also lead to emissions of CO, NOx and SO_2. CO_2 emissions come from the mineralogical transformation process used during production, as well as from the use of energy. While the industry therefore has strong incentives to reduce its costs through curbing energy use (and subsequently CO_2 emissions), CO_2 emissions cannot be reduced beyond a certain level without compromising the quality of the product, because of the significant process emissions produced. The industry has also reached a level of performance which in many cases cannot be improved upon with current technologies (European Commission, 2010c). Furthermore, lime kilns last for about 40 years, so it can be difficult for producers to comply with legislation and regulation in the short term.

As one of the earliest industrial commodities, several different applications for lime have been developed over time[44]. One of the most basic is the purification of iron and steel. Reduced consumption of lime by the steel industry caused the production of lime to fall in the late 1980s. However, since then lime has developed an increased importance in many environmental applications, including soil remediation, and water and sludge treatment. Notably, lime can be used to capture SO_2 and other acid gases produced in flue gas, which reduces atmospheric acidity; clearly there are trade-offs involved in the use of lime. The extensive list of applications for lime also includes civil engineering, construction materials, agriculture, food and pharmaceutical sectors.

More recently, the economic and financial crisis has caused a considerable slowdown in activity within the sector. This was due, in particular, to sharp reductions in demand from key markets such as steel production and construction.

Changes expected in the coming decade

The European Lime Association (EuLA, 2010) has expressed concerns that environmental policy, particularly plans to increase the GHG emissions reductions from 20% to 30% will have substantial detrimental effects on the lime sector. The EuLA states that around 70% of the sector's carbon emissions come from the chemical reaction required for producing lime, and that such emissions cannot be reduced without compromising the quality of the final product. Furthermore, NERA (2008) shows that, even at a conservative prediction of the carbon price (€30/tCO_2), this is more than three times the long-term margin for the sector. The fall of the carbon price to below €14/tCO_2 in early 2009 as a result of the recession still left a higher

[44] See http://www.eula.eu/fileadmin/user_upload/Publications_miscellaneous/Lime_Fact_Sheet.pdf for a more detailed description of the applications of lime.

price than the profit margin for the industry. In a public consultation between the EuLA (2010a) and the European Commission, the EuLA suggested that the increased competition within the sector, as producers try to make use of free capacity, is likely to decrease market prices and make it very difficult for operators to pass on higher carbon costs to consumers. The association states that the risk of carbon leakage would come primarily from operators in the immediate neighbourhood of the EU, for example with producers in Russia, Ukraine, the Middle East and North Africa already benefitting from cheap raw material deposits, and lower fuel and operating costs. The US and China do not compete directly with the lime industry in the EU. Finally, the EuLA recommends that free allowances should be issued to avoid carbon leakage within the industry, with the amount of emissions allowances granted to be associated with the best available and practically implemented technologies in the sector (identified by the best 10% of installations).

The concerns of EuLA clearly reflect a likelihood that carbon pricing in the ETS, particularly if a unilateral 30% was agreed (and carbon prices were higher), could pose significant cost pressures which would add to the competitive pressures already faced by the industry. Naturally, there would be a subsequent risk to employment within the sector. The EuLA recommends that the lime industry should be covered by different regimes for horizontal kilns and vertical kilns, as there is scope to improve the resource efficiency of vertical kilns by reducing the acceptable stone-size of kiln-feed EuLA (2010a).

To summarise, the lime sector faces particular difficulties in reducing CO_2 emissions as its emissions are the result of productive processes rather than fuel combustion. It is thus severely limited in abatement options by current technology and would be forced to pass on carbon costs or operate at loss. This could lead to relocation of production to non-European countries, although high capital costs mean that European operators may continue to produce in the short term.

Aluminium The aluminium sector has a NACE code of 24.42, which includes both upstream and downstream production.

Aluminium production is the largest of the five NACE class activities within the EU27's basic precious and nonferrous metals manufacturing sector (Eurostat)[45]. It is also the most energy-intensive part of the sector (approximately 15 MWh are needed to produce one tonne of aluminium, compared to 6 MWh for steel, for example). According to European Commission figures carbon costs account for more than 15% of the sector's GVA, mainly indirectly through electricity consumption[46].

In 2009, the industry employed 255,000 people in Europe and produced 4.4m tonnes (a 17% reduction from 2000) across 34 plants (EAA, 2010). Germany is the main producer in the EU with around 0.85Mt (megatons) in 2009, followed by Spain (0.58Mt) and France (0.55Mt). Aluminium smelters within the EU are relatively small, with an average annual capacity of 150.0ktpa, in comparison to an average of 202.3ktpa outside of the EU (ECORYS, 2011). Aluminium's main applications are for transport and buildings. In 2009, aluminium primary production[47] accounted for 59%

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[45] See http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-BW-09-001-09/EN/KS-BW-09-001-09-EN.PDF

[46] See http://ec.europa.eu/clima/documentation/ets/docs/leakage/20090701_list_sectors.pdf

[47] Primary aluminium production is when aluminium is produced from ore; secondary production involves production from scrap and recycled aluminium.

of total production and France was the main EU primary producer with 0.42Mt. Spain, the Netherlands and Germany followed with an output of 0.30-0.34Mt.

The European aluminium industry benefits from high productivity rates of its smelters, high recycling and recovery rates in production and also a highly qualified and skilled labour force. However, it operates in a high-cost environment, due in part to environmental policy but also to intervention from third countries in the form of industrial and trade policy. China, Russia, India and the Gulf States are notable examples of this. Also, Europe lacks its own resources of bauxite used for production and as such relies heavily on imports from elsewhere. Aluminium has a relatively high trade ratio in the range of 30-40%.

Changes expected in the coming decade

Although the modelling results suggest that the basic metals sector as a whole could benefit in employment terms from environmental reform (due to the use of metals in investment goods), it should be noted that the energy-intensive nature of aluminium production makes it particularly exposed to higher costs. The European Aluminium Association (EAA) states concerns that the European Commission's proposal to include both primary and secondary aluminium production in ETS phase III from 2013 could have negative impacts on the aluminium industry[48]. The association suggests that due to carbon leakage there could be no environmental benefit of including the industry within the ETS, and additional cost pressures would harm the competitiveness of the European aluminium industry within the global market. This would naturally be expected to negatively impact employment within the sector.

Road haulage

The final sector to be considered is road haulage, defined as freight transport by road under rev 2 NACE code 49.41. In 2009, approximately 14.25bn tonnes of goods were transported nationally within the EU27 countries (Eurostat). Germany, France and Spain accounted for the largest shares, of 18%, 13% and 12% respectively. Regarding road freight transport between countries, 299m tonnes of freight was unloaded in EU27 countries while 346m tonnes were loaded, implying that EU27 is marginally a net exporter of goods through road haulage. The relatively small share of goods that are transported internationally compared to nationally is not surprising as international haulage relies more heavily on shipping and air transport. International flows within the EU27 show that the majority of flows occur between countries with a common border. Germany and the Netherlands, who together account for 33% of the EU's international road haulage (both loaded and unloaded) have a higher level of trade with each other through road haulage than any other pair of countries within the EU27 (European Commission, 2009a).

The number of employees in the road haulage industry was estimated to be 2.2m in 2009 (Eurostat). This is an increase from 1.8m in 1999 and 2.1m in 2005. From 1995 to 2006, road freight transport increased more quickly than GDP (with tonnes-km increasing faster than tonnes, suggesting the average distances also increased over this time). This sustained increase in road haulage has occurred due to changes in the structure and location of the manufacturing industry and also an increased demand for 'just-in-time' shipments (European Commission, 2009a). However, the sector was more heavily impacted in the recent recession than the economy as a whole due to its dependency on trade. It appears therefore that the road haulage industry is very sensitive to wider economic trends.

[48] See http://www.eaa.net/en/press-room/press-releases/_doc/58/

Finally, CO_2 emissions from transport in general, and road transport in particular, have been rising faster than all other major sectors of the economy. In 2008, transport accounted for 19% of total CO_2 emissions, with road transport taking up 94%[49] of this share (Eurostat).

Changes expected in the coming decade

Due to road transport's substantial contribution to total CO_2 emissions, it is almost inevitable that the road haulage industry will see some changes within the next decade. It is likely that there will be a long-term shift to the use of biofuels (and also possibly electric vehicles), though this would not be expected to affect employment within the sector. The most immediate concern facing the industry is its recovery from the economic recession which, alongside increasing fuel prices, has significantly affected profit margins. Improvements in fuel and vehicle efficiency standards are expected to have only a minor impact on employment in the wider transport industry (IEEP, 2008). Although the share of international deliveries within the industry is small, the potential for drivers to buy fuel in low-cost countries could cause significant differences to emerge in fuel demand between EU countries. EU coordination in the development of efficient fuel use is therefore important if this is to be avoided.

Evidence from historic trends suggests that the road haulage industry is a high-risk industry, reacting sensitively to wider economic conditions. Therefore, perhaps the most significant impact of environmental policy on this sector will be through the indirect effect of policy on general economic conditions. The general consensus is that the measures to achieve the 2020 targets will have a small positive effect on employment and economic activity in general (European Parliament, 2010), so the sector may also see some benefits. While the road haulage industry would inevitably suffer if there was a decline in heavy manufacturing, there will also be opportunities for growth due to the emergence of green sectors.

A final factor that is important for consideration is the railway and shipping freight transport sectors, and the dynamics that may emerge between these sectors and road haulage. As road transport is accountable for such a large share of emissions within the wider transport sector, environmental legislation is likely to put greater cost pressures on the road haulage industry. This may cause demand for freight transport to shift towards the use of rail, given the strength of Europe's railway network. This dynamic is less likely to occur between road haulage and shipping.

Skills and training implications

The 20/20/20 agenda has an impact on employment and skills in the six sectors in a number of ways:

- affecting the demand for employment
- creating a demand for the implementation of energy-saving and energy-efficient production systems
- making the workforce aware more generally of the need to reduce energy consumption
- creating a demand for environmental assessments

The principal impact on employment is at the margin where the impact of the environmental regulation potentially affects the price of products. But this needs to be seen in the context of the other product market pressures the sectors face. The demand for coal, for example, is dependent upon the availability of coal in other areas of the world which may be more accessible or of higher quality. Similarly, the demand for

[49] Note that this figure includes non-freight road transport.

lime is dependent upon conditions in its principal consumer markets (e.g. iron and steel). In relation to fertilizers one of the drivers of development in the EU is the capacity to incorporate biotechnologies into products; an area in which the EU is quite well placed to develop a lead.

Most of the sectors are major energy users so there is a need to introduce technologies which potentially reduce the consumption of energy and/or develop new markets which might mitigate the effects of climate change. Hence the lime industry potentially gains from the processes which can absorb CO_2. Hence all sectors are looking to develop and implement processes which reduce their energy costs.

If the development of new, energy-efficient production processes is to be successful then there is a need for workplaces and workforces to implement such systems. In the road haulage industry there is evidence that telematics which monitor drivers with respect to their fuel consumption have been successful in reducing fuel costs. But such systems need to be used effectively for the gains to be realised. Hence there is a skill requirement which is cascaded down the occupational hierarchy.

Finally, the 20/20/20 Agenda increases the need for environmental assessments, especially in relation to extractive industries such as coal and lime. What is less clear in the literature is whether this is creating a skill demand within sectors or whether this activity is being outsourced to the eco-sector.

Table 5.1 summarises current skill demand in the various sectors.

With the exception of road haulage there is likely to be a loss of employment in all of the sectors as a result of the long-run decline in employment resulting from structural changes in the EU economy. This long-run decline could be stimulated further by the introduction of green policies. With demand falling the industries are faced with the problem of developing new products and processes which will stem that decline by bringing about productivity gains through reducing energy consumption. This is likely to result in managers, professionals, and associate professionals needing to acquire new skills in their existing jobs. It also places a considerable emphasis on R&D skills (especially where there is the potential to move into new sectors of activity – e.g. biotechnologies in fertilizers).

The extent to which all of the above is due to green policies as opposed to the longer-term problems the industries face should not be over-estimated, but it illustrates how green policy can affect job content at the margin. It also needs to borne in mind that the skills required by the sectors are often industry-specific such that there is often little skill supply available in the labour markets outside of these sectors.

Table 5.1: Employment and Skill Demand in Sectors Vulnerable to Restructuring

EMPLOYMENT AND SKILL DEMAND IN SECTORS VULNERABLE TO RESTRUCTURING	
Sector	**Emerging Green Employment and Skill Demand**
Coal	Weakening labour demand but with new skills to be acquired by all staff in order to develop and implement new mining and processing technologies which reduce energy consumption, open up new reserves of coal, and limit environmental damage.
Petrol	The use of heavier crude oils increases the use of energy in refining which creates demands upon engineers within the sector to develop more efficient refining technologies.
Fertilizer	Currently fertilizers require a large amount of energy in their production. With the development of biotechnologies there is the potential, over the long run, to develop fertilizers that are less dependent upon energy consumption in their production. This places a strong emphasis upon R&D skills.
Lime	The problem the sector faces is that of producing lime at a cost which consumers in the EU are willing to pay. Implicit in the commentary above is that the nature of the production process is such that CO_2 emissions cannot be avoided which will, given the operation of the ETS, drive down employment. The skill requirements resulting from the 20/20/20 agenda for the sector are not readily apparent.
Aluminium	The high levels of energy consumption in the sector results in it being susceptible to green policy. The key issue is the extent to which investments in more energy-efficient production systems are introduced and the skill demands (in installation and operation) this gives rise to.
Road Haulage	Fuel economy is the key to the sector's future productivity gains. The use of telemetrics which monitor fuel consumption in vehicles has the capacity to affect driver behaviour (adoption of eco-driving) if used effectively by road haulers. This requires drivers and their managers to adopt new technologies and modify their driving.

5.3 Focus on sectors: Sectors that could benefit from restructuring

Introduction

The results in Chapter 3 consider the impacts of the 2020 targets at the broad 2-digit level. However, as in the previous section it is also important to take into account changes within sectors as well as changes between sectors, particularly if these result in new skills requirements.

We have selected five sectors where the policies required to meet the targets could have significant labour market impacts. These sectors are considered in more detail. The choice of sectors is partly informed by the modelling results and partly from findings in the literature review that is summarised in Chapter 2.

The specific sectors are:

- production of renewable electricity
- manufacture of renewable energy equipment
- energy-efficient buildings
- production of biofuels
- production of electric vehicles

Producing renewable electricity

For this section, we define the sector as the production and distribution of electricity through renewable sources, which falls under the NACE code of 40.1 (rev 1.1). Equipment manufacturing is treated separately below.

According to the European Commission's progress report in 2009 (European Commission, 2009), Germany produced the largest amount of electricity from biomass. Among other countries, Sweden and Belgium have been very active in biomass generation.

There has been an increase in the share of electricity generated from wind turbines and photovoltaics (solar panels) in Europe. Germany has the largest number of wind turbines and photovoltaic installations, followed by Spain. The UK has one of the main offshore wind sectors. Other countries that have significant shares of wind power are Denmark and the Netherlands, while those developing solar energy include Portugal and Luxembourg.

A study by the Global Wind Energy Council (GWEC, 2008) states that, in 2009, wind turbines and solar panels employed 400,000 people worldwide in their manufacture (see below), installation and maintenance. A study by the European Wind Energy Association (EWEA, 2009) further suggests that the wind industry can create around 329,000 jobs in Europe by 2020 and 377,000 by 2030, although this is a gross measure and ignores the possibility of displacement elsewhere.

Changes expected in the coming decade as a result of the green agenda

The PRIMES model results (European Commission, 2010) indicate that the share of renewables in electricity generated is expected to increase from 19% in 2010 to 32% by 2020 if renewables targets are met. Of all the renewable sources, the share of hydro power is the highest at present but it is not expected to increase further. Generation from wind power is expected to increase substantially by 2020.

Under the EC directive (European Commission, 2008), renewable electricity generators are guaranteed a connection to the transmission system. This is particularly important for wind farms that are located far from the centres of electricity consumption and so are heavily dependent on transmission networks. The distribution of renewable electricity is often constrained by insufficient grid capacity. For these reasons, countries accounting for a large share of wind power, such as Germany, Spain and Denmark, prioritise the transmission of renewable electricity to the market through the network. However, since grids are typically designed to transmit electricity from a small number of power stations, substantial investment is needed to accommodate a large number of small renewable generation sites.

It is noted that renewable energy projects will reduce demand for fossil fuels, resulting in potential job losses. Even so, a number of studies reported in WWF (2009) include suggestions that the shift to renewable sources is expected to result in net job gains in Europe. With the policies currently in operation, the modelling results from the mitre project[50] estimate a net gain of 950,000 full-time Equivalent (FTE) jobs by 2010 and 1.4m by 2020, although this includes production of the investment goods as well as operation.

Skills and training implications

The sector is a relatively highly skilled one with a strong demand for both professional/associate professional engineers and technicians and skilled trades workers involved in the operation and maintenance of renewable energy installations. Around a fifth of the workforce are employed in professional or associate professional occupations with around a quarter engaged in skilled trades jobs.

To some extent the skills required in the sector are ones generic to both electricity generation and engineering in general, though organisations are often looking for specific experience, such as working offshore. The sector is therefore in competition with other sectors for highly sought after skills including, potentially, the offshore oil and gas sector. Studies from Germany and Denmark, where the industries are well established, suggest that many of the skills needed in the sector already exist, but there are sub-sectors of activity, such as solar energy, which have experienced skill shortages in relation to skills specific to it (Vogler-Ludwig, 2010; CEDEFOP 2010d).

Nuclear, if considered a low-carbon energy source, is a sector with very specific skill needs (e.g. for nuclear physicists). There is some evidence that countries have an aging workforce with respect to these skills, especially where there has been limited investment in nuclear power plants over recent years (for example, see UK Government, 2008). Given uncertainties across the Member States with respect to the development of the nuclear sector, this has affected skills supply to the sector, which suggests that any rapid expansion of the nuclear sector might well result in the emergence of skill shortages.

Suggested policy requirements

The sector is an emerging one in many Member States, employing relatively few people currently, but with the potential to employ many more in the future. Reports of skill shortages emerging now are likely to reflect the nascent state of the sector in many Member States. But as the sector develops, its demand for highly skilled and qualified staff will grow. This is likely to pose less of a problem in those countries with well-established engineering and electricity generation sectors, with associated skills infrastructures, compared with those Member States where these sectors are relatively less well developed. This suggests that growth in the latter set of countries is likely to be constrained at least over the medium term.

In the onshore wind market Germany and Denmark have been able to secure a relative advantage. There are various reasons for this, but skills have played an important part. These are also countries with distinct approaches to initial vocational education and training; for instance, both have well established apprenticeship systems which have

[50] See http://mitre.energyprojects.net/

been able to provide a strong supply of people skilled at an intermediate level (Steedman, 2010). It is, however, necessary to build up an initial critical mass of capacity that is able to then support future development in the sector.

Building renewables capacity

This sector is defined here as the manufacture and construction of renewable forms of electricity generation, excluding operations as defined above. This includes production and installation of equipment and therefore falls under two or more NACE codes and E3ME sectors:

- Mechanical engineering (NACE rev 1.1 29)
- Construction (NACE 45)

The first of these activities could be located anywhere in Europe or elsewhere (see below), but the second is fixed to the location of the chosen site.

According to European Commission (2010), renewables accounted for around 19% of total electricity generation in the EU in 2010. Half of this was in hydroelectric power, a quarter in wind power (mainly onshore) and the rest split between solar, tidal and biomass/waste. A report published by the WWF (WWF, 2009) reported on estimates from various separate studies of the number of jobs in the sector:

- 85,000 wind energy jobs in Germany (O'Sullivan et al, 2009), 21,000 in Denmark[51] and 20,000 in Spain (GWEC, 2009; EREC, 2007)
- 208,000 jobs globally in solar power[52], with 57,000 in Germany (O'Sullivan et al, 2009).

The European Wind Energy Association states that 192,000 people are employed in the sector.

Changes expected in the coming decade as a result of the green agenda

The E3ME modelling results show that this sector will face some of the largest impacts from the 20/20/20 targets. Firms that construct renewables will benefit substantially from the 20% renewables target and the investment that is required to meet it. Some gains will be at the expense of companies that produce conventional plant.

The results from the PRIMES model (European Commission, 2010) suggest that, although hydroelectric power provides the largest share, this share is not expected to increase, even with the 20% target; this is at least in part due to geographical capacity constraints. Other technologies, such as tidal and geothermal, are at a relatively early stage of development. Our focus is therefore on the following:

- wind power
- solar power
- biomass/waste

Of these, wind power has the largest market share and is expected to see strong growth by 2020. Three countries in Europe dominate production of wind turbines (Denmark, Germany and Spain) although multinational producers have factories in other European countries. However, there is also strong competition from developing countries, particularly China, which is eroding European companies' market share. A

[51] Danish Wind Industry Association, 'Employment,' www.windpower.org/composite-1456.htm

[52] European Photovoltaic Industry Association (EPIA) and Greenpeace International, Solar Generation V– 2008 (Brussels and Amsterdam, 2008).

proportion of the new wind capacity will be offshore, which has specific installation requirements.

Installation of new solar capacity is also expected in the period up to 2020. In Europe, by far the largest production of photovoltaic cells is in Germany. China and Japan also have significant production.

Expansion of renewables will require improvements to transmission networks, which will also create jobs in firms supplying the relevant equipment.

Sectors that might lose out

The model results from E3ME show that there is a large net increase in investment required to meet the renewables targets. However, there will also be some investment diverted from construction of fossil-fuel based power stations. Firms that specialise in large construction projects could therefore lose out, although there should be similarities between production methods for existing gas/coal plants and for biomass generation.

Skills and training implications

The sector as a whole has a strong demand for intermediate level skills related to both construction and engineering. Around one third of employees in the sector are employed in skilled trades, with around a further fifth engaged in semi-skilled manual occupations. With respect to skills, the sector is in competition with the construction and civil engineering sectors generally, and with the engineering sectors (especially those sectors concerned with the manufacture and maintenance of turbines). It is not obvious from the available literature that the sector requires engineering construction skills which are unique to its needs; rather it generally appears to require skills generic to the engineering construction sector. However, a need for specific skills may be articulated as a demand for experience of working in the renewable energy sector rather than a demand for specific skill sets.

The long-term employment trend in the engineering sector is one of overall decline, but this masks the considerable positive replacement demands in the sector. This can often result in the sector being a potentially unattractive one to suitably qualified young people considering their career options. This could exacerbate any current skill shortages in the sector.

Suggested policy requirements

The primary policy implications relate to policies which will stimulate the supply of intermediate level skills supply in engineering and construction respectively, and the combination of skills required in the engineering construction sub-sector. The capacity to provide people with these skills which would equip them to participate in the construction of renewable energy installations will be of critical importance to the sector. There is, however, uncertainty about how many renewable energy sites will be built over the medium term and whether this will generate a steady demand for skilled labour or produce an initial surge in demand as Member States look to meet various international and domestic policy targets. This accounts for the emphasis on providing skills which are additional to those acquired through more traditional training pathways into engineering and construction.

More energy-efficient buildings

This sector consists of the activities relating to improving the insulation standards of buildings, and promoting the use of renewable energy technologies in the residential, commercial and industrial sectors. This includes measures undertaken by suppliers to ensure efficient use of energy, such as inspecting and installing efficient heating, air conditioning, and other microgeneration technologies in homes. These energy-efficient measures broadly come under construction (NACE code 45) and, in particular, insulation work activities (45.32).

According to EuroAce (2004), buildings in the EU used 40% of total energy consumption in 2003 and are an area of potentially large energy savings. When it was launched, the EC's 6th Framework Programme of research included an aim to reduce the building sector's energy consumption in the EU by 30% in 2010, and 50% in future to ensure energy security and to help achieve carbon emission targets. In 2002 all EU countries adopted the Directive of Energy Performance of Buildings; the main objectives were as follows:

- to improve the efficiency of the existing stock of buildings
- to ensure that new buildings meet minimum energy-efficiency requirements

Number of jobs in the sector

Retrofitting is very labour-intensive, creating local, semi-skilled jobs. The money saved from reduced energy consumption can be spent in sectors that are more labour intensive than energy production. According to the European Commission (2008b), retrofit housing could generate around 280,000 - 450,000 new jobs (gross measure) for energy auditors, certifiers, inspectors of heating systems, renewable technology installers and industries producing energy-efficient materials for buildings by 2020.

Changes expected in the coming decade as a result of the green agenda

The central and eastern European countries have the least energy-efficient buildings, which implies that they have the potential of achieving the largest energy savings and thus creation of jobs. However, it is more expensive to introduce energy-efficiency improvements such as space, water heating and lighting by renovating existing buildings than by building new energy-efficient buildings.

Transaction costs involved in financing small-scale energy-efficiency measures in homes and small businesses are high, and this is reflected in the modest scale of lending activity by financial institutions for this purpose. In the UK, the government has encouraged public private partnerships to support this sector.

Another issue is that the new technologies may be considered less reliable, especially if initial installations are not fully successful. Demonstration projects and training are being undertaken to understand the operations of the new energy-efficiency technologies, which are becoming increasingly complex. For example Hungary had 20 energy advice centres that can be consulted on energy-efficiency measures. Although a relatively large share of R&D is directed towards energy efficiency, the expenditure is still small compared to that in the US and Japan.

According to WWF (2009), various studies indicate that efforts to improve the building efficiency will result in net job gains. For example a study by Oeko Institute in 2003 predicted that efficiency measures in the building sector could lead to a net gain of 110,000 jobs in Germany by 2010 (Cames et al, 2003). The European Commission's green paper (European Commission, 2005) estimated that the investment in energy-efficiency measures has the potential to create 3-4 times more jobs in comparison to the investments in coal-fired and nuclear power stations. It also suggests that the 20% savings achieved through energy-efficiency measures could create an additional 1m jobs (direct and indirect) in the whole economy.

Skills and training implications

It was apparent that when the economic crisis was at its peak during 2008-09, many of the fiscal stimulus measures introduced in the Member States included generating jobs by insulating buildings. These measures, in many instances, generated low skilled jobs. Fully retrofitting buildings is likely to be more skill-intensive than that experience suggests. An estimate of the sector's skill demand suggests that over half of it is concentrated in skilled construction jobs.

The provision of energy-efficient buildings will depend upon their effective design and construction. This implies a demand for new skills at both the design and construction stages. But this is not a new challenge for the building industry with architects, building engineers, and construction professionals having a long-standing interest in how to design and construct energy-efficient buildings. Hence the skill and training implications of the demand for more energy-efficient buildings may not be profound. The key issue is the extent to which good practice in both design and construction is being adhered to and whether existing training provision – especially continuing vocational education and training (CVET) – pays sufficient attention to energy efficiency.

Suggested policy requirements

Initial vocational education and training (IVET) is likely to encompass the principles of designing and building energy-efficient buildings via the standards set by the various institutions which regulate IVET in the Member States. This is further reinforced by the building standards which exist in the Member States. Perhaps the most pressing training need is to ensure that there is sufficient CVET – provided through formal and informal mechanisms – to ensure that workers already trained acquire the skills in those processes which are required to ensure that buildings are energy efficient.

Producing biofuels

For this section we define the production of biofuels as a combination of growing the crops and the process of using the crops to produce biodiesel. Production therefore falls under NACE codes 01 (agriculture) and 23 (manufactured fuels), which correspond to E3ME sectors 1 and 9. We are not considering next generation biofuels, such as algae-based fuels, although there are research-based jobs in this area. We are not expecting any major changes in employment in the distribution and retailing of biofuels, compared to conventional fuels.

Location of production in Europe

This sectoral distinction is quite important when considering potential locations of production. Countries with a large amount of space available for agricultural production may benefit from increased demand for biodiesel. The most common crop used in production is rape seed, but it is also possible to use other crops. On the other hand, the manufacturing process requires a plant similar in nature to a refinery, although usually on a smaller scale. According to the latest available Eurostat data, Germany, France and Sweden are among the largest suppliers of biomass[53]. Studies mentioned in a report published by the WWF (WWF, 2009, reporting on O'Sullivan et al, 2009, Nieto Sainz, 2007, and Worldwatch Institute, 2007) estimate that there are around 95,800 direct and indirect jobs in the biofuels sector, while Spain employs around 10,000 workers directly in the bioenergy sector (4,948 in biomass for heat generation, 2,419 in biofuels and 2,982 in biogas).

According to European Commission (2010), biofuels accounted for around 4% of Europe's consumption of transport fuels, although this share is increasing.

[53] Figures are for primary production of all biomass and waste so includes other materials (for this reason we exclude Finland from the list). However, this finding is consistent with that from other more specific sources, such as greenplanet.net (2010). Austria and Spain are also recognised as medium-sized producers.

Changes expected in the coming decade as a result of the green agenda

The scenarios that were modelled assume that the share of biofuels in road transport increases to 10% by 2020. There are ambitions to increase this further up to 2030, but these may be called into question given some of the negative impacts of biofuel use that have been seen in some areas outside Europe.

The impacts on employment in the agricultural sector are not immediately clear. If it is not possible to increase the amount of land in production, there is likely to be an increase in prices rather than real output (as was suggested when food prices rose). This is not likely to lead to more jobs but would have social impacts.

Sectors that might lose out

In the processing sector, there could be an increase in employment, although this could be at the expense of workers in existing fossil-fuel based refineries. Overall, we would expect fuel prices to increase, which could have knock-on effects on other sectors, such as road haulage services (see previous section).

Overall impacts

In 2006 a European Commission report suggested that each 1pp increase in the share of biofuels could lead to 45,000-75,000 jobs in rural areas (European Commission, 2006), implying that the 10% target could lead to 300,000 new jobs (gross measure), if all fuels were domestically produced. However, when secondary effects are taken into account the total net impacts would range from -240,000 to +60,000, according to results from the QUEST model.

Skills and training implications

For many Member States the key issue is how to stimulate the production of energy using biomass given its capacity to provide jobs in rural areas that lack other employment opportunities. The skill needs of the sector relate in part, at least, to the collection of (waste) material as an input into energy generation (UNEP, 2008). There are, however, well paid highly skilled jobs upstream in the processing of biomass. This includes professional and technician level skills in mechanical, electrical, and chemical engineering, alongside machine operating skills. To some extent these are generic skills which may already be found in agricultural and chemical sectors. There are, however, some specific skills relating to safe handling and storage of bio-ethanol and biodiesel.

Suggested policy requirements

At the time of writing the scale of activity in many Member States is quite modest, with Germany having the most jobs (around 95,000 according to UNEP in 2008). Accordingly, the skill needs of the biomass sector are not yet clear. There is also a debate about the environmental benefits of biofuels (i.e. the amount of carbon used in processing biowaste versus the carbon savings from its use) and ethical considerations (i.e. the extent to which it diverts activity away from food production and the impact this has on food prices, though this may be less of an issue for the EU than in other parts of the world) (Doornbosch and Steenblik, 2007). While the skill needs of the sector can be identified, the extent to which there is likely to be large-scale future demand across the EU is dependent upon the extent to which the issues identified above are resolved. Public policy in Germany, for example, is very much oriented towards increasing the use of biofuels. Should there be substantial future employment demand in this sector the skills required are to some extent already met in the agriculture and chemical engineering industry.

Building electric vehicles

This sector is defined as the manufacture of hybrid-electric vehicles (HEVs) and plug-in hybrid electric vehicles (PHEVs), which falls under the NACE code 34.1 (rev 1.1), manufacture of motor vehicles.

Production of HEVs and PHEVs in Europe is low in comparison to countries such as Japan and the US, where consumer demand and sales are much higher. Research published by RNCOS suggests that Europe accounts for only a small share of global hybrid sales (with the US dominating). Japanese manufacturers Toyota and Honda lead in the production of electric vehicles while US-based Ford is the third-largest manufacturer. Within Europe, the UK leads on production of hybrid vehicles since the only mass-produced vehicle of this kind aimed at the European market is produced at the Toyota plant based in the English midlands. The only other production of hybrid vehicles in Europe takes place at the Volkswagen plant based in Bratislava, Slovakia.

Overall employment at the two aforementioned plants totals around 11,300, although not all of this employment can be attributed to the production of HEVs and PHEVs.

Changes expected in the coming decade as a result of the green agenda

The PRIMES model results (European Commission, 2010) indicate that demand for electricity from the transport sector is set to grow by 0.7% pa between 2010 and 2020, which is broadly in line with total fuel consumption (even in the Reference case). This is dominated by the use of electricity in rail transport, but it probably still implies a smaller increase in road transport than the 30% pa growth expected in demand for diesel biofuels, suggesting Europe's transition to a 'green' transport sector will occur through the use of biofuels, while the market for electric vehicles will remain small in comparison to countries such as Japan and the US.

A report published by PWC (PWC, 2009) estimates that global production of electric cars will be around 500,000 by 2015, suggesting that the share of electric vehicles as a proportion of all car production would be 0.65%, but it is anticipated that there will be much stronger growth over 2017-20, leading to annual production of 9m units[54]. According to Collina et al (2008), there is a general call for the EU to move towards a greater proportion of electric vehicles by 2020. Although Europe currently lags behind Japan and the US in the production of electric vehicles, it is likely that production will accelerate as the requirement for low-carbon transport fuel grows.

Employment opportunities are not limited to the manufacture of the cars themselves, as the increase in demand for electric vehicles will enhance employment in the manufacture of inputs such as batteries and charging stations. A WWF report (WWF, 2009) states that the continuing development of HEVs and PHEVs and the boost in demand for manufacturers of batteries could lead to the creation of jobs at companies specialising in this type of production in Germany (Varta, Bosch, Continental, Evonik Industries) and France (Saft).

Currently, the market for PHEVs is small. However, a number of manufacturers have announced plans to mass produce these types of vehicles, including Europe-based Volkswagen. Nevertheless, as the WWF report notes, it is too early to predict the extent of employment that will arise from this branch of the motor vehicles sector, and how much production will take place within Europe.

Skills and training implications

The 'green' vehicle sector is estimated to employ around 150,000 people out of the 2m who work in the automotive sector in the EU (UNEP, 2008).

The principal skill needs of the sector relate to the combination of electrical and mechanical skills required in the production of electric or hybrid cars, but there are also backward linkages to consider (e.g. production of batteries) and forward linkages

[54] http://www.big4.com/news/pwc-success-of-electric-vehicles-depends-on-cooperation-3292

(maintenance, battery charging, etc.). The introduction of hybrid cars and the capacity of manufacturers to come up with a design capable of capturing a lead in the market, places a heavy onus on design engineers in the automotive industry. At the current rate electric cars are being produced it is unlikely to impose a major change on the industry.

The CEDEFOP studies (Vogler-Ludwig, 2010; GHK, 2010) into the skill needs of companies engaged in the production of hybrid cars or electric cars suggests that the skill requirements have been incorporated into initial vocational education and training programmes and retraining programmes for existing workers. So whilst there are new skills to be learnt (e.g. those relating to hybrid and high voltage techniques), these appear to be being taken up by companies.

The automotive industry has substantial experience of managing organisational and technical change – this occurs every time a brand new model is introduced to the market. From this perspective, the introduction of electric cars is unlikely to pose a substantial threat to existing skills in the sector.

Suggested policy requirements

The key issue is how to develop technologies which are cost-effective (once the whole life cost of a vehicle is taken into account) and which prove attractive to the consumer. Should this occur, there will be substantial changes in the market with the introduction of charging points (instead of petrol stations), as well as new skills required in the production and maintenance of vehicles. The issue of charging points suggests substantial infrastructure investments will be required. At the moment this appears to be developing at an incremental pace and, from an employment perspective, there appear to be few policy interventions required at this point in time insofar as the major manufacturers have initiated their own training activities (CEDEFOP, 2010a).

5.4 Focus on bottlenecks

Overview

The findings of this study indicate that the overall net impact of future environmental policies on employment in the EU is negligible or only slightly positive. However, this net impact on employment hides many underlying changes. At sectoral level, significant gross changes in employment are likely as a transition to a green economy takes place. For example in the energy sector a shift in technology and accompanying skills from conventional energy production to renewables could result in significant changes to the type and quantity of employment available. In this context, it is important to consider bottlenecks in labour and capital supply, as each can restrict the capability of industries to respond to such changes and the pace of transition. Localised and sectoral economies can consequently find it difficult to rebound from periods of restructuring or contraction due to recession. At the positive end of the business cycle, bottlenecks can prevent the maximisation of growth due to shortages in the supply of labour and capital dedicated to green industries.

The modelling approach adopted in this study assumes that transitions in the economy driven by factors such as green taxes and carbon pricing and regulations occur sequentially and without such bottlenecks. An analysis of these bottlenecks which goes beyond the model analysis is therefore provided in what follows to elicit those employment policies which could be adopted to promote more seamless labour market responses to the development of the green economy.

Labour market bottlenecks

A key source of bottlenecks in the economy can occur in the labour market due to the geographical immobility of workers to migrate from regions suffering a decline in employment to regions of employment growth (some examples are provided in Section 5.7). Bottlenecks in this context can include language, property ownership and cultural factors. In terms of occupational mobility, factors such as skills, qualification recognition and lack of awareness regarding the availability and local of employment in the economy can also represent significant bottlenecks to transition. Of these, research identifies[55] 'reskilling' as the most significant hurdle to meeting labour market requirements across the EU in the green jobs field.

Skill profiles Difficulties in forecasting future skill needs of employers and upgrading and matching skills of key target groups in the population are major challenges in key growth sectors, such as in the green economy (Employment Committee, 2010). This issue is of particular relevance for young people of up to 24 years of age (youth unemployment levels are two to three times as high as those among adult workers aged between 25 and 74) in most EU Member States in 2010[56]. Reasons for this bottleneck can be summarised as follows:

- In a recession, employers often prefer hiring experienced workers, which squeezes the opportunities available to youth, especially the less skilled, to find jobs and make the transition from education to work. This highlights the importance of industry-oriented training programmes and apprenticeship schemes for young people.
- Educational attainment levels of young people pose another challenge, as in some Member States relatively high proportions of early school leavers and youths classed as being 'neither in employment nor in education or training' (NEET) are simply not qualified or have the skills required by a range of sectors, leading to bottlenecks in labour supply. This problem is often acute in 'niche' sectors where specific skills are demanded and in which substantial training may be required to meet the needs of employers.
- A large proportion of young people are unable to find employment in spite of having obtained university education and even degrees, as their qualifications are not in line with the requirements of employers. This emphasises the significance of skills matching, through which education systems are aligned with industry needs. Over the longer term, a lack of skills matching can disenfranchise skilled workers from the labour force, leading to longer-term unemployment and preventing many from reaching their potential at a cost to industry and society.

Intervention to remove these bottlenecks is crucial to avoid persistent unemployment and social exclusion, in addition to ensuring the smooth transition and restructuring to a green economy and maximising the green jobs opportunities that exist. As documented in Box 1, a range of measures have been initiated across the Member States to address these issues.

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[55] See House of Commons (2009): Reskilling for Recovery: After Leitch, Implementing Skills and Training Policies, published by the Innovation, Universities, Science and Skills (IUSS) Committee February 2009; ADAPT International/Syndex (2011): Towards a low carbon electricity industry: employment effects & opportunities for the social partners, joint study for EPSU/EURELECTRIC/EMCEF, January 2011; and GHK (forthcoming): "Impacts of Structural Change: Implications for policies supporting transition to a Green Economy" for the European Commission DG Environment

[56] Ibid.

Box 1: Measures aiming to address skill-related bottlenecks in EU labour supply[57]

To raise the quality of education, new systems for teacher training and evaluation of the effectiveness of teaching have been introduced in Sweden and Cyprus (respectively).

Belgium has sought to better enforce equal access to primary education by putting in place school allowances and ceiling on ceilings on bills.

In Finland application procedures for vocational education have been streamlined and the number of entry positions increased in order to promote better access.

New scholarship programmes have been launched in Hungary and Slovenia to promote the study of vocations facing inadequate supplies of trained workers.

Several Member States have introduced initiatives aiming to tackle the problem of early school leavers – Finland, for example, has allowed for flexible basic education in a bid to reduce school drop-out and education interruption rates, while Greece has schools of ‘second opportunity’ to allow youth over the age of 18 who have not completed compulsory education a second chance.

Required skills

A CEDEFOP paper raises the issue of equity and cohesion concerns resulting from a ‘polarisation’ of employment opportunities, driven by the increased demand for highly skilled workers as well as a subset of less skilled workers, owing to structural shifts in the economy (CEDEFOP, 2009). The rest of the less skilled would, in this instance, face job cuts and lower pay rates on the whole. The results of the study indicate that while 13m net new jobs are projected to be created for Europe in 2006-15, 12.5m jobs added are likely to require high qualification levels (ISCED 5 and 6), with medium qualification levels (ISCED 3 and 4) accounting for a further 9.5m jobs. In contrast, the projections estimate that a decline of about 8.5m jobs will occur for those with the lowest qualification levels (ISCED 0 to 2). This highlights the importance of formal education and apprenticeship and training schemes designed to increase worker competencies and make their profiles better oriented to labour-market needs. In the context of EU 2020, this requires immediate action to prepare future employees for the green economy. The conclusions are reinforced by the finding that ‘higher level’ jobs (in terms of knowledge and skill requirements) such as posts for managers, professionals and technicians already account for nearly 40% of the European labour force, with this figure projected to rise to 42% by 2020 (CEDEFOP, 2010e). The spectre of job polarisation is expected to impact more fundamentally on Member States still experiencing transitions to service-based economies (such as the majority of the new Member States). Given the increasing importance attached to higher level education in the BRIC[58] economies and other rapidly developing countries, continuous training and skill upgrading will be of paramount importance in terms of maintaining the competitiveness of the EU workforce.

CEDEFOP (2009a) has also documented that the proposed greening of the EU economy is likely to raise demand for the requisite new skills, and that education and training systems should be geared to meet this challenge. Within major sectors such as

[57] Ibid.

[58] Acronym commonly applied to refer to Brazil, Russia, India and China.

renewables, certain skills are likely to be in greater demand than others in the coming years; for instance, a 2004 survey of 334 companies in the German renewable energy industry revealed that client counselling vis-a-vis the systems in place, knowledge of public subsidies and consultancy relating to reductions in energy consumption were likely to be in greater demand than more conventional skills such as brazing, soldering and repairing of electronic devices or modules[59]. A study of the Spanish wind energy sector indicates that while there are bottlenecks in the supply of skilled workers in subsectors such as medium and low-voltage specialisation, this is due in part to skill shortages and in part to the premature advancement level of the industry[60]. Further, less skill-intensive jobs in the industry tend to be subcontracted, which results in a two-tiered labour market; it is important that training programmes account for orientating the labour market to fulfil relative labour demand in both these tiers.

Cost implications

In recent years, skill shortages have been documented to have contributed to increases in the costs of a range of low-carbon technologies in the UK, including solar photovoltaic cells and wind turbines (Committee on Climate Change, 2008). This could further dampen the employment potential in the renewables sector by dampening demand for the products of the industries in question. Other potential bottlenecks may be driven as much by demographic change as by skill shortages – for instance, in the UK nuclear power sector, a significant proportion of the workforce was nearing retirement age in 2008, with education levels in the industry having declined for a substantial period (although they have increased of late)[61]. In a 2005 UK nuclear sector survey, nearly three quarters (72%) of employers reported skill gaps, primarily in project management and technical and practical skills (ETUC, 2008).

Competition between sectors

Bottlenecks in labour supply are likely to be experienced across a range of key subsectors in the renewables and wider energy generation industries. In the UK, for example, while different types of energy generation call for certain area-specific jobs (e.g. nuclear energy specialists), there are several professions which straddle several areas, including engineers, project managers and R&D, which could exacerbate supply bottlenecks by leading to competition between subsectors for a limited labour supply (Syndex et al, 2009). Companies, in particular SMEs, might be expected to face constraints in terms of the number of workers they could hire or train, which would entail delays in technology development, especially in areas such as carbon capture and storage (CCS) which may be perceived to be significantly high risk relative to more established renewable energy industries. The inability to forecast future skill requirements in specific sectors also creates impediments to policy-driven orientation of training programmes to meet skill shortages where they are especially prominent.

While the emphasis on training initiatives in areas where 'new' skills are increasingly demanded by the industries benefiting from a 'green' emphasis in policy making in Member States is important, systemic weaknesses in the EU skills base which limit productivity and competitiveness must also be highlighted (GHK, 2010a). An emerging consensus indicates that few of the skills critical to the low-carbon transition may be new – the bulk of the skills deficit may lie in management and technical areas, primarily as regards science, technology, engineering and mathematics (STEM) skills. Several employment avenues – whether falling under the 'new green jobs', 'existing

[59] Ibid.

[60] Ibid.

[61] Ibid.

occupations requiring greening of skills' or 'requiring retraining' categories – already benefit from a sound, highly relevant skills base and only need a 'topping up' of competences. In other words, the proposed skill-driven bottlenecks in several 'new' green areas may not be as difficult to overcome given the 'knowledge add-ons' suggested in the context of selected Member States in Table 5.2.

Table 5.2: Member State Examples of 'Upskilling' to New Occupation

MEMBER STATE EXAMPLES OF 'UPSKILLING' TO NEW OCCUPATION

Member State	Occupation(s)	Core training	Upskilling	New occupation
DK	Industry electrician/ energy technologist	VET qualifications/ tertiary engineering qualifications	Knowledge of energy sources, ability to integrate energy systems, project management	Manager in renewable energy
DK	Industrial operator/ industry electrician	VET qualifications/ upper secondary qualifications	Assembly, installation of parts, use of tools	Wind turbine operator
EE	Construction worker	No professional standard	Knowledge of energy systems, data analysis, project management	Energy auditor
FR	Recycling sector worker	General certificate of vocational training (CQP)	Sorting and reception techniques, knowledge of conditioning and storage	Waste-recycling operator
FR	Product design and services	22 initial training courses with varying specialisation	Integrating environmental criteria in design process, integrated assessment and life cycle analysis	Eco designer
DE	Electronic/ mechatronic technician	Initial vocational training	Electronics and hydraulic systems, safety procedures, operation and services	Wind power service technician
DE	Plumber/ electric and heating installer	Initial vocational training	Technical training, knowledge of administrative procedures, entrepreneurial skills	Solar energy entrepreneur/ installations project designer
UK	Engineer in energy section	Tertiary engineering qualifications	Installation and maintenance of low-carbon technologies, customer service skills	Smart-energy expert/ smart-energy manager
UK	Commodity trader/ Broker	Tertiary qualification	Practical skills on functioning of carbon market, understanding of trading tools	Carbon trader/ broker

Source(s): GHK Consulting (2010, forthcoming): 'Skills for green jobs – European synthesis report', CEDEFOP, Thessaloniki.

Capital and technology Bottleneck concerns in the supply of labour may also arise due to capacity constraints in terms of the capital and technology bases necessary to support the implementation of climate related policy. Capacity constraints arise in instances where the European market displays insufficient potential to fulfil the demand for new technologies. This would necessitate EU intervention to facilitate capacity creation in the market in order to prevent significant losses of market share, and even the 'first-mover' advantage, to competitors based in third countries.

For example, without the establishment of economically viable wind turbine or solar panel manufacturing capacity prior to the maturity of the technology and its uptake by users, non-EU producers could enter the market more quickly and compete more aggressively once the market is established. This clearly has a negative impact on the employment potential within the EU for green technologies. Similarly, innovation in the environmental and eco-technology sector should be supported to create the future products that will generate EU employment. Interventions could include investment support to innovative companies, initiatives to promote and bring to market beneficial technologies much more quickly and incentives to users to adopt the technologies in question (i.e. through price support, tax rebates, etc.).

The role of innovation The constraints created by slowly rising carbon and fuel prices limit the scope for technological breakthroughs by raising production costs. This is likely to result in sub-optimal employment 'multiplier' effects, as innovation is stifled. The sensitivity of industrial progress to price volatility has been documented in the instance of the European glass sector, where major operators often refrain from making substantial investments in emission-reduction R&D given their relatively stable short-run positions and risk averse business strategy (Syndex et at, 2009). Declining levels of innovation and technological progress, in effect, would tend to have 'knock-on' impacts on the generation of environment-friendly jobs.

One instance of the potential influence of such factors is visible in the case of the renewable energy sector, within which certain energy sources may be perceived as being more feasible for development in a Member State, based on the availability of capital and the feasibility constraints imposed by technology. A UK Committee on Climate Change (2008) report notes that '*if concerns about bioenergy production cannot be overcome via new technology developments, the role of appropriate biomass use in power generation may be limited given other opportunities to use bioenergy where either transformation losses are lower (e.g. heat) or where alternative low-carbon energy sources are less likely to be available (e.g. aviation).*'

Further, wind generation costs have undergone a fourfold decline in the last three decades; coupled with advancements in energy storage technologies and load balancing mechanisms (such as smart metering), this is likely to lead to greater labour demand in the sector relative to alternative clean energy areas such as solar power, low yields of which are likely to keep costs fairly high in temperate regions such as Western Europe[62].

The importance of accurate skills needs forecasting is also evident from the fact that optimal utilisation of new or emerging technologies and innovative production processes requires skilled labour in the application, maintenance and operation of these technologies throughout their life cycle. This underscores the need for

[62] Ibid.

institutions and feedback mechanisms which help to ensure that technologies and labour skill needs are matched and that appropriate modifications to training offers are made (CEDEFOP, 2009a). France already has a 'technology forecasting' scheme for this purpose; similar initiatives would benefit other Member States.

Research by GHK (forthcoming) suggests that sectoral setups inhibiting innovation tend to 'lock in' prevailing production methods and approaches for substantial periods and constitute a major barrier to structural change. This leads to 'path dependency', under which final outcomes are largely the result of chance, deriving primarily from apparently insignificant initial developments and trends rather than from policy shifts. The 'lock-in' is often strong enough to resist pressures for change even where there are demonstrable advantages in doing so, partly because of cultural pressures to downplay the significance of such arguments. Recent modelling of environmental policy instruments in the context of technological lock-in suggests that in cases where the preferred technology is not known, market-based instruments are preferable to regulation based on technology choices (Castellucci et al, 2009), as they are inherently more flexible and allow time to establish the sustainability of technological pathways involved.

Other bottlenecks

Apart from problems rooted in workers' skill levels and access to capital and technology, a host of other factors could function as bottlenecks to labour supply in the EU context. In 2008, a European Commission official[63] pointed out that worker mobility levels across the EU were fairly low, especially in light of the fact that the internal markets were open and there were no official restrictions preventing EU citizens from travelling across the Continent. Four key impediments to labour mobility across the EU Member States were mentioned:

- the language barrier between Member States
- different rules and administrative requirements
- problems for partners or spouses in finding employment
- the finding that, in practice, peoples' university degrees or other qualifications are not well understood

CEDEFOP (2009a) documents that in several OECD economies[64], deindustrialisation and the 'off shoring' of manufacturing capacity (in a bid to cut production costs and boost profit margins) contribute to the demand-supply imbalance vis-a-vis skilled labour. This can be countered to some extent by means of provision of specialised training and the 'upskilling' of existing occupations, as already discussed. In terms of educational levels, a study of German energy-intensive industries concluded that the green transition would lead to a reallocation of employment in favour of job-seekers holding either university or bachelor degrees, as well as specialist vocational qualifications such as those required by foremen and technicians.

The potential for off shoring is also highlighted in a 2009 IPPR study focusing on the UK (Bird and Lawton, 2009), which highlights that a detailed consideration of gross employment impacts (in terms of job creation as well as job loss numbers) is essential if policy makers are to be in a position to evaluate the 'fairness' of the low-carbon

[63] http://m.publicservice.co.uk/article.asp?publication=European%20Union&id=353&content_name=Employment%20and%20Social%20Affairs&article=10377

[64] 21 of the 34 OECD member countries are EU Member States: see http://www.oecd.org/document/25/0,3746,en_36734052_36761800_36999961_1_1_1_1,00.html

transition. In this context, the report also emphasises gender-centric profiling as a key qualitative issue driving bottlenecks in sectors such as construction and manufacturing, where there is considerable potential for low-carbon growth but women constitute only 14 and 20% of the workforce respectively. To some extent these low percentages are rooted in a perceived lack of part-time and flexible working arrangements offered by employers[65].

In summary, any discussion of the employment impacts of environmental policies in the EU should account for the potential for significant shortages in the supply of skilled labour across key sectors, even in the leading Member States. Policies targeting a more flexible and competitive labour market and reliable forecasts for future skills needs for employees, employers and education providers could help address these challenges.

5.5 Analysis of churn

Overview

When discussing the impacts of environmental policy on employment, it is important to evaluate any changes or projections of employment in the context of the counterfactual (what magnitude of change would occur anyway) at sectoral or whole economy level. Only by considering these impacts can the true impact of environmental policies be assessed. The counterfactual 'churn' in the economy is discussed as follows, highlighting the impact of environmental policies where possible.

Even if employment levels were fixed, companies and other employing organisations are born and die. This can be a particularly important issue if there is significant technological and structural change taking place which may itself influence the birth and death of companies, depending on how successfully they adapt to the threats and opportunities presented. There may as a result be considerable structural costs that offset job gains and losses and that are not revealed by the net changes projected in the modelling.

A second aspect relates to turnover of people within employing organisations. Even if the number of employers was fixed there would be turnover of people due to retirement and other factors causing people to leave their current jobs and apply for new ones. This is taken into account to some degree in the replacement demand estimates presented. However, these focus primarily on 'semi-permanent withdrawals from the current workforce (such as retirement at old age or (mainly) women leaving to bring up a family). The estimates below include various other aspects of 'churn' or labour turnover.

Whole economy 'churn'

An indication of the total net number of jobs created and lost in an economy can be estimated from changes in employment/unemployment levels in the economy. Comparison against the net employment predictions of the studies reviewed can then be used to indicate the scale of the green jobs impact relative to the counterfactual churn of the economy. Table 5.3 presents estimates of EU labour market turnover based on OECD and Eurostat Labour Force Survey (LFS) data. The table also provides the annual net impacts on employment generated in the green jobs literature,

[65] While the majority of employers surveyed in this study reported offering part-time and flexible working options, the authors note that several employees may not perceive these options to be flexible enough to benefit them, especially those occupying senior roles.

indicating the proportion of total 'churn' accounted for by the green economy. As a rule, this proportion may be estimated to be between 2 and 3% of the overall estimate of a little less than 48m for annual labour market churn in the EU in 2009 (Governatori, 2009). As the table indicates, the extent of churning varies considerably across the sectors for which data are available. From the point of view of policy makers, the churn is likely to have greater impact on segments of the economy that are more amenable to 'green' policies (e.g. renewables) than on conventional sectors such as iron and steel.

Table 5.3: Employment Turnover in the Whole and Green Economy

EMPLOYMENT TURNOVER IN THE WHOLE AND GREEN ECONOMY

	2005	2006	2007	2008	2009
EU 27 employment (000's)*	210,794	214,936	219,070	221,674	217,813
EU labour market turnover rate**	22%	22%	22%	22%	22%
EU labour market turnover ('000s)	46,375	47,286	48,195	48,768	47,919
Fraunhofer ISI and partners (2009)	Renewables focus: net employment creation 0.83-0.90% (by 2020/2030) of overall 'churn' (labour turnover) in 2009				
WWF (2009)	Renewables: net employment creation of 3-5% of overall 2009 churn by 2020				
ECOTEC (2008)	Renewables: net employment creation of nearly 2% of overall 2009 churn by 2020				
ETUC (2007)	Iron and steel: net job losses of 0.05 – 0.09% of overall 2009 churn by 2030				
ETUC (2009)	Electricity, automotive and machinery and electrical manufacturing: Net employment creation of 2.55% of overall 2009 churn by 2020				

Source(s): * Eurostat (LFS 2009), **2002-07 annual average, assumed to hold for 2008 and 2009[66].

A significant proportion of the shifts visible through labour turnover figures for the EU are driven by business cycle trends. The financial crisis of 2008 is an instance of a major 'shock' to the economy, from which a range of sectors might not be expected to recover fully for some time. The EU is estimated to have lost 4m (net) jobs in 2008-2009, when the crisis was at its worst, with the impact falling disproportionately on the manufacturing and construction sectors (World Bank, 2010). The estimates in Table 5.3 suggest that job losses in 'green' sectors which could be linked to the impacts of the crisis may not have been very significant (1 to 2% of 4m amounts to 40,000 to 80,000 jobs and this is likely to be an overestimate given that manufacturing and construction, where the losses have been more significant, do not comprise most of the green industries). Further, with employment figures tending to be lagging the recovery and restructuring process of the economy by a year or more, long-term structural employment shifts might occur over considerably longer periods. These effects are discussed briefly below, with additional detail and examples provided in the following section.

Movement of heavy industry outside the EU

The potential for substantial cost reductions has been known to lead employers to outsource manufacturing processes and even certain types of service provision to lower cost locations in third countries. This impact is likely to be visible in case of

[66] Governatori (2009).

certain ‘green’ sectors, in particular those calling for substantial manufacturing or R&D investment – while the R&D centres are likely to remain in leading EU markets in the short term, labour-intensive operations (for example, manufacturing of solar photovoltaics and biomass plant set-up) could be moved to third country locations. Although these changes are ongoing across the economy, it is unlikely that the green agenda will contribute to the movement of such industries outside of the EU, as a similar proportion of green manufacturing could be located in third countries comparable to the rest of the economy. In certain cases, this process could be reversed, with government incentives and support ensuring that green industries locate in the EU. However, post-2020 and when subsidies run out, it is likely that industry will revert to the longer-term trend of outsourcing.

Part-time work

A services driven economy is more likely to have a higher proportion of part-time workers relative to an economy dominated by manufacturing industries, owing to the greater potential for flexible working afforded by service sectors. A report by the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2008) confirms this for the western EU15 economies, where the transition to service industry dominance has led to significant growth in part-time employment, as against in the ‘new’ EU10 Member States where no prominent effect to this end has been visible. The degree to which part-time employment trends are affected by green jobs is inconclusive as information is scarce on this topic.

Growth of the service sector

A common stage in conventional development models involves a substantial expansion of service industries in an economy after a period of dominance enjoyed by manufacturing. Most OECD economies, as well as major emerging markets such as China, have taken this route to rapid development. The lessons learnt by ‘first movers’ in each transition (initially from agriculture to manufacturing and subsequently from manufacturing to services) often enable late arrivals to leapfrog their way to more rapid advancement. In terms of green sectors, this transition is likely to occur in the longer run, once markets as well as technologies are better established and more mature (i.e. as renewables targets are achieved, employment is likely to shift from manufacturing and installation of renewables to the maintenance and operation of this technology). The first-mover advantage could be of special importance in environmental sectors, especially from the perspective of EU companies engaged in exporting increasingly advanced green technological products to third countries. The ETS, carbon trading and green finance are all examples of where the EU could become a sustainable leader in the service sector and could generate a substantial number of indirect jobs. Interestingly, while the ETS is a market-based instrument and fiscal measures are often needed to support the development and uptake of technologies, many of the green services mentioned are often more responsive to regulatory conditions (i.e. in financial services, global carbon trading, environmental regulations, etc.).

Limited resources

Resource limitations act as a natural constraint on growth rates (in the absence of productivity increases in labour and capital) and an incentive for the development of alternative energy sources, plus improvements in resource and energy efficiency as prices gradually increase with increasing resource scarcity. This ongoing trend is therefore likely to promote the green economy, and with it jobs.

Sectoral churn

As discussed in previous sections, certain sectors are expected to enjoy relatively greater net employment benefits in the coming years. In particular, electricity generation and construction are anticipated to lead in terms of net employment creation up to 2020. Within these sectors, green policies are likely to play a key role in driving employment creation in subsectors such as renewable energy and energy-efficient buildings. An inter-sectoral churn is predicted, on the basis that conventional energy generation and other fuel or energy-intensive areas will witness gross job losses to offset the gross positive employment impacts in the aforementioned areas. Estimates of sectoral employment impacts generated in a number of recent studies are reproduced in Table 5.4. The table summarises the net impacts of changes to employment based on a variety of empirical findings, data analysis and quantitative methods (typically adopting labour-intensity indicators). The table clearly demonstrates that net job creation is greatest in energy sectors and those where energy efficiency is prevalent (i.e. machinery and electrical equipment). In addition, impacts are higher over a longer time horizon (up to 2030).

Table 5.4: Examples of Estimated Sectoral Employment Impacts

EXAMPLES OF ESTIMATED SECTORAL EMPLOYMENT IMPACTS

Sector (time horizon)	Direct Jobs (FTE)	Indirect Jobs (FTE)	Total (FTE)	Details
Electricity (2030)	251,000-277,000	27,000-30,000	278,000-307,000	Net impact above baseline scenario 2010-20. Quantitative estimate based on NSAT scenario
Steel industry(2020)	175,000			Gross jobs threatened based on qualitative estimate of employment in integrated liquid steel production sites
Refineries (2020)	-3,000	-3,000	-6,000	Expected gross impact of closure of ten smaller refineries
Automobile sector (2030)	Job losses: 17,000 – 34,000 Gains: 80,000 – 160,000			Direct impact. Quantitative estimate of net impact of shift to electric engines based on McKinsey (2009) and main scenarios
Machinery and electric equipment (2020)	670,000	250,000	920,000	Quantitative estimate of net employment creation in energy efficiency and production using McKinsey (2009a)

Source(s): GHK, Syndex et al (2009).

At a broader level, a report by the European Foundation for the Improvement of Living and Working Conditions (Eurofound, 2008) investigated the nature of job creation and job destruction in the EU and highlighted the effects of structural change on employment patterns. The report looked at the extent to which jobs were being created or lost within five quintiles of the 1995-2006 period, defined by the average hourly wage (i.e. the 20% of lowest paid jobs etc.). A distinction was drawn between the EU15 and the New Member States (NMS10). Trends were found to vary across the Member States – in some instances, a process of 'polarisation' was observed, with a growth in employment in the highest and lowest paid quintiles (e.g. in the Netherlands and France), whilst in others there was a process of 'upgrading', with job loss in the lowest paid quintiles and job gains in the highest paid quintiles (e.g. in Finland and Portugal). For broad sectors, a shift towards a service economy is visible, but with variations in sub-sector level performance. In the 1995-2006 period, significant numbers of jobs were lost in the manufacturing sector in the EU15, though this was particularly acute in the lowest paid quintile, where around 1.4m jobs were lost in low paid, low technology manufacturing positions. Interestingly there was also a net loss of employment in higher-technology manufacturing positions in the EU15.

The major decrease over the past 40 years, according to Eurofound (2008), has taken place in the number of people employed in what the report termed 'intermediate' occupations (craftsman, skilled agricultural workers, etc.). These long-term occupational changes have been attributed to a range of structural drivers, primarily technological changes (e.g. computerisation) which has impacted most on medium skilled routine activities (e.g. assembly-line workers and clerical positions). These changes are linked also with sectoral shifts, specifically the decline in manufacturing positions (characterised by routine occupations) and the growth in knowledge-intensive services (which require more professional occupations) and other services (e.g. personal services, which often require elementary occupations).

Examples of sector-specific qualitative and quantitative impacts on occupations are listed in Table 5.5 based on the literature review. Net job numbers are likely to rise in R&D, manufacturing, operation and maintenance and management across a range of sectors, although the gains may be small, and there will probably be significant reallocations within sectors, as highlighted above.

Table 5.5: Impact on Occupational Profiles of Economic Restructuring

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING			
Sector overview	**Key Policies/ Industry drivers relating to green jobs**	**Projected change in job numbers**	**Associated impact on occupational profiles**
Renewable energy (Manufacturing/Services) EU employment: 1.4m in 2005 (0.65% of EU 27 workforce[67]) Total gross value added: €58m in 2005 (0.58% of EU GDP)	EC Renewable Energy Directive, COM (2008) 20% renewables-centric target (2020) EU ETS Fiscal stimulus measures (‘green’ counter-recessionary investment) Subsidies	Projected to create about 396,000-432,000 net jobs in the EU27 by 2020, i.e. 28-31% of 2005 employment figure for the sector (Fraunhofer ISI and partners, 2009) UNEP (2008): Between 1.4m and 2.5m net full-time jobs (direct and indirect) in renewables development in EU15 by 2020 (WWF, 2009) (i.e. up to 2.5m net jobs, or about 1.5% of overall EU15 employment in 2010[68]) Employment generation likely to be greatest in biomass, hydro power, wind and solar energy (ETUC, 2009)	Jobs generated in construction, manufacturing and installation of renewables – in particular, in installation and maintenance of solar PV and solar thermal systems ETUC (2007): More stringent energy-efficiency norms should engender more jobs in energy consultancy, engineering and energy service provision (mainly power suppliers, operating service providers and installers (e.g. of grids or co-generation units)
Conventional power generation (Manufacturing/ Services) EU employment: 1.62m in 2010 (0.77% of EU 27 workforce[69])	EU 20/20/20 targets EU ETS Infrastructural investment	At a broader level, up to 48,000 refining jobs could be lost at a gross level by 2020 (a decline of about 40% from current levels) owing to development of organic fuels and tightening of carbon constraints (ETUC, 2007) Closure of ten (relatively small) refineries could lead to loss of 6,000 gross jobs (half direct and half indirect) by 2020 (ETUC, 2009) Employment in coal-fired plants likely to decline by 2030, unless CCS procedures advance sufficiency (ETUC, 2007). Significant gross job losses owing to shift towards renewables, but	More jobs likely in natural gas sector, primarily owing to current dominance of the industry in power generation, rapid investment return and relatively low carbon footprint – however, future price and availability of gas reserves could be a major challenge (ETUC, 2007) Maintenance likely to continue to remain an area of importance (even assuming shift in favour of renewables) – training programmes desirable (ETUC 2007, 2009) Jobs in marketing, project management and customer service

[67] Source(s): Fraunhofer ISI and partners (2009).

[68] Eurostat: Overall employment in EU15 in 2010 approximately 170m (see http://epp.eurostat.ec.europa.eu/portal/page/portal/employment_unemployment_lfs/data/database).

[69] Eurostat: Employment in electricity, gas, steam and air conditioning supply (see http://epp.eurostat.ec.europa.eu/portal/page/portal/employment_unemployment_lfs/data/database).

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING

Sector overview	Key Policies/ Industry drivers relating to green jobs	Projected change in job numbers	Associated impact on occupational profiles
		these are largely offset by jobs indirectly created in renewables construction, manufacture and installation – only an ambitious 4.4% annual emission reduction target leads to net job losses of around 140,000 (ETUC, 2007)	also likely to hold ground
Cement (Manufacturing – Basic industry) EU25 employment: 53,300 in 2003 (0.03% of overall EU25 workforce)	EU ETS (ETUC, 2007: over-allocation of allowances to sector in 2005 led to sales of unused quotas worth nearly 1% of sector's turnover in the EU25) Energy-efficiency policy CDM – demand for new technologies R&D investment	8,000-20,000 gross job losses expected by 2030 (between 15% and 40% of total EU sectoral employment) as labour productivity improves, given current industry trends; import restrictions and curbs on relocation could mitigate these figures (ETUC, 2007) MOSUS (2005): Predicts EU15 industrial employment in 2020 to be 1% lower in a 'high' ('strong sustainability') scenario (reduced material and energy use of 30-40%) than in a baseline scenario (no additional policy measures implemented for sustainable resource management)[70]	UNEP (2008): Shift towards energy-efficient plants, both newly constructed and retrofitted, will probably generate some jobs in short run, but might prove counterproductive over a longer period as 'greener' plants tend to be more automated and require less labour Surviving jobs could require higher skill levels and retraining ('green' jobs), but would not be a major employment source
Iron and steel (Manufacturing – Basic industry) EU27 employment: circa. 550,000 in 2006 (0.26% of overall EU27 workforce in 2006[71])	European Ultra-low CO_2 Steelmaking programme (ULCOS) – flagship project of the European Steel Technology Platform (ESTEP) EU ETS (ETUC, 2007: relative proportionality between production and emission levels as regards ETS quotas for steel industry)	ETUC (2007): Reduction in production by 2030 likely to put 80,000-120,000 gross jobs at risk, R&D investment and low-carbon production estimated to be able to offset 50,000 of these, thus 30,000-70,000 net job losses expected (i.e. circa. 8-18% of a total of 370,000 employed in integrated sites) Further, ETUC (2009) estimates that taking account of jobs in cold processing and tubes domains would raise overall sectoral employment figure to almost 550,000; estimate of net jobs lost by	Making steel mills greener and more competitive – essential for job retention, although these mills not necessarily labour intensive (UNEP, 2008) Business-as-usual outlook refers to ongoing employment retrenchment, but a proactive policy favouring jobs in green, high-quality space could encourage job retention (e.g. the EU's 'Ultra-low CO_2 Steelmaking' (ULCOS) initiative) ETUC (2009): Potential for specialist qualifications to

[70] MOSUS evaluation scenario descriptions available at http://seri.at/wp-content/uploads/2009/09/SERI-Studies1.pdf

[71] Eurostat: Overall employment in 2006 in EU27 was about 213m (see http://epp.eurostat.ec.europa.eu/portal/page/portal/employment_unemployment_lfs/data/database).

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING

Sector overview	Key Policies/ Industry drivers relating to green jobs	Projected change in job numbers	Associated impact on occupational profiles
		2020 revised to 24,000-45,000 (i.e. less than 10% of overall employment in the sector) MOSUS (2005): Industrial employment in EU15 1% lower in 2020 under a 'strong sustainability' scenario as compared to baseline (as described above)	replace jobs currently held by general technicians; energy-efficiency culture would be key for production and maintenance operators Productivity gains will necessitate greater emphasis on computer-centric processes, worker security (vis-a-vis rigorous operating standards) and training Potential for a third of jobs at risk likely to be replaced by positions vulnerable to poorer working conditions and increased health risks, owing to need for greater contractual flexibility and outsourcing (ETUC, 2007)
Machinery and electrical equipment (Manufacturing) EU27 employment: 3.7m in 2006 (ETUC, 2009)	EU ETS Energy-efficiency policies SME-centric policies (given importance of SMEs in this industry)	ETUC (2009): Energy efficiency and production (core of industry) could see gross increase of about 670,000 jobs; an additional 250,000 jobs possible via advanced supplier investment – thus, potential for gross job creation amounting to 920,000 (nearly 25% of total employment in sector as of 2006 – 3.7m)	Findings subject to assumptions regarding relocation potential, role of imports and labour productivity in the EU Market-share trends will hinge on industry-academia proximity and supply of highly skilled labour As SMEs comprise 50% of market, their integration into support programmes and regional competence networks will prove crucial (ETUC, 2009)
Construction (Services/	Energy Performance of Buildings Directive (EPBD) – Directive	ETUC (2007):	Green job creation primarily in installation and delivery of material and equipment, but also in management,

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING

Sector overview	Key Policies/ Industry drivers relating to green jobs	Projected change in job numbers	Associated impact on occupational profiles
Manufacturing) EU27 employment: about 16.1m in 2010[72] (7.65% of overall EU27 employment)	2002/91/EC Directive on the final use of energies (2006/32/EC) EU Green Building Programme (launched 2004)[73] EU ETS, especially for construction and insulation materials	Alternative 'Eurima' (European Insulation Manufacturers Association) scenario: 70,000-200,000 gross jobs created annually across the EU25 by 2017 (i.e. 700,000-2m gross jobs over ten years, or 4-12% of 2010 sector employment), owing to extended reach of regulation Implementation of an aggressive residential-sector focused investment strategy aiming at €137bn a year could create up to 2.59m FTE jobs (gross impact) per year in the European sector over the 2006-30 period, or an annual gross rise of 16% on 2010 estimate of 16.1m jobs (hypothesis of €53,000/year/FTE job) Implementation of aggressive investment programme ('Factor 4' scenario) would lead to highest cost of works (per sq. m) in Finland and Belgium (owing to high energy intensity of homes), whereas costs would be much lower in Spain, Portugal and other Member States MOSUS (2005): 1.6% more employment in EU15 construction sector in 2020 under a 'strong sustainability' scenario as compared to Baseline (as described above)	administration, auditing and R&D (UNEP, 2008) Job generation potential positively linked to energy savings potential (ETUC, 2009)
Transportation (Services/ Manufacturing) EU27 employment in transportation and storage:	EC transport-related directives and measures (as described in Chapter 2), e.g: Road transport: Regulations 443/2009	ETUC (2009): Replacement of conventional engines by greener alternatives (e.g. electric engines) by 2030 could lead to net job gains in range of 62,000-125,000 (i.e. 2.7 to 5.4% of the 2.3m people directly employed in vehicle production space in 2007, although only	UNEP (2008): More sustainable systems will have to be based on shorter distances. Balancing shift in modes of transportation would give greater weight to public transit systems, walking and biking - could lead to considerable net

[72] Source(s): Eurostat.

[73] Voluntary initiative aimed at non-residential buildings: see http://www.eu-greenbuilding.org/

IMPACT ON OCCUPATIONAL PROFILES OF ECONOMIC RESTRUCTURING			
Sector overview	**Key Policies/ Industry drivers relating to green jobs**	**Projected change in job numbers**	**Associated impact on occupational profiles**
around 10.8m in 2010 (5.12% of overall EU27 employment)	and 715/2007, Directive 2009/33/EC Air transport: Regulation 82/2010, Decisions 2009/339/EC and 2009/450/EC Maritime transport: Recommendation 2006/339/EC, Directive 2005/33/EC	0.5 to 1% of overall EU employment in transport, storage and communication – 13.4m[74] – in 2007) ETUC (2007): 'Extended Policy' scenario visualises shift in favour of public and rail transport (vis-a-vis BAU case): by 2020, would lead to employment increases of over 24% in public passenger road transport, of 20% in rail passenger transport – employment in private transport domain, predictably, rises less rapidly than in BAU case as focus shifted to public-transport domain (more environmentally friendly and labour intensive) Overall, over 2000-30, such policies could lead to 2% average annual employment growth in passenger transport and 1.25% in freight transport Railways – over last few decades, trend of decreased development noticed in several countries, accompanied by corresponding employment declines. EU: railway employment down to about 900,000 jobs; number of workers in manufacturing rail and tram locomotives and rolling stock down to 140,000. Policies focusing on sustainability and strategic investment necessary to counter these trends	employment gains, reduced emissions and better air quality More jobs in vehicle maintenance and servicing than in manufacturing – e.g. in fuel refining, wholesaling and retailing; freight services; rental and repair activities etc. Degree to which jobs may be classified as 'green' dependent on vehicles and fuel type, content of biofuels and sustainability ETUC (2009): Restructuring of value chain would necessitate mobilisation of resources to finance professional mobility and skill upgrading ETUC (2007): emphasises importance of legislation on social conditions in influencing distribution of transport across modes (particularly road and rail transport) Skills shortages emerging in rail transport – apprenticeships and vocational training in decline although significance remains high given this mode is greener and more labour intensive than car industry

[74] Source: Eurostat.

5.6 Overview of the social implications of the targets

This section considers the possible social impacts as indicated by the modelling results. It is designed to supplement the analysis in Section 4.5, focusing in particular on unemployment and the distributional outcomes of the policies.

Impacts of environmental policy on unemployment

In all the policy scenarios that are shown in Chapter 3, unemployment falls from the baseline level. These falls are driven by a combination of higher labour demand and lower labour supply. The main factors are:

- an increase in GDP leading to job creation
- some switching from energy to labour due to relative costs
- a small reduction in labour supply

The magnitude of the changes roughly follows the scale of the GDP impacts, with the scenarios showing large changes in GDP also seeing larger reductions in unemployment (see Figure 5.1). This is thus the dominant factor in those listed above.

As with the employment results, the unemployment results are net, and the treatment of the labour market in the model does not capture mismatches in skills that could arise from structural change. If it is not possible to match available workers to available openings then the economic and labour market outcomes would be less positive. However, although there may be some very specific bottlenecks (see Section 5.4), this report has found little evidence of this on a large-scale basis.

Longer-term outcomes

Many of the jobs that have been created are in the investment sectors and would not be expected to remain in place beyond 2020 without further policy stimulus. Any significant reductions in unemployment would therefore be unlikely to persist. In any case, in the long run we would expect to see wage rates adapting so that unemployment returns towards long-term average rates.

Unemployment by country

Unemployment is measured as the difference between employment demand and labour supply (i.e. the results presented in Chapter 3). In most countries the scenarios show a reduction in unemployment (see Table 5.6) as employment demand grows and labour supply only changes slightly. There are differences between countries in the results due to the different patterns of job creation in the sectors most affected.

Unemployment increases very slightly in Italy, as the increase in labour supply slightly outweighs the increased number of jobs. However, the difference is very small.

The effects of revenue recycling

The use of revenues gathered from market-based instruments can also have an impact on the results for unemployment. In the scenarios shown in Figure 5.1 the revenues were used to reduce direct taxes boosting GDP, but the alternative options provide different outcomes for unemployment. Detailed unemployment effects of the different revenue recycling scenarios may be found in Table 7.16 (Appendix C).

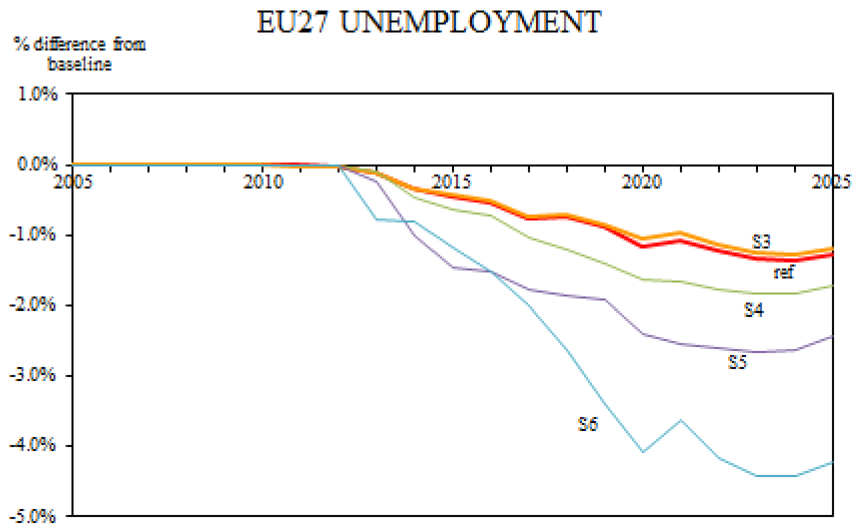
The key findings are:

- Using the revenues to increase social benefit rates instead of tax reductions leads to an increase in unemployment in the EU by around 200,000 in 2020.
- Using the revenues to instead invest in renewables also leads to higher unemployment (+76,000). This is because the investment replaces costs that would have been met by energy companies, so energy prices fall and energy imports increase, with a large share of the revenues flowing outside the EU.

- Using the revenues to reduce employers' social security contributions leads to the lowest unemployment rates but the difference is small compared to income tax reductions (-19,000) because labour supply and demand both increase.
- The other investment options have little overall impact on unemployment compared to reductions in income taxes.

These effects are reasonably consistent across countries, although the results for the investment options can vary depending on local industry (e.g. if a country has a large car industry then a larger proportion of investment in vehicles stays domestically). In some countries higher benefit rates can lead to lower unemployment rates due to people dropping out of the labour force.

Figure 5.1: EU27 Unemployment



Source(s): E3ME, Cambridge Econometrics.

Table 5.6: Unemployment Impacts in 2020 (000s)

UNEMPLOYMENT IMPACTS IN 2020 (000s)						
	ba	**ref**	**S3**	**S4**	**S5**	**S6**
Italy	1,967.2	2.6	5.5	1.4	2.6	-2.4
Netherlands	313.7	-0.5	0.3	-3.9	-23.6	-18.7
Finland	223.6	-1.0	-0.9	-1.4	-2.0	-7.3
Estonia	56.1	-1.1	-1.2	-1.2	-1.3	-3.2
Lithuania	130.3	-1.3	-1.1	-1.5	-2.3	-10.4
Ireland	111.4	-1.4	-1.0	-3.4	-2.0	-6.6
Latvia	89.9	-1.5	-1.1	-1.4	-1.8	-4.1
Slovenia	63.9	-1.6	-1.2	-2.0	-2.8	-8.4
Austria	196.2	-1.6	-1.6	-3.6	-5.7	-9.8
Greece	498.2	-1.8	-1.3	-1.7	-4.5	2.1
Denmark	107.7	-2.0	-2.1	-3.5	-4.8	-10.5
Belgium	328.6	-2.4	-1.7	-3.9	-8.5	-7.8
Slovakia	257.5	-3.8	-3.5	-2.6	-5.8	-11.5
Bulgaria	221.6	-4.2	-4.2	-3.9	-7.7	-13.1
Romania	568.8	-4.2	-5.0	-7.6	-13.3	-35.1
Hungary	313.4	-4.4	-4.3	-4.4	-7.5	-7.0
Czech Republic	273.4	-6.6	-6.7	-9.6	-12.0	-23.1
Sweden	337.2	-7.1	-6.5	-4.7	-7.1	-14.5
Portugal	441.8	-7.4	-7.3	-9.7	-15.9	-40.5
United Kingdom	1,704.2	-13.5	-9.0	-17.7	-15.7	-53.5
France	2,090.2	-14.0	-11.4	-25.4	-31.3	-97.3
Spain	2,319.7	-17.6	-13.4	-37.5	-42.7	-70.0
Poland	1,490.6	-44.9	-41.8	-45.0	-59.6	-100.5
Germany	3,080.9	-61.2	-61.0	-91.8	-140.0	-160.1
EU27	17,243.3	-202.5	-181.5	-286.0	-415.3	-713.3

Note(s): Countries are ordered according to change in the Reference case. Unemployment in Luxembourg, Malta and Cyprus is not modelled due to their size.
Figures shown are difference from Baseline, 000s.
Source(s): E3ME, Cambridge Econometrics.

Distributional income effects

The main household distributional results from the environmental policy scenarios are presented in Table 5.7. The table shows the impacts of the scenarios on real incomes. These are affected by four main factors:

- changes in real wage rates
- changes in income tax (where there are revenues to recycle)
- share of energy consumption in total consumption
- changes in the prices of goods bought by each group (including effects from higher electricity price to fund for renewable investment)

Impacts on average household real incomes are broadly neutral. Any positive impacts are partly explained by higher economic activity generated from renewable investment but more clearly (in the MBI case) from the revenue recycling. Because direct taxes are reduced, the majority of households benefit from higher disposable income.

Average household real disposable income falls slightly in the regulation case (S3) as there are no revenues to be recycled.

There are falls in real household income in the energy-efficiency case (S6) and also slightly in the 30% case (S5). This is because much of the revenue raised is used to fund investment rather than to increase household incomes so, at least in the short run, households face the negative impact of higher energy costs without the benefits of the reductions in income taxes.

All of these factors can play an important role in determining the results by household group.

By socio-economic group

The results show how incomes of different socio-economic groups are affected in the scenarios. In all cases, there are some differences between the groups. There are two main explanations for this. The first relates to the assumption that revenues raised from MBIs, ETS and energy taxes are used to reduce income taxes. This shows up in the results for lower-income, retired, inactive and unemployed workers who do not benefit from this policy (or benefit less than other groups). Alternative means of redistributing income are discussed below.

Second, it also reflects the fact that the poorer household groups spend a larger share of their income on energy products. The effects are greatest in S6 where the targets affect energy prices directly. This is a fairly well-known result and is demonstrated quite clearly here. This also explains why the households in rural areas are typically worse off in the scenarios.

Information from Table 5.7 is also provided at a country level (see Appendix C). There is a small level of variation between countries, due to different levels of income effects, but these variations are not substantial. The results show that Portugal, Estonia, Hungary and Romania in general see more positive effects on real incomes than other countries. Although there are differences in spending patterns between the different socio-economic groups in Europe (e.g. due to climate, energy grids), the pattern of results is quite consistent across most Member States.

Income polarisation effects

It should be noted that these model results do not include any possible income polarisation effects. For each economic sector and country, a single wage rate is estimated in the modelling, regardless of skill level. If the policy changes are introducing larger wage differentials between skill levels, the effects on income distribution would be in addition to those described above and could change the conclusions quite significantly. This issue is covered in the discussion of vulnerable groups and bottlenecks in sections 4.5 and 5.4 respectively.

Table 5.7: Real Incomes in 2020, % Difference from Baseline

REAL INCOMES IN 2020, % DIFFERENCE FROM BASELINE					
	Ref	**S3 (Reg)**	**S4 (MBI)**	**S5 (30%)**	**S6 (E-E)**
All households	0.0	0.0	0.1	-0.1	-0.4
Expenditure Groups					
First quintile	-0.1	-0.1	0.1	-0.2	-0.7
Second quintile	0.0	-0.1	0.1	-0.2	-0.6
Third quintile	0.0	-0.1	0.1	-0.1	-0.5
Fourth quintile	0.0	0.0	0.2	0.0	-0.4
Fifth quintile	0.1	0.0	0.2	0.0	-0.3
Socio-economic groups					
Manual workers	0.0	0.0	0.2	0.0	-0.3
Non-manual workers	0.0	0.0	0.1	0.0	-0.3
Self-employed	0.0	-0.1	0.0	-0.3	-0.9
Unemployed	-0.1	-0.2	-0.1	-0.4	-1.3
Retired	-0.2	-0.3	-0.1	-0.5	-1.3
Inactive	-0.2	-0.3	-0.1	-0.5	-1.3
Population Density					
Densely-populated	0.0	0.0	0.1	-0.1	-0.4
Sparsely-populated	0.0	-0.1	0.1	-0.2	-0.8

Source(s): E3ME, Cambridge Econometrics.

Effects of the revenue recycling

The investment options for revenue recycling do not really have any distributional impacts, with the exception of the renewables scenario which leads to lower energy prices and so counters some of the impacts above. However, when the revenues are used to reduce employers' social contributions, or to increase social benefits, the distributional impacts are larger (see Table 5.8).

In the scenario where employers' social security contributions are reduced there are larger benefits for businesses (which face lower costs) and less for households. In terms of relationships between the household groups, there is little difference from the scenarios where income taxes are reduced. It should be noted, however, that the groups for unemployed and inactive become smaller in size.

In the scenario where social benefits are increased, it is assumed that all benefits are increased equally. There is a larger gain in incomes for all households but particularly those on low incomes, the inactive, the unemployed and the retired. If the benefits were more specifically targeted, larger effects still could be seen in the vulnerable groups (see Section 4.5). The conclusion from this is that the use of MBIs does provide sufficient revenues to partially or fully offset the negative distributional effects of environmental policy.

Table 5.8: Real Incomes in 2020, % Difference from Baseline

REAL INCOMES IN 2020, % DIFFERENCE FROM BASELINE		
	Benefits	**Employers' Soc Sec**
All households	0.4	-0.5
Expenditure Groups		
First quintile	1.1	-0.5
Second quintile	0.7	-0.4
Third quintile	0.6	-0.4
Fourth quintile	0.3	-0.5
Fifth quintile	0.2	-0.5
Socio-economic groups		
Manual workers	0.2	-0.4
Non-manual workers	0.3	-0.3
Self-employed	0.2	-0.3
Unemployed	0.9	-0.3
Retired	2.1	-0.4
Inactive	1.5	-0.4
Population Density		
Densely-populated	0.4	-0.4
Sparsely-populated	0.4	-0.4

Source(s): E3ME, Cambridge Econometrics.

Table 5.8 is shown at country level in Appendix C. Although the country variation here is fairly small, within the benefits scenario the results show that the countries that demonstrate the most positive effects on real income are the same as in the main scenarios above (mainly Portugal, Estonia, Hungary, Romania).

Looking beyond the broad groupings

These groups are quite broad and so it is also important to consider effects within groups, especially when considering specific targeted policies. For example, households in the lower income groups are less likely to own cars but those that do will be much worse off as the cost of transport fuels increases. Similarly, families that live in older or energy-inefficient buildings will have higher heating expenditures.

There are also the wider social effects to consider of localised impacts of particular plant closures that may occur because of mitigation policies or related competitive effects. This is discussed in Section 5.4 and some examples are given in Section 5.7 but the possibility of social exclusion resulting from local plant closures is one of the main factors in the analysis.

How this relates to policy

It is important to make the distinction between changes within and between groups because the analysis could inform thinking about policies that could compensate for the negative distributional effect of meeting the targets. In some cases these may also have wider economic and employment benefits, and may represent alternative uses of the revenues gained from MBIs. Some suggestions of policies that could have positive economic and distributional effects, based on the examples above, include:

- retro-fitting buildings
- expansion or provision of public transport

Policies that move individuals between socio-economic groups will have positive benefits; an obvious example is given in the results for unemployment above. Examples of other ways to do this could include training schemes, job-matching services or increasing retirement ages.

5.7 Location-specific impacts

The final section in this chapter focuses on geographical rather than sectoral constraints and considers the localised impacts of large plant closures. This is an issue that cuts across some of the other parts of the report, for example the discussions of bottlenecks and the discussion of social impacts (which although localised may be quite severe).

Three examples are discussed below. One of these is an actual case study based on a plant that did close, the other two are hypothetical in nature. Although the plant closures could easily be for reasons other than environmental policy, they are all in energy-intensive sectors that have been identified as at risk.

Some brief conclusions are drawn at the end of the section.

Example: Anglesey, UK

The closure of the Anglesey Aluminium smelting plant in September 2009 gave some indication of the policies undertaken by local and regional government when the closure of a major plant provides a severe shock to the local labour market.

Redundancies from the plant took place in two waves following the initial disclosure of plans to shut the plant in January 2009, with 140 people taking voluntary redundancy in July 2009 and a further 250 upon the cessation of smelting activities at the end of September 2009. In total this represented close to 1½% of all jobs in the NUTS3 region of the Isle of Anglesey. The region lacks any alternative sources of jobs with a similar skill set (the decision to close Wylfa nuclear power station, which happened in December 2010 at a cost of 650 jobs, had already been announced and precipitated the closure of the aluminium smelter).

The unemployment created by the closure of this plant was met by several schemes undertaken jointly by the employer Anglesey Aluminium Metal Ltd (AAM), the local government (Isle of Anglesey County Council) and the regional government (the Welsh Assembly). Careers Wales and DBM (a private sector careers service provider) set up an advisory centre on the site, and these organisations, in conjunction with AAM, provided former workers with the opportunity to undertake training and reskilling activities.

At the same time, efforts to find a new use for the site centred, at least initially, around the power generation industry, in the hope that the skilled workers made redundant from the plant could be persuaded to stay in the region. Plans for the creation of a new nuclear power station continue to face opposition, however, while suggestions to construct a wood-burning power plant, a biomass plant and a wind turbine production plant have also been floated without any concrete plans behind them.

With the region having no definite scope for offering employment opportunities in the same or similar sectors, many workers were faced with the choice of migrating to new locations (a number of managers had already departed for a new aluminium smelter in Abu Dhabi, while there is anecdotal evidence that some workers moved to India, where the aluminium smelting industry is growing rapidly) or accepting different (typically lower paid) jobs in the region; workers were thus faced with a severe gap in their wage earning potential after the closure of the smelter. Regional policy has concentrated on developing the tourism industry, and this has created employment opportunities (boosted by Welsh Assembly schemes to encourage entrepreneurship), although only to those workers that have successfully reskilled.

Those workers that were unable to find jobs were (either as a result of an inability to reskill adequately, unavailability of suitable jobs or geographical immobility) were faced with a difficult situation; while their wages were high compared to many in the region the remaining workers (in general those with relatively poor skill sets) had a lack of savings and many have fallen back on social security payments in the absence of work, placing a further burden on the state.

This evidence suggests that the impact of the closure of an energy-intensive plant is highly dependent both upon measures put in place (generally, but not exclusively, by the public sector) to mitigate the effects on the labour market and also upon the ability of the regional economy to generate jobs (either in similar sectors or after re-training) to allow the workers back into employment.

Example: Duisberg, Germany

If the Hüttenwerke Krupp Mannesmann steel production plant in Duisburg, Germany were to close there would be up to 3,480 jobs lost, around 1½% of total jobs in the NUTS3 region. While German labour laws have been loosened recently in response to the recession they remain amongst the tightest in Europe; the employer would have to seek permission from the German Labour Office for such mass layoffs, and would be obligated to find alternative jobs (initially within the firm but also amongst others operating in the region/nation) for workers where possible. The region of Duisburg (and the wider Dusseldorf region more generally) is home to a number of high-tech manufacturing plant (such as the Schwelgern coke burning facility) which may present opportunities of re-employment in similar jobs for a number of workers. High-tech manufacturing has a large role in the German economy and this would enhance the prospects of employment for workers with a suitable skill set in other parts of Germany. Alternatively, Germany has well established re-training schemes designed to get people back into work which would be placed at the disposal of the workers that wish to reskill in different sectors; the relatively prosperous nature of the German (and particularly western German) economy could provide numerous employment opportunities.

Given large redundancy settlements (or at the very least a significant notice period) workers would have ample opportunity to secure alternative employment. The higher-than-average savings ratio prevalent amongst Germans is also likely to reduce their dependence upon the state, at least in the short term, as the workers should have savings to protect themselves. Although recent legislation in reaction to the economic downturn reduced unemployment benefits, they remain reasonable, and would provide security for the small number of workers unable to find a new job.

Overall, the strength of the Germany manufacturing sector, strong re-skilling schemes and tight labour laws should limit the damage to the local labour force of any plant closure, and as such this could perhaps be seen as a best-case scenario for the impact of the closure of a large-scale plant on a regional economy.

Example: Olt, Romania

In contrast to this is the example of the Alro Slatina aluminium smelt in Olt, Romania. The plant employs 4,300 people, representing around 2½% of total employment in the

NUTS3 region. While there are other firms in the region involved in the metallurgy sector, if the Alro Slatina plant were to close it is likely that much of the other activity in the sector would close with it or move to alternative locations such as Bucharest where the plant owner Vimetco has further premises. The heavy industry left would be limited to Pirelli and a few smaller domestic firms, which are unlikely to generate sufficient demand to require enough workers to absorb a significant share of those made unemployed from the Alro Slatina site. As such it is likely that the closure of the plant would lead to high localised levels of unemployment, as was the case in Anglesey. The former workers would be left with a very stark choice between moving great distances (most likely to the United Arab Emirates or India, as the two areas experiencing growth in aluminium smelting) to keep their well-paid jobs or taking up significantly poorer paid jobs in the current locale (or, in the worst case, unemployment benefit).

While the Romanian education system has undergone significant transformation since the revolution in 1989, it remains in quality terms below the OECD average. This is likely to mean that re-skilling into new areas will be difficult. This is without taking into account the fact that, given the absence of developed market services or alternative high-tech manufacturing in Olt, there is a significant shortage of well-paid jobs, and thus any re-skilling is likely to be into a job which is poorly paid. Romanian unemployment benefits last for a maximum of twelve months, and are pegged at a rate below the national minimum wage, and as such provide only a short-term basic allowance as a support mechanism for unemployed workers. Beyond this it is likely that workers would be forced into jobs, most likely in the poorly paid and low skilled agricultural sector which dominates the regional economy.

The lack of alternative sources of employment and the relatively poor social security system in Romania suggest that the closure of a large plant would have a large negative impact upon the regional labour market and regional economy as a whole.

Conclusions

The three examples, one actual and two hypothetical, presented in this section suggest that there are some cases where there could be important localised effects from the closure of a large plant (whether due to environmental legislation or otherwise). The impacts of such a closure are heavily dependent on local conditions, including the state of the local economy and the alternative types of jobs available. The impacts are also partly dependent on the cooperation between the employer, the regional public authorities and labour groups.

In two of these examples, it was suggested that alternative jobs could be available in other parts of the world. This is a rather extreme case of geographical labour mobility but it should be noted that many of the more negative labour market effects are increased as labour mobility, both between sectors and between regions, becomes more restrictive. The aims of the policy responses are thus relatively easy to identify, either finding a replacement employer (as was tried in Anglesey) or improving mobility and job prospects of the redundant workers. However, the problems caused by structural shocks can prove to be quite intractable for policy to address.

6 Designing Policy to Limit Adverse Effects on Europe's Labour Markets

6.1 Summary of findings

We begin by summarising the key results from earlier chapters, to which policy needs to respond.

The framework for analysing restructuring effects

Figure 6.1: The Restructuring Effects Associated with a Shift to a Lower-Carbon Economy

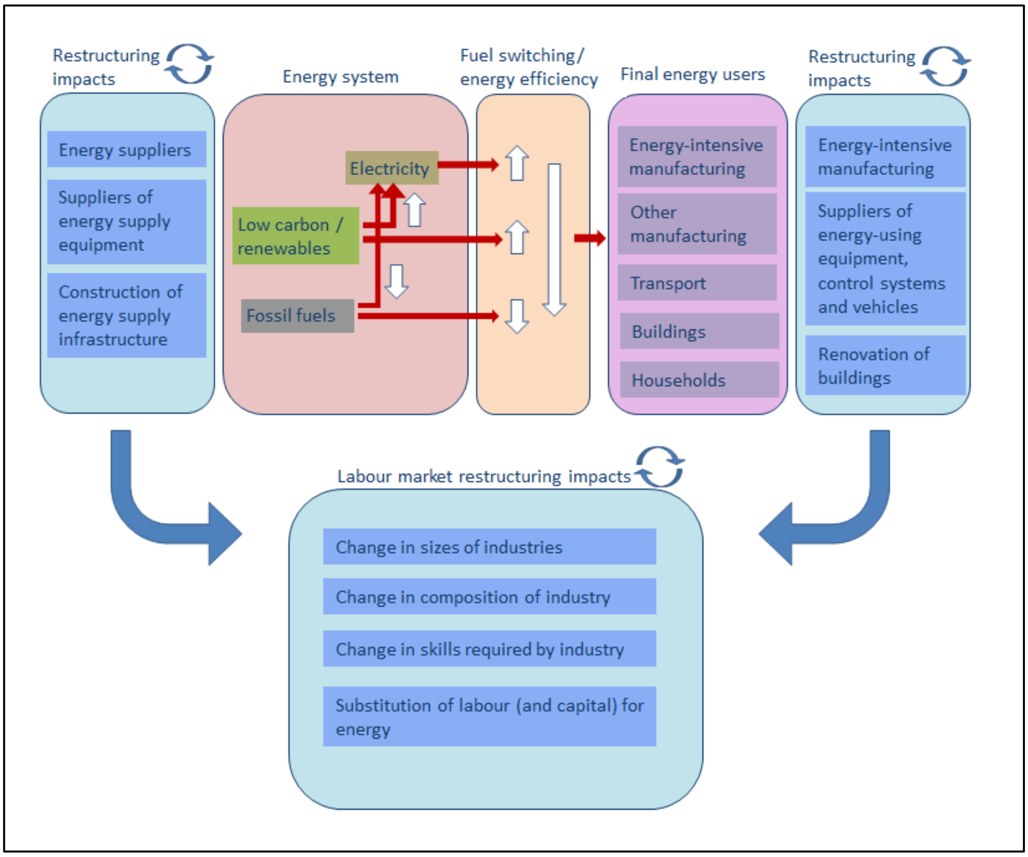


Figure 6.1 shows the main restructuring effects that are associated with a shift to a lower-carbon economy. Within the *energy system* itself, there is a shift away from the production of fossil fuels (except where carbon capture and storage technology is used) and towards low-carbon or renewable sources. This shift applies both in respect of the fuels used to produce electricity and the fuels used directly by final energy users (principally for heat and transport). To the extent that this shift towards the use of low-carbon or renewable sources within the energy system is associated with a higher price of energy to final users, there is also an overall reduction in the energy intensity of economic activity.

These changes in the energy system have restructuring impacts on economic activity both upstream and downstream in the supply chain. *Upstream* there is obviously a shift away from energy suppliers based on fossil fuels and towards those based on low-carbon or renewable sources, and a reduction in the overall demand for energy.

These impacts feed through to the suppliers of energy supply equipment and those who build energy supply infrastructure. Since the movement to a low-carbon economy to which the EU is committed over the coming decade is quite sharp, the scale of investment in low-carbon and renewable energy supplies is substantial.

Downstream higher energy/carbon costs affect the choice of energy-using (and carbon emitting) technologies of final users, shifting demand among the suppliers of those technologies. To the extent that the costs of production are increased, there is a shift away from carbon-intensive products by final consumers, resulting in a restructuring of economic activity. Where carbon leakage is significant, the loss of international competitiveness exacerbates the loss of demand for producers of carbon-intensive products.

The impact on *labour markets* follows from these shifts in economic activity. There are shifts in the relative size of industries and, probably more significantly, *within* industries. These changes then have implications for skill requirements.

Conclusions from previous studies

The findings of the substantial literature review undertaken for this study suggest that after an initial cost to the EU economy to make the switch to a greener economy (i.e. implementation of the EU 20-20-20 targets), over the longer term, most studies indicate a modest positive outcome for GDP growth and employment increasing by around 1-1.5% (in net terms) by 2020.

When looking at specific policies and areas, these impacts are much more differentiated. Some energy-intensive or high GHG emitting sectors, such as iron, steel, cement and petroleum, are expected to experience a decrease in employment. Sectors such as construction and transport, and those in which Europe can gain and maintain a leading edge in export markets (e.g. renewables, environmental technology) are predicted to witness positive jobs growth by 2020.

Measures to support innovation (often driven by regulation) can have substantial positive employment impacts. Revenue recycling of green tax revenues was found to achieve the best employment and GDP outcomes when used to subsidise low-carbon technologies (not employment). Developing new technologies with environmental performance credentials not only contributes to energy and resource efficiency, but can also directly generate EU jobs where these technologies give EU companies a leading edge in manufacture/distribution, and drive further innovations.

The effect of environmental legislation and the drive towards a low-carbon economy may involve or result in skills shortages but this is not specific to any one sector. Skills profiles are changing across the economy as a whole and retraining is needed both in technical and managerial occupations. Where skills shortages are specific to a certain sector, training can effectively be provided by sectoral or regional agencies but often cross-sectoral training is needed for green occupations, which are often ‘hybrid’, incorporating skills from various sectors and professions.

Conclusions from the modelling results

Economic restructuring

The modelling results show that, at the 2-digit sectoral level, the restructuring of the economy that is expected to occur over the decade to 2020 in the baseline (a case in which there is some shift towards lower carbon intensity but in which the 20% CO_2

reduction target is not met) is quite substantial. This restructuring reflects the impact of carbon mitigation policies, but also includes the impact of other trends in economic development (notably increased globalisation and continued technological progress). The restructuring impact of the *additional* policies tested in the modelling to achieve more stringent targets is, by comparison, quite modest at the 2-digit sectoral level.

The biggest impacts come from the efforts to increase the share of renewables in electricity generation. This requires a large amount of investment which benefits investment-related sectors, such as engineering and construction. The positive multiplier impacts of investment on GDP outweigh the negative impacts from price increases by electricity companies to fund this investment. Other sectors will also need to make additional investments to meet the targets but on a much smaller scale. In the energy-efficiency scenario, investment required to achieve the energy saving targets plays a crucial role in stimulating the economy.

Although the investment in renewables and energy savings has a positive economic impact, the policies to reduce GHG emissions and energy consumption in the scenarios have a small negative effect on GDP, as costs of achieving these targets are high. However, the analysis shows that if revenues collected from the policies are recycled back to the economy, non-negative outcomes on the economy can be achieved at the same time as meeting the environmental and energy targets. The impact of such recycling of revenues was largest in a scenario in which a range of investment measures was used.

Skills, quality of work, and vulnerable groups

The projections of future employment levels by occupation and qualification reveal substantial changes taking place over the long term, albeit slowly and steadily. There is relatively little difference between any of the scenarios from that projected under the baseline scenario. In part this reflects the level of detail and the limitations of the model being used, which does not include much sensitivity of skill structures to the various exogenous changes between the scenarios.

Similarly, the results suggest that environmental policy is unlikely to have much impact on the quality of work, or on vulnerable groups, over and above that expected under the baseline scenario. To suggest, however, that environmental policy has potentially no impact on skills, job quality, or the employment prospects of vulnerable groups would be to misread the data. A number of key issues can be highlighted:

- the shift towards reducing the EU’s reliance on fossil fuels and towards the increasing importance of renewable will result in detailed changes to specific skill requirements
- there will be a requirement on final energy users to redesign their products and production systems to reduce energy consumption – which will have skill implications
- policy which stimulates investments in new, green technologies will have detailed implications for the sectoral structure of employment and the occupational distribution of employment within sectors
- the sectoral and occupational changes that will take place will have some implications for both the quality of work and the labour market prospects for vulnerable groups, especially at a more micro level

The shift towards a greater reliance upon renewable energies creates a *demand for engineering and technical skills related to generating electricity from wind, marine, and solar sources*. The projections of employment suggest a *greater demand for* *professional, associate professional, and skilled trades workers* (Cedefop, 2010; CE/IER, 2011), but they do not go into detail on implications for specific areas such as science, technology, engineering and mathematics (STEM). Other evidence suggests this may result in *increasing demand for specific types of engineers* and technicians who are not only highly qualified and skilled in their general discipline, such as electrical engineering, but can apply their skills within a renewable or green policy environment.

Essentially there is likely to be an *increasing demand for a form of hybrid skill (the general engineering or technical discipline, plus specific knowledge or experience of renewables*) [75]. There is also an increased demand for *more renewable-specific skills related to, for example, hydrology, hydraulics, aerodynamics, ornithology, environmental impact assessment, etc*. Both the hybrid and renewable specific skill sets need to be deployed in *a number of functions: R&D, design, operations, and maintenance*. The number of people required to fill these jobs, in any one of these functional areas, might be relatively small but they are critical to the success of the renewable sector. For example, the growth of the large on-shore wind sector in the UK was constrained initially to some extent by a shortage of these critical skill sets.

As well as addressing the specific needs of the energy system there is also a need to look at the result of shifting towards *more energy-efficient production*, and its impact on sectors of the economy more generally. The evidence suggests there are implications for employment in manufacturing, especially energy-intensive manufacturing (including the design of products and their eventual disposal), the transport sector, buildings (their design and construction), and households. The extent to which employment in the manufacturing and construction sectors is affected by environmental policy needs to be seen in the context of long-run trends. These have, amongst other things, seen mass production manufacturing transferred to countries with lower labour and other costs, and increased use of prefabrication in construction to bring about increases in productivity levels. Nevertheless, environmental policies will, over a short-run transitional period, increase production costs and thereby affect the number of people employed. It will *also increase the demand for relatively highly skilled and qualified workers (i.e. professionals and associate professionals)* who possess the skills which will facilitate the transition to more environmentally sustainable production of low-carbon products. Again the emphasis here is upon *hybrid skills*: being able to transform an existing production system or product design so that it meets a given environmental target.

There is also a potential boost to the manufacturing sector, insofar as it is able to capture the market for the production of renewable technologies. There is evidence that key producers in Denmark, Germany, and Spain have, to date, been successful in capturing not only the EU market but the global one too. Again, the capacity of countries to capture this market is dependent, in part, upon the availability of skills, especially those which *marry traditional disciplines such as electrical and mechanical engineering to the specific needs of the wind, marine and solar energy sectors*.

The direction of skill change, as described above, is very much towards both a demand for *higher level and intermediate level skills associated with managerial, professional, associate professional and, to a slightly lesser extent, skilled trades jobs*. These are the skills which will drive forward the environmental agenda within sectors.

[75] See for example Wilson (2009).

This has *implications for the quality of work and for relatively vulnerable groups in society* (i.e. those who are more at risk of not being in work). From a quality of work perspective *the direction of change is towards increasing the overall level of job quality* because of the growth in relatively high skilled jobs. In general, professional and associate professional jobs are associated with higher levels of job quality (with respect to both subjective and objective measures of this indicator). Being in a good quality job by definition means being in a job. The skill biased nature of occupational change envisaged in all of the scenarios suggests that, other things being equal, *relatively less skilled employees will be more at risk* of not being in employment. Moreover, sectoral change in the economy, with a decline in employment in more traditional areas of the manufacturing and service sectors, may suggest that people may need to acquire new skills in order to obtain work in those sectors which are expected to show an increase in employment.

Two caveats need to be made to the above description. First, under all of the scenarios the number of people expected to be employed in relatively less skilled jobs will remain substantial, with some of these occupational groups continuing to experience employment growth. This is part of the process of *polarisation in the labour market* which, over recent years, has seen an increase in the number of both relatively high and relatively low skilled jobs.

Second, the projections of future employment levels do not distinguish *replacement demand*. This recognises that because of the number of people exiting an occupation for various reason (e.g. due to retirement, labour turnover, etc.) there is an increase in demand for people to replace them in that occupation even though its overall employment level may be in decline. Hence the position for more vulnerable groups in the labour market, which have been, historically, dependent upon relatively less skilled occupations for employment may not be so pessimistic as first assumed. That said, over the long-term, the more technology oriented scenarios envisage an EU labour market increasingly characterised by more high skilled, high quality jobs.

Conclusions from the supplementary assessment

The supplementary analysis reported in Chapter 5 examined specific issues for which a more detailed approach than is available in the modelling is required.

The broad conclusions from the assessment are summarised below:

- A series of small case studies was carried out to consider the impacts of environmental policies on a key set of industries defined at the NACE 4-digit level. This included industries that could be expected to see a decline in production and industries that may demand additional skills to meet production needs. The findings were that in most cases the green transition required a subtle shift in existing jobs rather than a large-scale change in the types of jobs required. In some cases, such as the car industry, companies were able to provide the training required to bring about this shift.
- The transition to a low-carbon economy will have some impact on all the broad skills categories, (i.e. jobs requiring low, medium or high level qualifications). However, in the short run there is likely to be a higher demand for high skilled jobs due to design requirements for new technologies.
- The skills required for green jobs are often similar to those in existing occupations. Some of the new environmental sectors will be in direct competition with existing sectors (e.g. retro-fitting buildings with other construction activities).

- Skill change is frequently within existing occupations and of an incremental nature which allows existing IVET and CVET infrastructures to manage the transition to a greener economy.
- Specific managerial skills will be required to ensure adoption of new technology and the implementation of more efficient production methods.
- Companies and labour markets will to some extent adapt by themselves to the challenges. Much of the policy should focus on how to ensure that this happens efficiently, rather than direct intervention in labour markets.
- The creation of 'bottlenecks' where supply-side constraints limit production has the potential to reduce EU output in key growth sectors. Bottlenecks can arise from limitations in skills, in technology or in other factors of production. The most likely occurrence of bottlenecks due to skills is if key sectors start competing for scarce skills resources, some of which could be in sectors that already have tight labour markets. Policies to encourage mobility of labour, both between sectors and between geographical regions, could alleviate any potential bottlenecks.
- Geographical labour mobility is also an issue in cases where communities are dependent on a single employer that could be vulnerable to environmental policy and international competition. The findings from the analysis suggest that the problems caused by such a structural shock can prove to be quite intractable for policy to address.
- The modelling results provide insight to other social issues. Although unemployment tends to fall slightly as a result of the policies, the costs of reducing emissions can fall disproportionately on low-income households and the vulnerable groups described above (primarily as they spend a larger share of income on heating fuels). However, if the environmental targets are met through the use of market-based instruments, a share of the revenues can be used to offset this effect so that there is no net impact.

6.2 Environmental policy

All of the analysis presented in this study shows that the labour market impacts of climate change mitigation policies mostly depend on the scale of the impact on *economic activity and the associated restructuring of industry* (by sector and within sectors). Consequently, the goal of limiting negative *labour market* impacts has many of the same implications for the design of environmental policy as the goal of limiting negative impacts on *economic activity*. However, some priority areas can be identified where the impact on labour markets is likely to be more important.

The EU's environmental policy architecture

We summarise briefly here the four key policies of the 'climate change and energy package', designed to implement the 20-20-20 target which became law in 2009:

- a revision and strengthening of the Emissions Trading System (ETS) in Phase III from 2013 by the introduction of a single EU-wide cap aimed at reducing allowances by 21% below 2005 levels by 2020; the progressive replacement of free allocation of allowances by auctioning; and by a modest expansion of gases and sectors covered
- an 'Effort Sharing Decision' governing emissions from non-EU ETS sectors such as housing, transport and agriculture, with national targets so as to cut

the EU's overall emissions from these sectors by 10% by 2020 compared with 2005 levels

- binding national targets for renewable energy aimed at increasing the average renewable share across the EU to 20% by 2020 (more than a double the 2006 level of 9.2%) and contribute to reducing the EU's dependence on imported energy and also to reducing GHGs
- a legal framework to promote the development of carbon capture and storage (CCS) with the intention of establishing a network of CCS demonstration plants across Europe by 2015 to test their technical and economic viability, with the aim of commercial update of the technology by 2020 and with national governments permitted under revised EU state-aid guidelines to provide final support to pilot schemes

Although the climate change and energy package creates pressure to improve energy efficiency, it does not address it directly. This is being done through the EU's energy efficiency action plan aimed at exploiting the considerable potential for higher energy savings in buildings, transport, products and processes.

Issues in policy design and implementation that could raise the cost of restructuring

There are a number of ways in which sub-optimal policy design and implementation could raise the cost of restructuring, and hence impose an unnecessarily large burden on labour market adjustment.

Uncertainty about the policy regime

The most important issue is probably that of uncertainty in the policy regime, and particularly the price of ETS allowances in the long term. Many of the actions that firms and individuals need to take to facilitate the shift to a low-carbon economy require investment of capital, R&D resources, training resources and time. Some investment assets have a very long life. Some kinds of investment (notably in education and training) have a long lag between the decision to begin to undertake the investment and the pay-off. In these cases uncertainty about the policy environment can act as a particularly severe deterrent to investment. The result may be that:

- energy prices end up higher than they might otherwise have been, so that the loss of economic activity is greater than necessary (because capacity in low-carbon sources has not been developed rapidly enough)
- European capacity in the supply of 'green' goods and services is not developed as rapidly as necessary to meet the shift in demand, so that the associated economic activity is lost to a higher market share for imports from the rest of the world
- the supply of labour with suitable skills is not developed rapidly enough, resulting in skill shortages, higher labour costs and a larger pool of labour with skills that are not matched to new circumstances

An inadequately functioning energy market

If the policy environment allows energy suppliers to adopt technology solutions that are not least cost and requires consumers to pay the cost, or allows energy suppliers to make excess profits, the costs of adjustment to energy users, including the labour market impact, will be correspondingly higher.

Addressing market failures in sub-sectors where labour intensity is high

Some areas of the 'green economy' are more labour intensive than others, and so the consequences of lost opportunities due to policy failure are larger for the labour market in these cases. An example is the renovation of existing buildings (the housing stock and commercial buildings) to improve their energy efficiency. There are market failures (associated with the difference in interests between owners and tenants) which hinder mobilisation of the investment to take up these opportunities and which a higher carbon price alone will not address. If economic activity and jobs are to be generated in the work of renovation, policies need to address these market failures.

Carbon leakage

The transition to a reduced size and lower carbon intensity of industries producing carbon-intensive products carries the risk of an excessive loss of activity and hence employment in energy-intensive industries across Europe, if carbon leakage is severe. However, the impact in terms of relocation of industry outside the EU due to environmental policy may be limited a relatively small number of sectors where energy costs are a large proportion of total costs. Even here, the decision by companies to relocate production away from the EU may be related to other factors such as access to markets or raw materials or secure access to energy sources with long-term price guarantees.

6.3 Labour market policy

How can employment policy be adapted to respond to these effects?

This section focuses on how the labour market impacts of environmental policy can be addressed by labour market policies that fall within the direct remit of DG Employment and labour ministries. Specifically, the following questions arise:

- is the employment growth resulting from the current mix of policies and practices across the EU suboptimal in some way?
- are there specific areas, from an employment perspective, where interventions are required in order to facilitate carbon reduction, and potentially boost employment?
- to what extent is skill supply a constraint on development, and how can skill mismatches be avoided?
- are there unequal distributional effects mixed in with the overall results whereby some groups fare worse than others?

Table 6.1 below summarises the analyses undertaken and the key findings that answer each of these questions.

Table 6.1: Analyses to Answer Key Employment Policy Questions

ANALYSES TO ANSWER KEY EMPLOYMENT POLICY QUESTIONS					
Task	**Description**	**Is the employment growth suboptimal?**	**Are there specific areas where interventions are required?**	**Is skill supply a constraint; can mismatches be avoided?**	**Are there unequal distributional effects?**
Analysis of sectors expected to lose out	Detailed analysis of those sectors that may lose out from the restructuring required to meet the targets	There is no evidence at the sectoral level of sub-optimal performance.	Under the scenarios which envisage higher levels of investment in technologies of various kinds, including renewables, there is evidence of more high skilled employment being created. But the size of this effect is, at best, modest.	The more policy pushes towards greater investments in new technologies – as indicated under some of the scenarios – the more demand is increased for high skilled jobs, many of which have been associated with skill shortage in the EU (e.g. STEM professional and associate professional jobs).	The evidence is rather mixed here. In general, the trend of occupational change is skill-biased such that those with relatively low level skills will be at a disadvantage. But the scenarios reveal relatively little difference from baseline regarding this general direction of travel.
Assessment of impact of lower labour participation	Modelling impact of skills mismatch (labour force 0.5% lower than base) due to higher drop out from workforce because of new skills requirements			Skills mismatch of the assumed scale and nature results in a modest reduction in GDP and employment by 2020, due to the effects of higher wage demands (and implied lack of competitiveness) by the remaining part of the workforce.	

ANALYSES TO ANSWER KEY EMPLOYMENT POLICY QUESTIONS

Task	Description	Is the employment growth suboptimal?	Are there specific areas where interventions are required?	Is skill supply a constraint; can mismatches be avoided?	Are there unequal distributional effects?
Discussion of detailed policy responses	General level: principal policy mixes in place across the EU with respect to active labour market policy	Growth in high skill jobs is constrained to some extent by skills supply, though some MS have handled this better than others.	In general, any push to increase investments in green technologies will need a corresponding push in relation to improving the supply of those skills necessary to deploy those technologies. But again, the number of additional jobs being created is modest.	As noted, skills supply may be a constraint on deploying some new technologies at a detailed level, but only modestly so. It is mainly a question of getting the skills supply side to receive in a timely fashion the signals sent by the demand side, and to respond to these.	In general, vulnerable groups in the labour market are likely to be adversely affected by the move toward more high skilled employment.
	Specific level: policy levers available at the European level – principally the use of Structural Funds – within the context of the open method of coordination	The principal policy conclusion is that national labour market systems need to be able to anticipate change in the demand for skills and equip those at risk of losing their jobs, or who have lost their job, with the skills necessary to progress in the labour market.	There could be an emphasis on encouraging growth in technology investments (which will help to increase in overall labour demand), allied to an increase in good quality employment, but also an anticipation of the likely downside of this (e.g. the effect on the labour market for less skilled workers).	Member States have tackled skills supply in different ways. The key issue is to ensure that all, but especially the more vulnerable groups, have the skills needed to meet the changing demand for skills.	At its core is the need to ensure those at risk of losing their jobs, or who have lost their jobs, are provided with the skills which will allow them to retain their position in the labour market.
Focus on bottlenecks	Identify the nature and cause of the most severe bottlenecks	The creation of ‘bottlenecks’ where supply-side constraints limit production has the potential to reduce EU output in key growth sectors.		Skills bottlenecks are most likely if sectors compete for scarce skills resources, some of which could be in sectors that already have tight labour markets. Policies to encourage geographical and sectoral mobility of labour could alleviate potential bottlenecks.	

ANALYSES TO ANSWER KEY EMPLOYMENT POLICY QUESTIONS

Task	Description	Is the employment growth suboptimal?	Are there specific areas where interventions are required?	Is skill supply a constraint; can mismatches be avoided?	Are there unequal distributional effects?
Analysis of churn	Analyse rates of churn and turnover of employment in the most affected sectors	The proportion of churn (number of jobs created and lost) accounted for by the green economy is estimated to be 2-3% of economy-wide churn. The churn is likely to have greater impact on segments of the economy that are more amenable to 'green' policies (e.g. renewables) than on conventional sectors.			Trends in job creation and job destruction vary across income quintiles; in some Member States, a process of 'polarisation' was observed, with a growth in jobs in the highest and lowest paid quintiles (e.g. in the Netherlands and France), whilst in others there was a process of 'upgrading', with job losses in the lowest paid quintiles and gains in the highest paid quintiles (e.g. in Finland and Portugal).
Impact on the quality of jobs	Assess (a) the number of people employed in each of the green occupational categories; and (b) show how quality of jobs varies between the green / dirty jobs classification	Green jobs are not synonymous with high quality jobs at the sectoral level but, under the technology led scenarios there will be an increase in those jobs – including green ones which can be classified as high level, and which are generally associated with relatively good quality employment.	The more change is technology driven – as indicated in some of the scenarios – the more high quality jobs will be created. But the effects are small so green policy is unlikely to be successful in this regard.	Under the scenarios which assume increased levels of investment in new technology, there is some indication of increasing demand, *inter alia*, for highly skilled and better qualified employees. These are occupations where some Member States at least have experienced skill shortages and gaps.	By and large the greatest growth in high quality jobs is amongst high level occupations, so there is a clear distributional issue here.

ANALYSES TO ANSWER KEY EMPLOYMENT POLICY QUESTIONS					
Task	**Description**	**Is the employment growth suboptimal?**	**Are there specific areas where interventions are required?**	**Is skill supply a constraint; can mismatches be avoided?**	**Are there unequal distributional effects?**
Impact on vulnerable groups	Estimate the extent to which each vulnerable group is concentrated in occupations which are projected to grow or decline; to what extent will the employment outcomes under the different model scenarios differentially affect vulnerable groups	Vulnerable groups tend to be located in relatively low skilled jobs and to have been employed in sectors of the economy in which the demand for labour is weakening.	The scenarios which assume increased levels of investment tend to increase the demand for relatively high skilled jobs. The key issue is the extent to which creating new high skilled jobs creates, in their wake, less skilled ones. At the moment there is some evidence that overall levels of employment are created in some of technology scenarios which might help vulnerable groups, but the size of any effect is rather modest.	The key question here is the extent to which less skilled people can be trained to meet the increasing demand for relatively high skilled labour which is apparent in all of the scenarios. This is an issue which nearly every Member State has grappled and there remain no easy solutions.	Policies which generate greater employment growth will have the impact of stimulating demand for labour generally, which might be to the benefit of vulnerable groups. Again, the investment led scenarios are the most optimistic in this regard.
The use of revenues from market-based instruments	Modelling impacts of alternative uses: investment in R&D in specific 'green' sectors; increased social benefits to counter possible negative distributional effects of higher energy prices; reduced employers' social security contributions	The use of revenues from MBIs to offset other taxes, or to finance investment in energy-saving equipment, can have positive economic, social and/or labour market benefits.			MBI revenues can be used to offset the costs of reducing emissions that fall disproportionately on low income households and vulnerable groups.

ANALYSES TO ANSWER KEY EMPLOYMENT POLICY QUESTIONS					
Task	**Description**	**Is the employment growth suboptimal?**	**Are there specific areas where interventions are required?**	**Is skill supply a constraint; can mismatches be avoided?**	**Are there unequal distributional effects?**
Location-specific impacts	Discussion how locations that are dependent on a single or small number of producers could suffer disproportionately from a relocation of production and consider impacts and policy responses		The impacts of plant closure are heavily dependent on local conditions, including the state of the local economy and the alternative types of jobs available. The impacts are also partly dependent on the cooperation between the employer, the regional public authorities and labour groups.		Many of the more negative labour market effects are increased as labour mobility, both between sectors and between regions, becomes more restrictive.

The general importance of labour market flexibility

Since the labour market impacts associated with the shift to a low-carbon economy represent a particular form of restructuring among industries, within industries, and among skill types, the general importance of labour market flexibility to respond to restructuring of any kind is reinforced.

In the first instance, sectoral adjustments can take the form of changes to employment levels (and subsequent implications for unemployment). But at a national level there are a number of other ways in which adjustments can occur, notably through changes in average hours worked or wage levels in sectors affected by these changes as well as (in some cases at least) by changes in exchange rates[76].

To the extent that the impacts differ across Member States within the Eurozone, where exchange rate changes are not possible, flexibility in nominal and real wages are regarded by economists as crucial elements in adjustment to any external shocks. A second avenue is changes in average hours worked. Failing this, adjustment will take the form of changes to employment, unemployment, (and perhaps also via demography and labour market participation rates, the labour force). The evidence emerging in the current recession suggests that employers and workers have so far co-operated in such a way as to minimise direct job losses and to spread the impact by reducing average hours or wages.

The capacity of economies to adjust hours of work and wage rates in response to changes in labour demand has been subject to considerable scrutiny through the analysis of wage rigidities. There are two principal explanations of wage rigidities: (i) efficiency wage considerations and (ii) labour market institutions. Evidence for the important of efficiency wages comes from surveys of businesses (see Bewley (1999) and Agell and Bennmarker (2007)). These suggest that employers may not choose to reduce real wages because of concerns about the impact on workers' effort and hence productivity[77]. Cutting wages can reduce commitment, trust, cooperative behaviour, and worker morale. There are also issues about where the burden falls. Broad economy wide adjustments can spread the pain, but more often than not only a part of

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[76] One of the key ways an economy can adjust to external shocks is via the exchange rate. There is (of course) a huge literature on the role of exchange rates and the definition of Optimal Currency Areas (OCA). This has become especially pertinent in the light of the crisis in Greece and the problems of dealing with it within a situation of fixed exchange rates between countries that have adopted the euro. Fidrmuc (2003) and others have argued that limited labour mobility both within and across countries could threaten the viability of the EMU, increasing mismatching of skill demand and supply and raising the natural rate of unemployment, making these economies less able to adjust to exogenous shocks. In extreme cases this could result in high unemployment, political instability and increased demands for regional transfers (Fidrmuc et al (1999)). The OCA literature (Mundell, 1961) emphasises that countries that have similar economic structures can join a monetary union with little cost, especially if the conditions for good labour mobility, wage flexibility and fiscal transfers exist. It remains debatable whether the current euro area possesses the fundamental conditions for an OCA (for discussion see Kotilainen (1995), Alho and Erkkilä (1996), Sibert (1999), Sibert and Sutherland (2000), Saint-Paul and Bentolina (2000), Beetsma and Debrun (2004) and Deroose, Flores and Turrini (2006)).

[77] The organisation of working time is interesting in that there have been significant changes in the use of flexible working time arrangements across the EU, but this tends to post-date many of the econometric studies which have addressed wage rigidities in the EU. It is notable that in the UK (and in some other countries) the impact of the 2008/09 recession has had less of an impact on unemployment than initially feared. This has been explained partially with respect to increased flexibility in the labour market, which has allowed employers to cut hours rather than jobs (Hogarth et al, 2009).

the labour force (those made redundant) face a significant loss in their real wages. The potential for a trade-off between average wage cuts and wage cuts for marginal workers is drawn out in the search theories of the labour market, (such as Pissarides (2007)) which highlight the difference in wage rigidity with respect to those who remain in employment, those made redundant, and new recruits.

The role of labour market institutions is also crucial. Layard, Nickell and Jackman (1991), Nickell et al (2002), and others, suggest that the natural level of the unemployment rate is determined by structural features of the labour market that are set by institutional factors. These include the benefit system and tax rates, as well as employment protection laws (Naticcioni and Pagnigo, 2004) and union power (Lucifora, 1998). Other work such as Blanchard and Wolfers (2000), Nickel et al (2005) and Blanchard (2006) also focuses on the impact of institutions on labour markets, establishing an empirical link between labour institutions and the level of unemployment and employment in a series of countries. The EU itself admits that European economies typically adjust to shocks much more slowly than the USA, as a result of more rigid price and wage systems (European Commission, 2008).

Labour market flexibility and sectorally-specific impacts

Since the effects of restructuring are expected to be sectorally specific, the institutions which can facilitate sectoral adjustments in the labour market are therefore important. There are a range of issues here:

- managing sectoral transitions in the economy such that unemployment (especially structural unemployment) is avoided, and without significant industrial unrest
- ensuring that the quality of employment is maintained (i.e. that high skill and high wage jobs are not lost and replaced by low skill and low wage ones in other sectors)
- provision of an adequate skills supply to new sectors or activities in the economy, which emerge as a consequence of either environmental change or environmental policy
- supporting existing sectors to meet the challenges which environmental change and policy bring about

Thus the combination of environmental change and the introduction of policies designed to safeguard the environment has implications for industrial relations, employment, and training policies. National systems across the EU vary significantly with respect to all of these.

Reconciling labour market flexibility with income security

The OECD points to employment policy needing to reconcile a number of factors in relation to green growth, including:

> '*Policies aimed at reconciling high labour mobility with income security – such as the need to combine adequate unemployment benefits with effective activation measures – represent a first critical area for action. These policies will be key to ensuring that the large redeployment of workers, which will be required to support the transition to green growth, can be achieved relatively quickly and smoothly. They are also needed to ensure that the inevitable costs of the transition are not unjustly concentrated on a minority of unlucky workers. This, in turn, is*

also a precondition for building and sustaining political support for green growth.' (OECD Policy Forum 2010: Background Information[78])

The capacity to respond to structural adjustments in the economy without there being some diminution in job quality or risk to the EU social model of employment has been addressed through the concept of flexicurity (Madsen, 2006; Wilthagen and Tros, 2004). In the flexicurity model, as it has been explained in relation to countries such as Denmark and the Netherlands, the combination of employment protection regulations (which make it easy for the employer to hire and fire), coupled to active labour market policies (which provide people who lose their jobs with the training to find alternative employment), all underpinned by a relatively generous social security system (which allows people to retrain without a significant income penalty), effectively allows structural adjustments to take place without a reduction in job quality[79]. This contrasts with the Anglo-Saxon model, which a stresses work-first approach (low replacement income levels in the social security system coupled to limited employment protection), and the more traditional west European model (high levels of job protection coupled to relatively high replacement incomes in the social security system).

Climate change, employment, skills, job quality and vulnerable groups

The EU policy agenda

From a policy perspective the question is how to manage the labour market transition envisaged under the scenarios. There are a number of inter-related issues to address in this regard, including the need to ensure that:

- the renewables sector has the skills it needs to develop in the future
- the final energy users have the skills which will allow them to transform their products and processes in the light of EU and national policies to reduce carbon emissions, such that employment growth opportunities are not jeopardised
- the direction of change enhances rather than worsens the quality of work
- vulnerable groups are not further excluded as a consequence of the changes highlighted above simultaneously

There are four interrelated sets of policy at play here: (a) energy policy; (b) employment policy; (c) skills policy; and (d) social policy. It is asking a lot of policy to successfully integrate all four.

At the level of the EU, these policies have usually been bundled in two parts: (a) energy policy in, amongst other things, the 20/20/20 agenda; and (b) employment, skills, and social policy in the EU sustainable development strategy, launched by the European Council in Gothenburg in 2001 and renewed in June 2006, which aims for the continuous improvement of quality of life for current and future generations. As a consequence, the Europe 2020 growth strategy sets out a number of policy areas, initiatives and targets[80]. In addition, the Agenda for New Skills and Jobs, for example,

[78] http://www.oecd.org/document/57/0,3343,en_21571361_44354303_44675513_1_1_1_1,00.html#Green_jobs_myth_or_reality

[79] The criticism of the flexicurity model is that it was developed during, and draws evidence from, a period of relative stability in macroeconomic conditions in the EU.

[80] http://ec.europa.eu/europe2020/index_en.htm

sets out a number of routes for bringing more people into employment, focusing on, '*... better functioning and less segmented labour markets, a more skilled workforce, better job quality and working conditions, and the promotion of both job creation and labour demand*' (European Commission 2011).

Policy within the Member States

Within particular Member States the situation reflects the same collection of policy areas as at the EU level. There is, on the one hand, a sustainable energy policy and, on the other, a set of integrated policies which aim to address skills development, job quality, and social inclusion in the labour market. In general, the two bundles of policy are not integrated and are largely considered as separate. A review of green employment measures undertaken by Eurofound (Broughton, 2009) reveals the extent to which there is 'green employment' policy in place across the EU (see Table 6.2). The general picture to emerge is of a number of initiatives, many concentrated in the construction and automotive engineering sectors, where the prime aim is to reduce job loss (in the context of the economic crisis of 2008/09), but with relatively little attempt to integrate employment and energy policy more systematically.

Table 6.2: Summary of Green Employment Policies Adopted in Member States

SUMMARY OF GREEN EMPLOYMENT POLICIES ADOPTED IN MEMBER STATES

Country	Policy
Austria	To date there has been limited attempts to coordinate green and employment policies. The government recognises that there may be scope to increase employment in green jobs so has set up a pilot programme of training in green technologies (e.g. biomass).
Belgium	Government wants to decrease dependence on energy-intensive industries by introducing green technologies. For example, jobseekers have been trained to carry out energy audits in order to support the government plan to reduce CO_2 emissions.
Bulgaria	There have been a number of initiatives to improve energy efficiency, eco-tourism, bio-agriculture etc, but the general view is that the country lacks financial resources to progress these policies.
Cyprus	There are a number of initiatives to create green jobs: organic agriculture, energy efficiency in the household, etc. There are also plans to avoid the desertification of Cyprus. Qualifications have been introduced for people who carry out energy audits.
Czech Republic	A key task for the Czech government is to clean-up the remains of heavy manufacturing, which is seen as a long-run project, but it is not clear how employment policy relates to this aim. Over the short run, scrappage schemes have been used to support the automotive sector and reduce air pollution.
Germany	Government has been active for a number of years. It supports the reduction of energy consumption in buildings, supports traditional industries to become more energy efficient, and supports developments in the car industry in developing electric and hybrid cars. The green agenda has been integrated into the existing employment and VET systems.

SUMMARY OF GREEN EMPLOYMENT POLICIES ADOPTED IN MEMBER STATES

Country	Policy
Denmark	At a national level, government has concentrated policies on employment in agriculture, otherwise employment policies are limited. The government also plans to place Denmark at the forefront of the development of green technologies. The trade union movement provides retraining in renewable energies to people displaced from the coal mining and steel industries.
Spain	There is a wide ranging green agenda to promote renewable energies, clean transport, etc. Whilst government is interested in promoting the green agenda, short-term economic pressures have led to worries about impact on competitiveness.
Estonia	Limited activity – much of the debate surrounds energy from oil shale which might provide Estonia with a relatively cheap source of energy but which raises a number of environmental issues. Employment policy appears to be silent on this issue.
Finland	Has been at the forefront of policies which use taxation as an incentive to reduce energy consumption but not clear what the employment effects of this have been.
France	There are a wide range of activities related to sustainable development, biodiversity, green technologies, etc, but it is not clear that most employment policy has been specifically adapted to meet the needs of the green agenda. France, however, has established a green employment observatory.
Greece	The Greek government does not see green jobs as an important concern at the moment. That said, programmes have been introduced over the recent past to retrain unemployed people to take advantage of jobs which might be generated from the emerging green agenda.
Hungary	There is an interest in eco-tourism and renewable energies but the scale of activity is relatively modest and employment policy in relation to green policies is quite limited.
Ireland	The Green Party is in the national coalition, which has resulted in a number of green initiatives that have generated employment gains. FAS has been introducing training policies – especially in assisting construction workers install energy saving devices in buildings.
Italy	Limited action at a national level but some regions are actively promoting green jobs. Scrappage schemes have been used to improve the take up of low-emission vehicles in part to support the metalworking sector.
Latvia	Limited activity.
Lithuania	Improving the energy efficiency of buildings which assists the construction sector. Ecological farming also seen as having potential.
Luxembourg	The Government has subsidised the purchase of energy-efficient consumer products (e.g. cars, freezers, etc.) through scrappage schemes.
Malta	Policies are aimed at protecting the environment rather than promoting jobs, but

SUMMARY OF GREEN EMPLOYMENT POLICIES ADOPTED IN MEMBER STATES

Country	Policy
	eco-tourism seen as having some potential for job growth.
Netherlands	There are a number of policies relating to a wide variety of green issues (energy efficiency, renewable energies, etc.), but actual measures have sometimes lagged behind policy developments.
Norway	Energy efficiency is high on the agenda. Government assists with reducing energy consumption in buildings and developing new sectors such as biomass. All this has received much public funding.
Poland	Rising in importance, but the economy is dependent upon high emitting sectors (such as coal mining and coal-fired power stations). The current economic climate makes it difficult to reduce the dependence upon these sectors. There are, however, a number of initiatives to promote clean transport, renewable energies, ecological farming, etc.
Portugal	Plan to link employment policies to green ones but this has not taken place. Employers sceptical about green policies because it may drive up their costs. Government is trying to foster investment in renewable energies and energy efficiency. The VET system includes courses for Technicians in Environmental Management.
Romania	The government wants to reduce energy consumption in buildings, and has invested in nuclear energy generation. It also recognises that the agricultural sector could be made more organic but lacks the resources to pursue this goal fully.
Sweden	Policy very much focused on supporting the automotive sector through the take up of green technologies. Unions worried that green jobs growth will displace employment elsewhere.
Slovakia	Want to reduce air pollution through car scrappage schemes and energy consumption in buildings.
Slovenia	Some co-financing programmes to promote eco-friendly industries but activities are small in scale.
UK	The outgoing Labour government promoted a low-carbon strategy which was seen as having the potential to increase the number of jobs, but skill shortages were thought to be a problem. New skills activism may help develop employment in the low-carbon sector through assisting with training measures. The incoming coalition government has maintained the political rhetoric but has taken a less interventionist stance.

Source(s): EIRR / IER / CEC.

The example of Denmark, a country which has been at the forefront of a shift towards capturing the renewables market across the EU and further afield is instructive in this regard (see Section 2.3). The example of Denmark illustrates the key issue for policy makers contemplating attempts to integrate energy (or green) policy with employment policy: the uncertainty attached to employment and skill demand emanating from the pursuit of policies to reduce carbon emissions. The dangers of too tightly aligning energy and employment policy relates to making the wrong decisions, such as the state investing in training programmes which produce the wrong type of skills, or engaging in training activities which companies would have engaged in any case (i.e. the problem of dead weight). Instead of looking at the integration of energy and employment policy there is, perhaps, more merit in looking at how employment policy systems are arranged across the EU. The benefit of these systems is that some of them, at least, are designed to ensure that employment demand, regardless of the factors giving rise to that demand, is effectively met.

Employment policy models associated with Member States

There have been numerous attempts to classify social and economic systems across the EU (Hall and Soskice, 1990). The attempt by Sapir provides a good a place to start. It outlines some of the key issues (Sapir, 2005). Sapir divides the EU countries into four groups, based on the level of equity and efficiency in their employment systems (see Table 6.3). Equity measures the extent of social inequality (measured with respect to the percentage in poverty), and efficiency measures the extent to which labour market policy is able to get people back into work.

Table 6.3: Sapir Classification of European Social Models

SAPIR CLASSIFICATION OF EUROPEAN SOCIAL MODELS

Equity	**Efficiency**	
	High	**Low**
High	Nordic countries	Continental Europe
Low	Anglo Saxon	Mediterranean countries

Source(s): Sapir (2005).

The Nordic model is one characterised by high levels of welfare expenditure, universal provision of benefits, state intervention in the labour market, and the strong hand of collective bargaining, which brings about wage compression. The Anglo-Saxon model is based on a benefits system which affords relatively little social protection and which pushes people back into, in many instances, relatively low paid work. The continental model is rather poorly defined, other than to point to its insurance based unemployment benefits system and the existence of strong trade unions. The Mediterranean model, to some extent, is characterised by the relative lack of employment policy compared with the other Member States, other than the provision of pensions.

The Anglo-Saxon model is associated with a relatively high employment rate, coupled with relatively high levels of poverty. The continental model has achieved the opposite, the Nordic model the best of, and the Mediterranean model the worst of, both worlds. For Sapir, the continental and Mediterranean systems are unsustainable if only because the weight of demand placed on them by an ageing population, in the context of relatively low employment rates, will lead them to crumble. The stark choice for Sapir is between the Nordic and Anglo-Saxon models, though it is apparent that, following the economic crisis of 2008/09, the German economy has fared relatively well given its capacity to capture export markets.

The discussion above suggests that there might in fact be four sustainable models:

- the general Nordic model with its strong emphasis on collective bargaining, active labour market policy designed to return people to work, and relatively high investments in education and training
- the Danish flexicurity approach – a variant of the Nordic model – which sees structural adjustments made via the external labour market given relatively low levels of employment protection – but providing high levels of benefits, contingent on people retraining, where they are out of work
- the German model, which also shares many of the features of the Nordic system (especially the commitment to initial vocational education and training, and a relatively co-ordinated approach to managing structural change through tri-partite structures), but which is selective with respect to who accesses the labour market
- the Anglo Saxon model (most commonly associated with the UK) which provides a relatively low level of income security to people out of work and has relatively low levels of employment protection regulation concerned with hiring and firing - which, in combination, pushes people into employment but, possibly, into low wage, low skill work in too many instances

In the Danish system there are relatively low levels of job protection, which facilitates the transfer of people between jobs. But if people lose their jobs there is a relatively generous social security system, continued access to which is dependent upon a willingness to train to obtain new employment. The evidence suggests this has contributed much to Denmark’s macroeconomic stability and its capacity to capture new, high value-added markets. An alternative explanation is that it is macroeconomic stability, which is unrelated to flexicurity, which has allowed Denmark to operate such as system. Nevertheless, there is a strong internal logic which suggests that a flexicurity model allows people to move relatively easily between jobs – and sectors – without too heavy a price being borne in terms of loss of income when they lose their jobs. In other words it has the hallmarks of both equity and efficiency.

The Danish approach stands in contrast to the German system, which relies much more upon training within companies to manage structural adjustments via the nexus of collective bargaining raising wage levels. The latter necessitates investments in new technologies and training, and the capture of new high value product markets in order to sustain rising real wages. Given the level of wage compression in German industry (the result of collective bargaining) there are strong incentives for employers to raise the skill levels of their employees. Arguably this model applies mostly to the German manufacturing sector. It is a moot point whether it applies to the service sector.

The UK case is one which relies much more upon the market to manage structural adjustments in the economy. The UK has been able to maintain high employment rates, employment growth, and growth in services relative to its European neighbours. This suggests, at face value, that this has been a successful approach. In the UK, notwithstanding its experiments with active labour market policy over the 2000s, it is very much up to the individual to take responsibility for their progress through the labour market. If an individual loses their job, unemployment and social security benefits are administered in such a way that individuals are pushed quickly back into employment. This is often low skilled, low waged work and has prompted a decades old debate about the low skills equilibrium. Nevertheless, it has allowed structural adjustment to take place much more readily than in some other Member States, but possibly at too high a cost. It was the concern about the low skill equilibrium which prompted the introduction of Train to Gain in the 2000s which sought to subsidise employer provided continuing vocational education and training. In this way, it was hoped, the direction of travel would be towards increased high skill, high value employment. This policy has now been discontinued, in part because it was thought to be associated with high levels of dead weight.

Employment policy options

The evidence points to energy policy being set, for the most part, separately from employment policy. As indicated in the example of the Danish case, the capacity to integrate energy and employment policy appears too difficult to achieve because of the uncertainties attached to the employment consequences of energy policy for employment and skills. Instead, Member States have adopted differing approaches to employment policy, each with the aim of being able to respond to, or anticipate, signals sent by the market (as described above). The key issue, therefore, is, *in the first instance, to devise energy or climate change policy as required*, and then *to ensure that employment systems are able read the signals and respond in a timely fashion*. Over the short to medium term Member States are unlikely to change the orientation of their employment systems, so it is a case of identifying how EU policy can play a role within these various systems.

Policy might be usefully developed along the following lines:

The energy sector:

- there is a need to be clearer about how the 20/20/20 agenda, and other energy policies, are affecting the demand for skills, and the quality of employment, in the energy sector
- the capacity of employment systems to deliver the skills needed in the sector needs to be identified and, where necessary, the structural funds used to facilitate the development of new skills
- the capacity to transfer employees from parts of the sector using fossil fuels to those parts focusing on renewables needs to be considered, as well as the skills required to make that transition

Energy users:

- there is an imperative to move towards the design and production of more energy-efficient products - industry has a need to ensure that the skills are available to allow that transition to take place effectively
- where job losses occur, there is a need to ensure that employment systems are effectively equipping people with the skills to obtain jobs in growth areas of the economy
- where people are not making the transition to new growth sectors of the economy, the structural funds can be a means of supporting activities through, for example, the public employment systems and training authorities
- there is a need for the structural funds to facilitate the shift towards more energy-efficient production

The above discussion is very much concerned with skills and avoiding skills mismatches. There is also a role for policy to ensure that any shifts in the sectoral and occupational distribution of employment avoids any diminution in the quality of work within Member States, and that it does not further weaken the position of vulnerable groups in the labour market. This might well require the development of a framework at the EU level to monitor the effects on the quality of work and social exclusion through the development of appropriate indicators.

Finally, there is a degree of learning which can take place across the EU. The various different approaches to employment policy considered above, with particular emphasis given to flexicurity, the Anglo-Saxon, and German models respectively, each have potential lessons for policy makers. Whilst it is not easy to transfer policy across Member States, there is nonetheless the capacity to learn from the successes, and failures, of Member States which have adopted different policy approaches.

The scenarios suggest that the scale of change anticipated with respect to employment levels, the occupational distribution of employment and the quality of jobs could be less significant than many had feared. Nevertheless, there are cumulative effects to consider, and the capacity of some Member States to more effectively manage the process of change could mean that the gaps between Member States increase over time.

6.4 Other policy areas

The final section in this chapter discusses some examples of where policies in other areas (i.e. outside the energy/environment and labour market areas that have already been considered) could complement those discussed previously. The structure of this section is based on the Eurostat Sustainable Development Indicators (SDIs), which suggest ten policy areas, although some policies cut across policy areas.

The theme for climate change and energy has been excluded as it has already been covered in detail in this report. It is often difficult to distinguish parts of the themes for sustainable consumption and production and natural resources so they have also been combined. There are thus eight policy areas considered below.

Socio-economic development

As this category includes taxation policy it is fairly clear that there are several possible interactions with environmental policy and its impacts on labour markets; some of these are discussed in earlier sections of this report. Other examples of taxes that could be adjusted are VAT rates and excise duties. Although in both cases these are generally unlikely to have distinctive labour market impacts there are possible examples where they could be used in specific situations, e.g. using differentiated VAT rates for energy and labour-intensive goods.

Recovery from recession

The economic stimulus packages that were introduced following the financial and economic crisis in 2008-09 included green elements in most European countries, typically accounting for around 10% of the packages. Although almost none of these measures were designed to have direct labour market impacts, in most cases there were indirect effects (Cambridge Econometrics and Ecorys, 2011, forthcoming), particularly in investment industries such as engineering and construction that rely on a combination of manual and skilled labour. However, although the measures were effective because these sectors were particularly affected by the crisis, the modelling results, based on the E3ME model, suggested that the jobs that were created were usually temporary. Looking forward towards 2020, the current measures will therefore probably have only limited impact but it should be remembered that future public investment programmes could have labour market benefits.

Austerity measures

The austerity measures that are currently being implemented in many European countries may have a more severe impact on employment in the period up to 2020. Many of the public sector service sectors that are affected are quite labour intensive and although economic recovery in the private sector is supposed to pick up the slack it is not clear that this will happen, especially in the peripheral Member States with high unemployment and low growth prospects.

The impact of austerity measures is therefore a source of considerable uncertainty. While there is not much interaction with environmental targets, when interpreting the results from this analysis it should be remembered that the baseline position could be substantially worse than the one used in the modelling exercise. Analysis carried out with the E3ME model for CEDEFOP suggested that public spending cutbacks could reduce employment in the EU by 0.5% in 2020 (Wilson et al, 2010).

Procurement rules

Green public procurement rules are currently being considered at European and Member State level. It is expected that this will lead to improvements in environmental performance but that these will be small at the macroeconomic level. The labour market impacts are mainly ones of training, both to those that commission large-scale public works and to those that bid for these contracts (e.g. construction firms). Public procurement regulations could provide an incentive for the latter.

Innovation, industrial policy and common standards

One of the themes throughout this report is that innovation is necessary for the targets to be met at low or no cost. Innovation policy therefore has a key role to play in the period up to 2020.

One possible way of encouraging innovation is through an active industrial policy. Where this is interpreted as the picking of ‘winners’ (technologies that will come to market successfully) by policy makers (who are in no better position to make such judgements than anyone else), it could lead to suboptimal outcomes. However, by providing research funding in new technologies at an early stage, it could be possible to drive down costs and encourage adoption. There are many examples of such policies in Europe.

There will be some direct impact on labour markets, particularly regarding the skills required by the chosen technologies. However, the major impacts will be indirect and more general; these technologies allow the 2020 targets to be met with lower energy prices and with less disruption to the wider economy and energy-intensive sectors.

Another way of encouraging innovation is through reducing uncertainty and creating a favourable climate for investment. This is perhaps more difficult post-crisis but fixed emission targets provide some benchmark indication to industry. A fixed minimum carbon or energy price would provide a higher level of certainty still. Adoption of common technical standards across Europe, as was achieved for mobile phones, would provide a larger guaranteed market.

It is also necessary to make the distinction between short-term marginal innovations and larger long-term developments. The former is more relevant to the 2020 targets and can be achieved through investment spending and improvements in production methods for existing technologies. The latter requires substantial R&D spending, highly skilled labour and is more relevant to meeting the emission targets that have been set for 2050.

Sustainable consumption and production, natural resources

In this report we have made only a few references to resource efficiency beyond the use of energy and fossil fuels that are relevant to the 2020 targets. However, there are clear linkages between material and energy consumption, for example:

- large amounts of energy are required to produce metals and mineral products
- mineral products have a high transport cost (in energy terms as well as price)

In many ways the methods to bring about reductions in material consumption are similar to those designed to reduce energy use, although the policy area is much less well developed. Other issues include the units used to measure consumption and defining the point of consumption.

The E3ME model includes a module for material consumption that is currently being developed. A prototype version was used in the Matisse[81] project and found that:

- measures to reduce material consumption could affect some of the energy-intensive sectors (e.g. basic metals) but also those that require skilled labour, such as engineering and construction, because these are quite intensive users of materials
- there was a potential trade-off between material and energy efficiency in that the investment goods required to reduce energy consumption (e.g. new buildings and cars) are material intensive

There clearly are linkages between policies designed to reduce resource use and those intended to reduce energy consumption, and there are potential labour market impacts. As the policy area becomes more developed this should be explored further.

Non-energy emissions

Our analysis has tended to focus on energy use and the greenhouse gas emissions that result from energy consumption. However, emissions directly related to agriculture, waste and land use should also be considered in meeting the targets (and the modelling includes an assumption that some reductions are made).

For example, increases in rates of recycling will reduce landfill and associated emissions. This will likely result in a small increase in employment in both the collection and processing of waste, but without any major skills implications.

It is less clear in the case of agriculture as the measures to reduce emissions combine changes in production (e.g. switch from animals to crops) as well as methods. Overall it is not obvious if, in aggregate, the measures would result in increases or decreases in rural agricultural employment but the types of jobs are likely to be similar to those that exist currently.

Social inclusion

It is quite clear that social policy could have a role to play in easing the transition to a low-carbon and energy-efficiency economy. Although the model results suggest that, at a macro level, the impacts are small, we have noted that detailed structural changes could result in impacts on specific vulnerable groups or specific locations. Furthermore, although this report focuses on the impact on jobs, a key impact on the real incomes of households also comes from the increase in energy prices associated with the key policies, and spending on energy has a higher weight for poorer households. There is clearly a case for using some of the revenues that arise from market-based instruments in the form of targeted compensation or to finance improvements to the energy-efficiency of the housing occupied by poorer households.

The discussion of labour market policy in Section 6.3 has already highlighted the following points:

- the general importance of labour market flexibility, so that labour mobility is one response to restructuring

[81] http://www.matisse-project.net/projectcomm/

- recognition that flexibility needs to be accompanied by measures to support incomes at the same time as retraining or other measures to equip those who have lost their jobs with the skills needed for alternative employment
- recognition that different social models have developed in different Member States which place different weights on the principles of flexibility and support, and these models are not easily transplanted to other countries because they are underpinned by particular social institutions and political consensus

A key lesson drawn from the case studies examined in Section 2.3 is that:

- it may not be practicable or desirable to tie labour market and/or social policies closely to most environmental policies, but rather to ensure that social policy responds adequately to restructuring impacts that arise from environmental or non-environmental causes

Clearly social inclusion concerns arise if the negative impacts of change are focused on those least well-equipped to adapt, particularly where there is a strong risk that they will become excluded from labour market participation or, at best, become trapped in low skill, low wage employment. Section 4.5 has argued that women and young people could be somewhat more exposed to the negative effects of change and less likely to benefit from green jobs growth. Section 5.2 has noted that certain, generally traditional capital-intensive, sectors could be vulnerable to job losses and Section 5.7 has noted the likelihood that some of these are sectors with large plants with workers whose skills may be less transferable to other sectors and where job losses have a substantial impact on the jobs market in the local area. These findings therefore reinforce the importance of social policies that address the disadvantages faced by women and young people in the labour market, and of those (notably older men) whose skills and work experience are no longer in demand when a large plant in a traditional sector closes.

More broadly, the study has found that there is some risk that the shift in occupations prompted by low-carbon polices will reinforce the trend towards polarisation of wage incomes (adding further to the demand for workers at the higher end of the occupational spectrum), although the scale of impact arising from these policies looks small compared to the historical trend due to other reasons.

Demographic change

When considering demographic change, the key issue is to bring the policies designed to meet the 2020 targets into line with a declining workforce and, in some Member States, a declining population. The most recent projections published by CEDEFOP suggest that the European labour force will peak in size shortly after 2015 and then slowly start to decline[82]. The effects of the ageing population are not yet fully understood but policies designed at reducing energy intensity and increasing labour intensity should be considered in this context.

It should also be considered that some of the additional jobs that would be created to meet the 2020 targets, such as construction of renewable electricity plants, would not be suitable for older workers (and traditionally have not attracted a large proportion of the growing female workforce).

[82] See also European Commission (2009b).

Pensions One point that has been noted in this report is that a shift in taxation from income to consumption (of energy) will have strong negative impacts on retired individuals. This could be compensated by higher state pensions but these are also likely to come under pressure due to both the ageing population and public debt levels. It could be possible to provide reduced rates or rebates on fuel excise duties to pensioners (as is done in the UK) but this is both difficult to administer and sends the wrong environmental signals. The issue is still open.

Migration Although our findings do not suggest that there will be large imbalances that need corrected, these could come up in very specific circumstances. In these cases, immigration could address these imbalances without the requirements for long training programmes. The economic argument of increased mobility of labour is well known, as are the political arguments for reduced immigration levels. Our results suggest that this issue is not specific to environmental policy (and it is possibly less so than in other policy areas as Europe has a leading position so the skill bases are already located within the EU) but is more generally related to imbalances that could result from any type of structural change.

Public health There is not a large degree of interaction between health policy and green jobs and few specific examples of policies that are relevant. It is noted that reduction of GHG emissions can have co-benefits of reductions in other harmful emission types (not included in our analysis), particularly from reduced use of coal.

There may be some occasions of workplace dangers in new types of jobs but no examples were found in this report.

Sustainable transport Transport policy is another area where at first view there is little interaction with green jobs. Although transport clearly has a role to play in meeting the 2020 targets, in most cases this does not have much impact on labour markets. For example the same skills are required to drive an electric vehicle as a conventional one.

Building infrastructure In the short term, transport policy could create jobs indirectly through the construction of new infrastructure. A network of charging points for electric vehicles is an obvious example, increased refining capacity for biofuels is another possible example. The type of jobs that this will create will in part be regular ones in the construction sector and related industries, but with some degree of specialisation related to the equipment involved.

Transport and labour mobility A more subtle point relates to commuting patterns and local workforces. If the measures required to meet the 2020 targets result in transport becoming more expensive (as seems likely) this will effectively reduce the local pool of labour. This could lead to disruptive effects and possible imbalances, particularly in cities where the cost of living makes commuting a requirement.

Transport policy therefore has a role to play in mitigating these effects, for example through the provision of (possibly subsidised) public services. However, as commuting seems likely to become more time consuming as well as more expensive a more feasible long-term outcome may be a better system of urban planning to reduce distances travelled.

Global partnership It is important to consider the policies in an international context. There are reasons for Europe to encourage other countries to take action for both environmental and economic (and therefore labour market) reasons. The sectors that will be most affected are ones that could suffer from competitiveness impacts in international trade, mainly energy-intensive sectors and the jobs that are dependent on these industries. If competitor countries took similar action, these competitiveness effects would be close to zero, depending on the relative energy intensities of the European and non-European sectors.

The relevant policy is thus the ongoing global and regional (and in a few cases sectoral) negotiations designed at reducing emission levels. Although our results in general suggest that the competitiveness effects are mainly small, where they do occur (in specific sectors) they will be reduced by similar action being taken in competitor countries.

Good governance The issues that arise here are to make sure that agreed policies are in fact implemented (both on the environmental and labour market side), to protect and expand the internal market, and to make every effort to reduce policy uncertainty which would otherwise hold back investment.

6.5 General conclusions

Main findings The main findings from the whole of this report can be very briefly summarised as:

- The transition to a green economy is an example of structural change and has similarities to previous technology-driven changes (e.g. ICT in the 1970s).
- Quite far reaching changes are expected to take place in Europe's labour markets in the period up to 2020, both as a result of existing environmental policies and other long-term factors such as globalisation. However, these are already factored into the baseline used in the study and the modelling results find that the policies required to meet the 2020 targets have very little further impact at the macro and NACE 2-digit sectoral levels.
- At a much higher level of disaggregation there could be some quite specific examples of bottlenecks and skills mismatches in areas where there are already some skills shortages. Our results suggest that these could be most likely to occur in the engineering sectors, particularly relating to renewables and energy efficiency in buildings. General management skills in all sectors, for example to implement efficiency improvements, will also play a key role in meeting the targets and most jobs are expected to be affected to some extent by the green agenda.
- Some groups have a higher risk of losing out from the developments. This includes those that work in energy supply sectors and energy-intensive industries but in particular the low skilled. Further polarisation of skills requirements and wage rates is also possible. There is a possibility that the new jobs created will not be suitable for some demographic and socio-economic groups, including some older workers, and traditionally have not attracted a large proportion of the growing female workforce.
- There is a wide range of possible policy responses across the Member States, although few examples of integrated environmental and labour market policy. Labour mobility, both in terms of retraining and movement between geographical regions, could ease the transition to a green economy. However, there is a clear role for a broader range of social policies to play as well. These could use the revenues generated from environmental market-based instruments.

Possible further research

This report has covered a wide range of different issues, including both model-based assessment and in-depth labour market and sectoral analysis. The findings from the modelling were limited in two ways:

- **The level of disaggregation was not sufficient to capture detailed industry impacts.** While the data prevent an economy-wide analysis beyond NACE 2-digit level, it could be possible to look at important sectors in more detail using a 'bottom-up' (i.e. more technology-driven) approach. This could in turn be linked to a macroeconomic model such as E3ME, so that the overall framework is able to address movements both within and between sectors. For example, a sector that warrants further investigation into its potential to generate employment and positive economic impacts, especially in rural areas, is agriculture, fisheries, forestry, etc.
- **There was no feedback from skills supply/demand to wages and economic outcomes.** This meant that the results showed no wage polarisation effects or different patterns in wage growth between labour groups. It may be possible to incorporate this feedback with the given data. In addition, the projected demand for skills might be refined to use theoretical assumptions about skill substitution possibilities rather than the fixed or trend extrapolated shares used in this study.

A wider issue which has been the subject of much past research is the question of labour market impacts of technological change and the long and short-term linkages between capital accumulation and labour demand. One of the conclusions from this report is that there are similarities between the ongoing structural change and previous technology revolutions. Looking further back in history, what can be learnt from this? What is the scale of overall 'churn' at the sectoral level and how does structural change contribute to the? How can Europe prepare for the next wave of development? Given older infrastructure and capital, what might be the particular challenges and opportunities for labour markets in the new Member States?

It may also be soon desirable to expand the analysis in this report to other policy areas. Without leaving the realm of environmental policy, there is the EU's Resource Efficiency Strategy[83], which is likely to have particular impacts on some key European sectors (e.g. agriculture or the extraction sectors as suppliers of resources, or construction as one of the main users). There are also several other driving factors, which we have touched upon in this report, but warrant closer attention:

- lasting effects of the financial and economic crisis
- public debt levels
- ageing population

Each of these has at least as much potential for disruption to Europe's labour markets as the transition to a green economy.

[83] See http://ec.europa.eu/environment/resource_efficiency/

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7.2 Appendix A: The E3ME Model

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Appendix A: The E3ME Model

Introduction

E3ME is a computer-based model of Europe's economic and energy systems and the environment. It was originally developed through the European Commission's research framework programmes and is now widely used in Europe for policy assessment, for forecasting and for research purposes.

E3ME's structure

The structure of E3ME is based on the system of national accounts, as defined by ESA95 (European Commission, 1996), with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, with estimated sets of equations for labour demand, supply, wages and working hours. In total there are 33 sets of econometrically estimated equations, also including the components of GDP (consumption, investment, international trade), prices, energy demand and materials demand. Each equation set is disaggregated by country and by sector.

E3ME's historical database covers the period 1970-2008 and the model projects forward annually to 2050[84]. The main data sources are Eurostat, DG Ecfin's AMECO database and the IEA, supplemented by the OECD's STAN database and other sources where appropriate. Gaps in the data are estimated using customised software algorithms.

The main dimensions of the model

The other main dimensions of the model are:

- 29 countries (the EU27 member states plus Norway and Switzerland)
- 42 economic sectors, including disaggregation of the energy sectors and 16 service sectors
- 43 categories of household expenditure
- 19 different users of 12 different fuel types
- 14 types of air-borne emission (where data are available) including the six greenhouse gases monitored under the Kyoto protocol.
    - 13 types of household, including income quintiles and socio-economic groups such as the unemployed, inactive and retired, plus an urban/rural split

Typical outputs from the model include GDP and sectoral output, household expenditure, investment, international trade, inflation, employment and unemployment, energy demand and CO_2 emissions. Each of these is available at national and EU level, and most are also defined by economic sector.

The econometric specification of E3ME gives the model a strong empirical grounding and means it is not reliant on the assumptions common to Computable General Equilibrium (CGE) models, such as perfect competition or rational expectations. E3ME uses a system of error correction, allowing short-term dynamic (or transition) outcomes, moving towards a long-term trend. The dynamic specification is important when considering short and medium-term analysis (e.g. up to 2020) and rebound effects[85], which are included as standard in the model's results.

E3ME's key strengths

In summary the key strengths of E3ME lie in three different areas:

[84] See Chewpreecha and Pollitt (2009).

[85] Where an initial increase in efficiency reduces demand, but this is negated in the long run as greater efficiency lowers the relative cost and increases consumption. See Barker et al (2009).

- the close integration of the economy, energy systems and the environment, with two-way linkages between each component
- the detailed sectoral disaggregation in the model's classifications, allowing for the analysis of similarly detailed scenarios
    - the econometric specification of the model, making it suitable for short and medium-term assessment, as well as longer-term trends

For further details, the reader is referred to the model manual available online from www.e3me.com.

A brief history of E3ME

Quantifying the short and long-term effects of E3 policies

E3ME was originally intended to meet an expressed need of researchers and policy makers for a framework for analysing the long-term implications of Energy-Environment-Economy (E3) policies, especially those concerning R&D and environmental taxation and regulation. The model is also capable of addressing the short-term and medium-term economic effects as well as, more broadly, the long-term effects of such policies, such as those from the supply side of the labour market.

The European contribution

The first version of the E3ME model was built by an international European team under a succession of contracts in the JOULE/THERMIE and EC research programmes. The projects 'Completion and Extension of E3ME'[86] and 'Applications of E3ME'[87], were completed in 1999. The 2001 contract, 'Sectoral Economic Analysis and Forecasts'[88] generated an update of the E3ME industry output, product and investment classifications to bring the model into compliance with the European System of Accounts, ESA 95. This led to a significant disaggregation of the service sector. The 2003 contract, Tipmac[89], led to a full development of the E3ME transport module to include detailed country models for several modes of passenger and freight transport and Seamate (2003/2004)[90] resulted in the improvement of the E3ME technology indices. The COMETR[91] (2005-07), Matisse[92] (2005-08) and CEDEFOP[93] (2007-2010) projects allowed the expansion of E3ME to cover 29 European countries, including the twelve accession countries. More recently the model has been used to contribute to European Impact Assessments, including reviews of the EU ETS, Energy Taxation Directive and TEN-E infrastructure policy. E3ME is now applied at the national, as well as European, level.

A full list of recent projects involving E3ME, and references from related publications, is available from the model website.

E3ME is the latest in a succession of models developed for energy-economy and, later, E3 (energy-environment-economy) interactions in Europe, starting with

86 European Commission contract no. JOS3-CT95-0011

87 European Commission contract no. JOS3-CT97-0019

88 European Commission contract no. B2000/A7050/001

89 European Commission contract no. GRD1/2000/25347-SI2.316061

90 European Commission contract no. IST-2000-31104

91 European Commission contract no. 501993 (SCS8)

92 European Commission contract no. 004059 (GOCE)

93 European Commission project no. 2007-0089/AO/AZU/Skillsnet-Supply/010/07 and European Commission project no. 2006/S 125-132790

EXPLOR, built in the 1970s, then HERMES in the 1980s. Each model has required substantial resources from international teams and has learned from earlier problems and developed new techniques. E3ME is now firmly established as a tool for policy analysis in Europe. The current version is closely linked to the global E3MG[94] model, which is similar in structure and dimensions.

A description of E3ME

Economic activity undertaken by persons, households, firms and other groups in society has effects on other groups after a time lag, and the effects persist into future generations, although many of the effects soon become so small as to be negligible. But there are many actors, and the effects, both beneficial and damaging, accumulate in economic and physical stocks. The effects are transmitted through the environment (with externalities such as greenhouse gas emissions contributing to global warming), through the economy and the price and money system (via the markets for labour and commodities), and through the global transport and information networks. The markets transmit effects in three main ways: through the level of activity creating demand for inputs of materials, fuels and labour; through wages and prices affecting incomes; and through incomes leading in turn to further demands for goods and services. These interdependencies suggest that an E3 model should be comprehensive, and include many linkages between different parts of the economic and energy systems.

These economic and energy systems have the following characteristics: economies and diseconomies of scale in both production and consumption; markets with different degrees of competition; the prevalence of institutional behaviour whose aim may be maximisation, but may also be the satisfaction of more restricted objectives; and rapid and uneven changes in technology and consumer preferences, certainly within the time scale of greenhouse gas mitigation policy. Labour markets in particular may be characterised by long-term unemployment. An E3 model capable of representing these features must therefore be flexible, capable of embodying a variety of behaviours and of simulating a dynamic system. This approach can be contrasted with that adopted by general equilibrium models: they typically assume constant returns to scale; perfect competition in all markets; maximisation of social welfare measured by total discounted private consumption; no involuntary unemployment; and exogenous technical progress following a constant time trend (see Barker, 1998, for a more detailed discussion).

E3ME as an E3 model

The E3ME model comprises:

- the accounting balances for commodities from input-output tables, for energy carriers from energy balances and for institutional incomes and expenditures from the national accounts
- environmental emission flows
- 33 sets of time-series econometric equations (aggregate energy demands, fuel substitution equations for coal, heavy oil, gas and electricity; intra-EU and extra-EU commodity exports and imports; total consumers' expenditure; disaggregated consumers' expenditure; industrial fixed investment; industrial employment; industrial hours worked; labour participation; industrial prices; export and import prices; industrial wage rates; residual incomes; investment in dwellings; normal output equations and physical demand for seven types of materials)

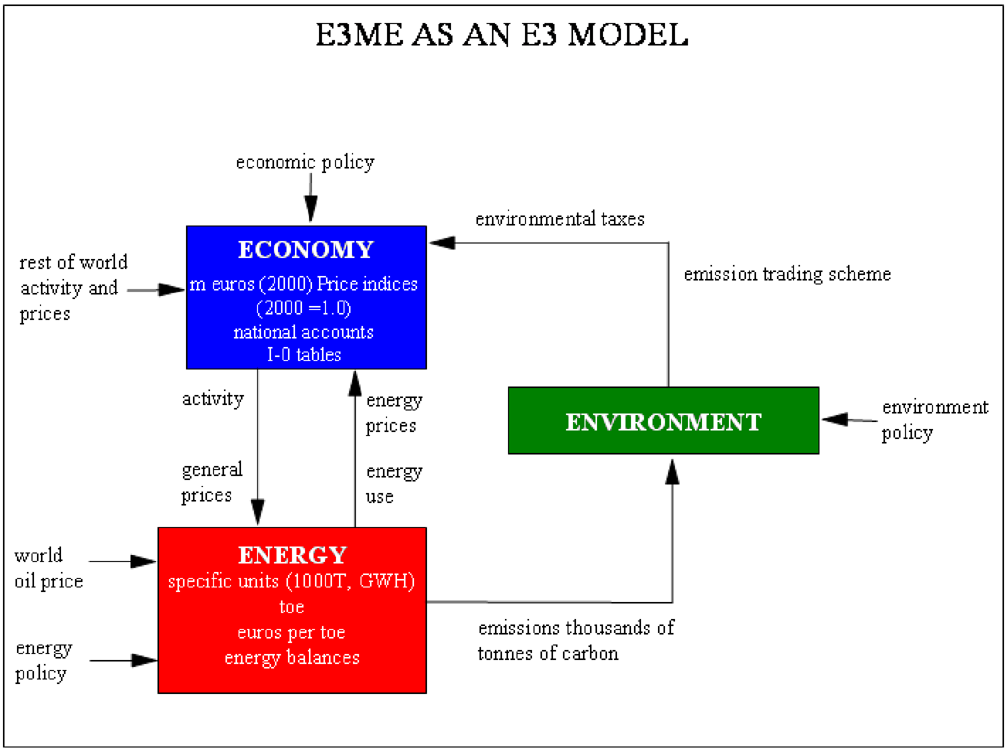
[94] See www.e3mgmodel.com

Energy supplies and population stocks and flows are treated as exogenous.

The E3 interactions

Figure A.1 shows how the three components (modules) of the model - energy, environment and economy - fit together. Each component is shown in its own box with its own units of account and sources of data. Each data set has been constructed by statistical offices to conform with accounting conventions. Exogenous factors coming from outside the modelling framework are shown on the outside edge of the chart as inputs into each component. For the EU economy, these factors are economic activity and prices in non-EU world areas and economic policy (including tax rates, growth in government expenditures, interest rates and exchange rates). For the energy system, the outside factors are the world oil prices and energy policy (including regulation of energy industries). For the environment component, exogenous factors include policies such as reduction in SO_2 emissions by means of end-of-pipe filters from large combustion plants. The linkages between the components of the model are shown explicitly by the arrows that indicate which values are transmitted between components.

Figure A.1



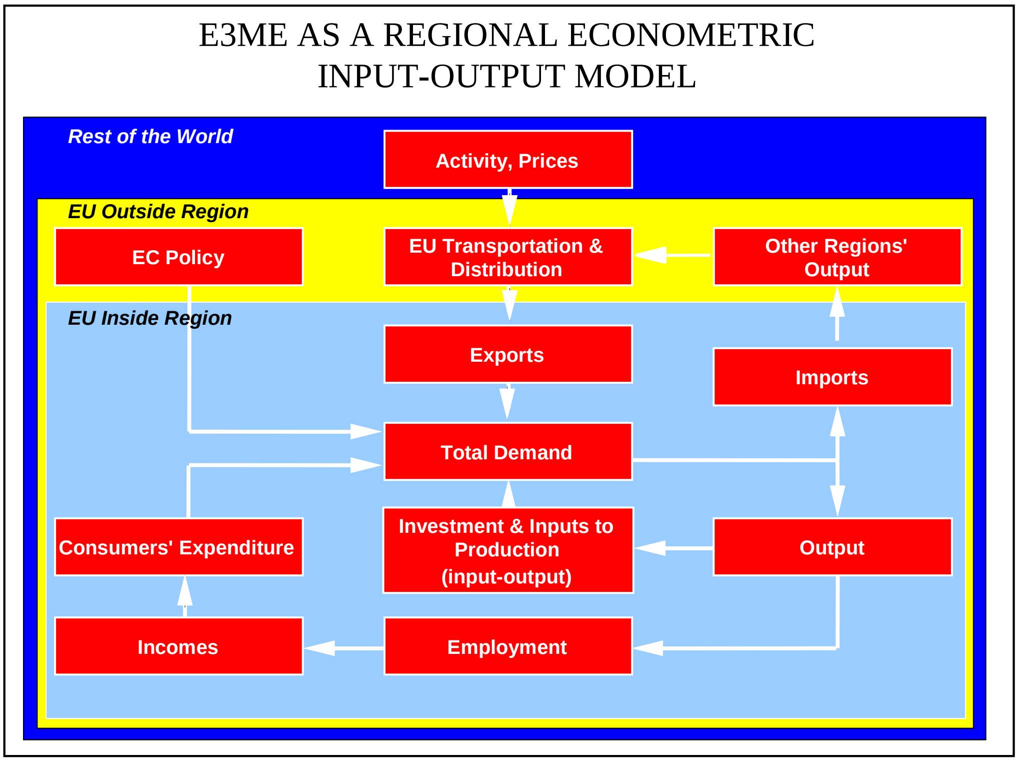
The economy module provides measures of economic activity and general price levels to the energy module; the energy module provides measures of emissions of the main air pollutants to the environment module, which in turn gives measures of damage to health and buildings (estimated using the most recent ExternE[95] coefficients). The energy module provides detailed price levels for energy carriers distinguished in the economy module and the overall price of energy as well as energy use in the economy.

[95] http://www.externe.info/tools.html

The E3ME regional econometric input-output model

Figure A.2 shows how the economic module is solved as an integrated EU regional model. Most of the economic variables shown in the chart are at a 42-industry level. The whole system is solved simultaneously for all industries and all 29 countries, although single-country solutions are also possible. The chart shows interactions at three spatial levels: the outermost area is the rest of the world; the next level is the European Union outside the country in question; and finally, the inside level contains the relationships within the country.

Figure A.2



The chart shows three loops or circuits of economic interdependence, which are described in some detail below. These are the export loop, the output-investment loop and the income loop.

The export loop

The export loop runs from the EU transport and distribution network to the region's exports, then to total demand. The region's imports feed into other EU regions' exports and output and finally to these other regions' demand from the EU pool and back to the exports of the region in question.

Treatment of international trade

An important part of the modelling concerns international trade. The basic assumption is that, for most commodities, there is a European 'pool' into which each region supplies part of its production and from which each region satisfies part of its demand. *This might be compared to national electricity supplies and demands: each power plant supplies to the national grid and each user draws power from the grid and it is not possible or necessary to link a particular supply to a particular demand.*

The demand for a region's exports of a commodity is related to three factors:

- domestic demand for the commodity in all the other EU regions, weighted by their economic distance from the region in question
- activity in the main external EU export markets, as measured by GDP or industrial production

- relative prices, including the effects of exchange rate changes.

Economic distance Economic distance is measured by a special distance variable. For a given region, this variable is normalised to be 1 for the home region and values less than one for external regions. The economic distance to other regions is inversely proportional to trade between the regions. In E3ME regional imports are determined for the demand and relative prices by commodity and region. In addition, measures of innovation (including spending on R&D) have been introduced into the trade equations to pick up an important long-term dynamic effect on economic development.

The output-investment loop The output-investment loop includes industrial demand for goods and services and runs from total demand to output and then to investment and back to total demand. For each region, total demand for the gross output of goods and services is formed from industrial demand, consumers' expenditure, government consumption, investment (fixed domestic capital formation and stockbuilding) and exports. These totals are divided between imports and output depending on relative prices, levels of activity and utilisation of capacity. Industrial demand represents the inputs of goods and services from other industries required for current production, and is calculated using input-output coefficients. The coefficients are calculated as inputs of commodities from whatever source, including imports, per unit of gross industrial output.

Determination of investment demand Forecast changes in output are important determinants of investment in the model. Investment in new equipment and new buildings is one of the ways in which companies adjust to the new challenges introduced by energy and environmental policies. Consequently, the quality of the data and the way data are modelled are of great importance to the performance of the whole model. Regional investment by the investing industry is determined in the model as intertemporal choices depending on capacity output and investment prices. When investment by user industry is determined, it is converted, using coefficients derived from input-output tables, into demands on the industries producing the investment goods and services, mainly engineering and construction. These demands then constitute one of the components of total demand.

Accumulation of knowledge and technology Gross fixed investment, enhanced by R&D expenditure in constant prices, is accumulated to provide a measure of the technological capital stock. This avoids problems with the usual definition of the capital stock and lack of data on economic scrapping. The accumulation measure is designed to get round the worst of these problems. Investment is central to the determination of long-term growth and the model embodies endogenous technical change and a theory of endogenous growth which underlies the long-term behaviour of the trade and employment equations.

The income loop In the income loop, industrial output generates employment and incomes, which leads to further consumers' expenditure, adding to total demand. Changes in output are used to determine changes in employment, along with changes in real wage costs, interest rates and energy costs. With wage rates explained by price levels and conditions in the labour market, the wage and salary payments by industry can be calculated from the industrial employment levels. These are some of the largest payments to the personal sector, but not the only ones. There are also payments of interest and dividends, transfers from government in the form of state pensions, unemployment benefits and other social security benefits. Payments made by the personal sector include mortgage interest payments and personal income taxes. Personal disposable income is calculated from these accounts, and deflated by the consumer price index to give real personal disposable income.

Determination of consumers' demand

Totals of consumer spending by region are derived from consumption functions estimated from time-series data (this is a similar treatment to that adopted in the HERMES model). These equations relate consumption to regional personal disposable income, a measure of wealth for the personal sector, inflation and interest rates. Sets of equations have been estimated from time-series data for each of the 43 consumption categories reported by Eurostat in each country.

Energy-Environment links

Top-down and bottom-up methodologies

E3ME is intended to be an integrated top-down, bottom-up model of E3 interaction. In particular, the model includes a detailed engineering-based treatment of the electricity supply industry (ESI). Demand for energy by the other fuel-user groups is top-down, but it is important to be aware of the comparative strengths and weaknesses of the two approaches. Top-down economic analyses and bottom-up engineering analyses of changes in the pattern of energy consumption possess distinct intellectual origins and distinct strengths and weaknesses (see Barker, Ekins and Johnstone, 1995).

A top-down submodel of energy use

The energy submodel in E3ME is constructed, estimated and solved for 19 fuel users, 12 energy carriers (termed fuels for convenience below) and 29 countries. Figure A.3 shows the inputs from the economy and the environment into the components of the submodel and Figure A.4 shows the feedback from the submodel to the rest of the economy.

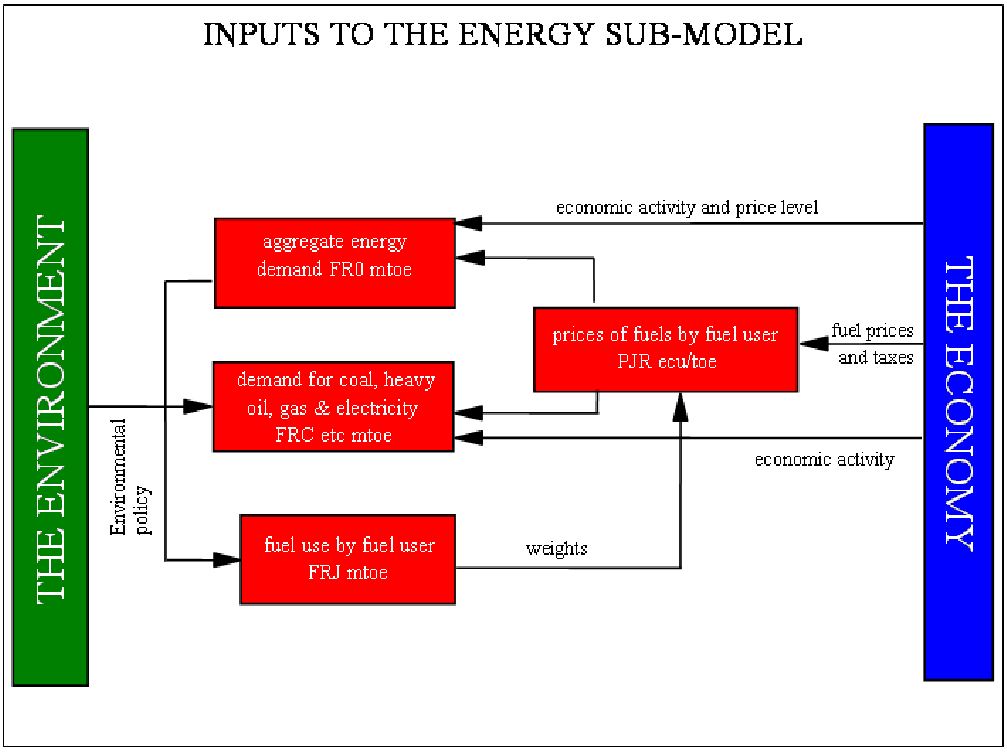
Determination of fuel demand

Aggregate energy demand, shown at the top of Figure A.3, is determined by a set of co-integrating equations[96], whose the main explanatory variables are:

- economic activity in each of the 19 fuel users
- average energy prices by the fuel users relative to the overall price levels
- technological variables, represented by investment and R&D expenditure, and spillovers in key industries producing energy-using equipment and vehicles

[96] Cointegration is an econometric technique that defines a long-run relationship between two variables resulting in a form of 'equilibrium'. For instance, if income and consumption are cointegrated, then any shock (expected or unexpected) affecting these two variables is gradually absorbed since in the long run they return to their 'equilibrium' levels. Note that a cointegration relationship is much stronger than a simple correlation: two variables can show similar patterns simply because they are driven by some common factors but without necessarily being involved in a long-run relationship.

Figure A.3



Fuel substitution Fuel use equations are estimated for four fuels - coal, heavy oils, gas and electricity – and the four sets of equations are estimated for the fuel users in each region. These equations are intended to allow substitution between these energy carriers by users on the basis of relative prices, although overall fuel use and the technological variables are allowed to affect the choice. Since the substitution equations cover only four of the twelve fuels, the remaining fuels are determined as fixed ratios to similar fuels or to aggregate energy use. The final set of fuels used must then be scaled to ensure that it adds up to the aggregate energy demand (for each fuel user and each region).

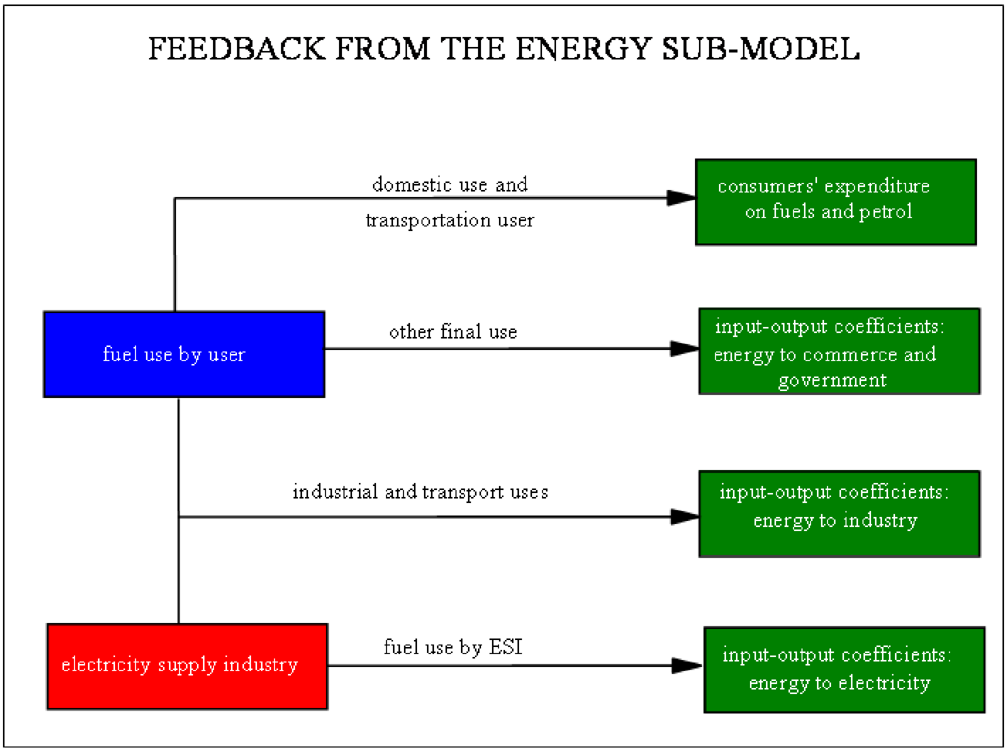
Emissions submodel The emissions submodel calculates air pollution generated from end-use of different fuels and from primary use of fuels in the energy industries themselves, particularly electricity generation. Provision is made for emissions to the atmosphere of carbon dioxide (CO_2), sulphur dioxide (SO_2), nitrogen oxides (NOx), carbon monoxide (CO), methane (CH_4), black smoke (PM_{10}), volatile organic compounds (VOC), nuclear emissions to air, lead emissions to air, chlorofluorocarbons (CFCs) and the other four greenhouse gases: nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), sulphur hexafluoride (SF_6). These four gases together with CO_2 and CH_4 constitute the six greenhouse gases (GHGs) monitored under the Kyoto protocol. Using estimated (ExternE) damage coefficients, E3ME may also estimate ancillary benefits relating to reduction in associated emissions e.g. PM_{10}, SO_2, NOx.

CO_2 emissions Emissions data for CO_2 are available for fuel users of solid fuels, oil products and gas separately. The energy submodel estimates of fuel by fuel user are aggregated into these groups (solid, oil and gas) and emission coefficients (tonnes of carbon in CO_2 emitted per toe) are calculated and stored. The coefficients are calculated for each year when data are available, then used at their last historical values to project future emissions. Other emissions data are available at various levels of disaggregation from a number of sources and have been constructed carefully to ensure consistency.

Feedback to the rest of the economy

Figure A.4 shows the main feedbacks from the energy submodel to the rest of the economy. Changes in consumers' expenditures on fuels and petrol are formed from changes in fuel use estimated in the energy submodel, although the levels are calibrated on historical time-series data. The model software provides an option for choosing either the consumers' expenditure equation solution, or the energy equation solution. Whichever option is chosen, total consumer demand in constant values matches the results of the aggregate consumption function, with any residual held in the unallocated category of consumers' expenditure. The other feedbacks all affect industrial, including electricity, demand via changes in the input-output coefficients.

Figure A.4



Parameter estimation

The econometric model has a complete specification of the long-term solution in the form of an estimated equation that has long-term restrictions imposed on its parameters. Economic theory, for example the recent theories of endogenous growth, informs the specification of the long-term equations and hence properties of the model; dynamic equations that embody these long-term properties are estimated by econometric methods to allow the model to provide forecasts. The method utilises developments in time-series econometrics, in which dynamic relationships are specified in terms of error correction models (ECM) that allow dynamic convergence to a long-term outcome. The specific functional form of the equations is based on the econometric techniques of cointegration and error-correction, particularly as promoted by Engle and Granger (1987) and Hendry et al (1984).

Application of E3ME

Although E3ME can be used for forecasting, the model is more commonly used for evaluating the impacts of an input shock through a scenario-based analysis. The shock may be either a change in policy, a change in economic assumptions or another change to a model variable. The analysis can be either forward looking (ex-ante) or evaluating previous developments in an ex-post manner. Scenarios can be used either to assess policy, or to assess sensitivities to key inputs (e.g. international energy prices).

For ex-ante analysis a Baseline forecast up to 2050 is required; E3ME is usually calibrated to match a set of projections that are published by the European Commission. The scenarios represent alternative versions of the future based on a different set of inputs. By comparing the outcomes to the Baseline (usually in percentage terms), the effects of the change in inputs can be determined.

Typical scenarios

It is important to design scenarios carefully so that they do not present a biased set of outcomes, for example in a scenario where public spending increases there should be a similar increase in tax receipts (ensuring 'revenue neutrality', so that the scenario represents a shift in resources rather than an increase or decrease).

It is possible to set up a scenario in which any of the model's inputs or variables are changed. In the case of exogenous inputs, such as population or energy prices, this is straight forward. However, it is also possible to add shocks to other model variables. For example, investment is endogenously determined by E3ME, but additional exogenous investment (e.g. through an increase in public investment expenditure) can also be modelled as part of a scenario input.

Price or tax scenarios

Model-based scenario analyses often focus on changes in price because this is easy to quantify and represent in the model structure. Examples include:

- changes in tax rates
- changes in international energy prices
- emission trading schemes

Regulatory impacts

All of these can be represented in E3ME's framework reasonably well, given the level of disaggregation available. However, it is also possible to assess the effects of regulation, albeit with an assumption about effectiveness and cost. For example, an increase in vehicle fuel-efficiency standards could be assessed in the model with an assumption about how efficient vehicles become, and the cost of these measures. This would be entered into the model as a higher price for cars and a reduction in fuel consumption (all other things being equal). E3ME could then be used to determine:

- secondary effects, for example on fuel suppliers
- rebound effects[97]

Standard outputs from the model

As a general model of the economy, based on the full structure of the national accounts, E3ME is capable of producing a broad range of economic indicators. In addition there is range of energy and environment indicators. The following list provides a summary of the most common outputs:

- GDP and the aggregate components of GDP (household expenditure, investment, government expenditure and international trade)
- sectoral output and GVA, prices, trade and competitiveness effects
- consumer prices and expenditures, and implied household distributional effects
- sectoral employment, unemployment, sectoral wage rates and labour supply
- energy demand, by sector and by fuel, energy prices
- CO_2 emissions by sector and by fuel

[97] In the example, the higher fuel efficiency effectively reduces the cost of motoring. In the long-run this is likely to lead to an increase in demand, meaning some of the initial savings are lost. Barker et al (2009) demonstrate that this can be as high as 50% of the original reduction.

- other air-borne emissions
- material demands

This list is by no means exhaustive and the delivered outputs often depend on the requirements of the specific project. In addition to the sectoral dimension mentioned in the list, all indicators are produced at the member state level and annually over the period up to 2050.

Limitations to the analysis

The main limitation of E3ME is the sectoral disaggregation of its sectors. The industry classification is relatively detailed, covering 42 sectors at the NACE 2-digit level. However, due to the availability of the data, it is not possible to go into more detail, for example to the firm-based level, or to very detailed product groups. For this type of analysis our recommendation is that the model (which provides an indication of indirect effects) is used in conjunction with a more detailed bottom-up or econometric analysis (which can capture detailed industry-specific effects).

The other main limitations to the model relate to its dimensions and boundaries. Broadly speaking E3ME covers the economy, energy and material demands and atmospheric emissions. While it is possible to provide an assessment of other policy areas, it is necessary to make assumptions about how this is translated into model inputs. Other limitations, such as the geographical scope (Europe) and time horizon (2050) are more obvious, although it should be noted that the global E3MG model can be used to address the first of these issues.

The System of Accounts and E3ME classifications

The accounting structure within IDIOM (International Dynamic Input-Output Modelling language) on which E3ME is based is that of the Eurostat System of Accounts 1995 (ESA95). The IDIOM functional classifications can be identified with accounts in the ESA95 with the exception of investment, area, employment and energy-use classifications. One of the characteristics of the ESA and E3ME is the disaggregation of economic variables. The industry and commodity classifications are in terms of industries or their principal products and are defined on the NACE Rev.1.1 (see Table A.1) and cover the EU 27 member states plus Norway and Switzerland (see Table A.2).

Energy – Environment classifications

Aside from the classifications relating to the economy, there are a number of energy-environment classifications.

- Fuel Users (classification FU, see Table A.3)
- Fuel Types (classification J, see Table A.4)
- Environmental Emissions (classification EM, Table A.5)
- Environmental Emission Sources (classification ES, Table A.6)

Input – Output tables

For E3ME46 a new set of input-output tables was obtained from Eurostat and the OECD. For each region, an input-output table for 2000 was estimated if this was not already available. E3ME's input-output tables include:

- domestic production
- imports from EC member countries
- imports from third countries

Evolution of E3ME classifications

The evolution of the E3ME classifications and databases has been characterised by the desire to cover more disaggregated sectors on one hand and the adoption of several additional classifications (energy-environment as mentioned above) on the other hand. E3ME classifications and datasets evolved (and continue to evolve) according to the objectives of the specific projects and policy applications involving the model.

Data sources The following sections only give a summary of data sources used in the E3ME model. The data need to be consistent across countries and in the same units. For monetary data the euro is used. The data are updated as and when new figures become available. For each set of model variables there are four possible groups of data sources with the following ranking:

Primary choice Eurostat is always the first choice which establishes a comparable basis across member states. Even where Eurostat data are incomplete or believed to be of poor quality, the Eurostat definitions are adopted and the data are improved via other sources. This allows the inclusion of improved Eurostat data on an annual basis.

Second choice Data from the AMECO database are used in order to make the Eurostat totals consistent with accepted macroeconomic totals, and also to provide limited sectoral information.

Third choice When Eurostat data are not available or need to be improved, other internationally available sources such as OECD or IMF are consulted. International sources are also important for data covering the world areas outside the E3ME regions.

Fourth choice Once these international data sources have been exhausted, national statistical agencies and other data sources are used to update the remaining missing series and gaps in the data.

As indicated above data from official sources are always preferred and are used in the most comprehensive possible way. There are also several sets of variables in E3ME that are calculated, and special variables that use different sources, as shown below.

Trade data Due to the way in which trade is modelled within E3ME, via a European pool rather than as a series of bilateral relationships, an aggregated version is used in equation estimation. The importance of one country's trade to another country's economic activity is determined using OECD bilateral trade data. This information is also used to construct trends for filling gaps in data for trade in services.

Energy fuel use The energy data in physical units are from the IEA energy balances. The database provides energy demand by energy carriers and by energy users over the historical period and is updated annually.

Detailed data on the power generation sector, including time series of generation and capacity by technology, come from Eurostat.

Energy price data Energy price data come from the IEA Energy Prices and Taxes publications. The publication provides time series for end-user prices and tax data for each of the E3ME countries.

CO_2 emissions by fuel and fuel user Total historical CO_2 emissions were obtained as time series by country from Eurostat. The emission values are converted into coefficients per unit of fuel use by the model code and used to project future emissions.

Other greenhouse gas emissions and pollutants data Non-CO_2 emissions in E3ME include SO_2, NOx, CO, methane (CH_4), particulates (PM_{10}), volatile organic compounds (VOC), ammonia (NH_3) and the other four greenhouse gases N_2O, HFC, PFC, SF_6. These data are obtained as single year estimates (most recently 2005) for each EU region from the RIVM-MNP project, using the EDGAR classifications databank. The EDGAR emissions data are allocated by source.

Classification tables

Table A.1: E3ME: Products and Industries

	Full industry heading	2-letter ID	NACE REV 1.1
1	Agriculture etc.	AG	01,02,05
2	Coal	CO	10
3	Oil & Gas etc.	OG	11,12
4	Other Mining	MI	13,14
5	Food, Drink & Tobacco	FD	15,16
6	Textiles, Clothing & Leather	TC	17,18,19
7	Wood & Paper	WP	20,21
8	Printing & Publishing	PP	22
9	Manufactured Fuels	MF	23
10	Pharmaceuticals	PH	24.4
11	Chemicals nes	CH	24(ex24.4)
12	Rubber & Plastics	RP	25
13	Non-Metallic Mineral Products	NM	26
14	Basic Metals	BM	27
15	Metal Goods	MG	28
16	Mechanical Engineering	MA	29
17	Electronics	IT	30,32
18	Electrical Engineering & Instruments	EI	31,33
19	Motor Vehicles	MV	34
20	Other Transport Equipment	TE	35
21	Manufacturing nes	OM	36,37
22	Electricity	EL	40.1
23	Gas Supply	GS	40.2,40.3
24	Water Supply	WA	41
25	Construction	CN	45
26	Distribution	DT	50,51
27	Retailing	RT	52
28	Hotels & Catering	HC	55
29	Land Transport etc.	LT	60,63
30	Water Transport	WT	61
31	Air Transport	AT	62
32	Communications	CM	64
33	Banking & Finance	BF	65,67
34	Insurance	IN	66
35	Computing Services	CS	72
36	Professional Services	PS	70,71,73,74.1-74.4
37	Other Business Services	OB	74.5-74.8
38	Public Administration & Defence	PA	75
39	Education	ED	80
40	Health & Social Work	HS	85
41	Miscellaneous Services	OS	90 to 93,95,99
42	Unallocated	UN	

Table A.2: E3ME: 33 European Regions (R)

1	Belgium	(BE)
2	Denmark	(DK)
3	Germany	(DE)
4	Greece	(EL)
5	Spain	(ES)
6	France	(FR)
7	Ireland	(IE)
8	Italy	(IT)
9	Luxembourg	(LX)
10	Netherlands	(NL)
11	Austria	(AT)
12	Portugal	(PT)
13	Finland	(FI)
14	Sweden	(SW)
15	UK	(UK)
16	Czech Republic	(CZ)
17	Estonia	(EN)
18	Cyprus	(CY)
19	Latvia	(LV)
20	Lithuania	(LT)
21	Hungary	(HU)
22	Malta	(MT)
23	Poland	(PL)
24	Slovenia	(SI)
25	Slovakia	(SK)
26	Bulgaria	(BG)
27	Romania	(RO)
28	Norway	(NO)
29	Switzerland	(CH)
30	Iceland	(IS)
31	Croatia	(HR)
32	Turkey	(TR)
33	Macedonia	(MK)

Table A.3: E3ME: Energy Users (FU)

			ISIC Rev 3.1	E3ME industrial sectors
1	Power own use & transformation	EL	401	22
2	Other energy own use & transformation	OE	10-12,23,402,403	2,3,9,23
3	Iron and steel	IS	271, 2731	.66*14
4	Non-ferrous metals	NF	272, 2732	.34*14
5	Chemicals	CH	24	10,11
6	Non-metallic minerals	NM	26	13
7	Ore-extraction (non-energy)	OE	13,14	4
8	Food, drink and tobacco	FD	15,16	5
9	Textiles, clothing & footwear	TC	17,18,19	6
10	Paper and pulp	PP	21,22	.9*7,8
11	Engineering etc.	EE	28 to 35	15 to 20
12	Other industry	OI	20,25,36,37,45	.1*7,12,21,25
13	Rail transport	RA	60.1	.15*29
14	Road transport	RO	60.2,60.3	.75*29
15	Air transport	AT	62	31
16	Other transport services	OT	61,63	.1*29,30
17	Households	HH	95	
18	Other final use	OF	1-5,41,50-55,64-93	1,24,26-29,32-41
19	Non-energy use	NE		

Note(s): The columns show the ISIC codes and how the energy users defined in E3ME relate to the economic sectors. Due to the data definitions, these are not always one-to-one, for example, the energy user Paper and Pulp accounts for 90% of economic sector number 7, plus all of economic sector number 8.

Table A.4: E3ME: Energy Carriers

1	Hard Coal	HC	Hard coal
2	Other coal etc.	OC	Lignite/Brown Coal/Sub-Bituminous Coal, Coking Coal, Other Bituminous Coal & Anthracite, Sub-Bituminous Coal, Lignite/Brown Coal, Peat, Patent Fuel, Coke Oven Coke and Lignite Coke, Gas Coke, BKB, and Charcoal
3	Crude oil etc.	CO	Crude/NGL/Feedstocks/Non-Crude, Crude Oil, Refinery Feedstocks, Additives/Blending Components, Inputs other than Crude or NGL, Refinery Gas, Ethane, and Liquefied Petroleum Gases.
4	Heavy fuel oil	HO	Heavy Fuel Oil, Naphtha, White Spirit& SBP, Lubricants, Bitumen, Paraffin Waxes, Petroleum Coke, and Other Petroleum Products.
5	Middle distillates	MO	Motor Gasoline, Aviation Gasoline, Gasoline type Jet Fuel, Kerosene type Jet Fuel, Other Kerosene, and Gas/Diesel Oil.
6	Other gas	OG	Gas Works Gas, Coke Oven Gas, Blast Furnace Gas, and Oxygen Steel Furnace Gas.
7	Natural gas	NG	Natural Gas, and Natural Gas Liquids.
8	Electricity	EL	Electricity
9	Heat	HE	Heat
10	Combustible waste	CW	Industrial Wastes, Municipal Wastes Renewables, Municipal Wastes Non-Renewables, and Non-specified Primary Biomass and Wastes.
11	Biofuels	BF	Primary Solid Biomass, Biogas, and Liquid Biomass.
12	Hydrogen	HY	Hydrogen

Table A.5: E3ME: Atmospheric Emissions (EM)

1	Carbon dioxide (GHG)	CO_2
2	Sulphur dioxide	SO_2
3	Nitrogen oxides	NOX
4	Carbon monoxide	CO
5	Methane (GHG)	CH_4
6	Particulates	PM_{10}
7	VOCs	VOC
8	Radiation - air	RAD
9	Lead - air	LEAD
10	CFCs	CFCs
11	N2O (GHG)	N_2O
12	HFCs (GHG)	HFCs
13	PFCs (GHG)	PFCs
14	SF6 (GHG)	SF_6

Table A.6: E3ME: Emission Sources (ES)

1	Energy & transformation industries	ET
2	Other industry	OI
3	Transport	TR
4	Other fuel combustion	OF
5	Fugitive fuel emissions	FF
6	Industrial processes	IP
7	Solvent & other product use	SO
8	Agriculture	AG
9	Waste treatment disposal	WA
10	Other	OT

Appendix B: The Demand for and Supply of Skills

The income loop

As noted in Appendix A, in the income loop within E3ME, industrial output generates employment and incomes, which leads to further consumers' expenditure, adding to total demand. Changes in output are used to determine changes in employment, along with changes in real wage costs, interest rates and energy costs. With wage rates explained by price levels and conditions in the labour market, the wage and salary payments by industry can be calculated from the industrial employment levels. These are some of the largest payments to the personal sector, but not the only ones. There are also payments of interest and dividends, transfers from government in the form of state pensions, unemployment benefits and other social security benefits. Payments made by the personal sector include mortgage interest payments and personal income taxes. Personal disposable income is calculated from these accounts, and deflated by the consumer price index to give real personal disposable income.

Labour market equations

E3ME includes a detailed treatment of the labour market with sets of equations for employment demand, labour supply, average earnings and hours worked. The equations for labour demand, wages and hours worked are estimated and solved for 42 economic sectors, defined at NACE 2-digit level. Labour participation rates are disaggregated by gender and five-year age band, and multiplied by Eurostat population data to obtain labour supply.

Employment is modelled using national accounts data, as a total headcount number for each industry and region as a function of industry output, wages, hours worked, technological progress, and energy prices. Industry output is assumed to have a positive effect on employment, while the effect of higher wages and longer working hours is assumed to be negative. The effects of technical progress are ambiguous, as investment may create or replace labour; this will vary between sectors.

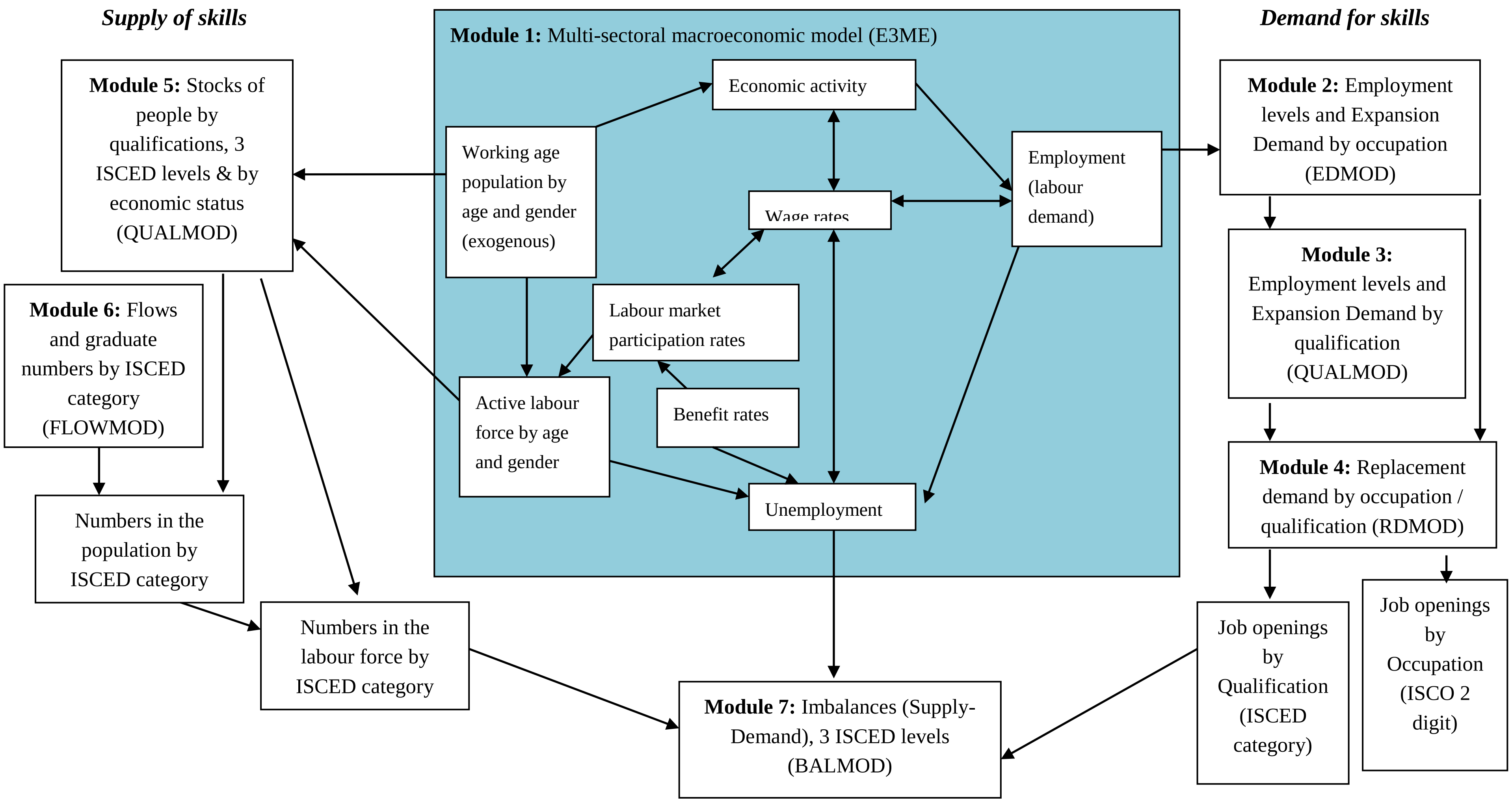
Labour market participation is estimated as a rate between 0 and 1 for each gender/age group. Labour market participation is a function of output, wages, unemployment and benefit rates. Participation is assumed to be higher when output and wages are growing, but falls when unemployment is high, or benefits create a disincentive to work. In addition, there is a measure of economic structure and the relative size of the service sector of the economy; this has been found to be important in determining female participation rates. The participation rates determine the stock of employment available (by multiplying by working-age population, which is exogenous). This is an important factor in determining unemployment, which in turn feeds into wages and back to labour market participation.

In E3ME wages are determined by a complex union bargaining system that includes both worker productivity effects and prices and wage rates in the wider economy. Other important factors include unemployment, tax rates and cyclical effects. Generally it is assumed that higher prices and productivity will push up wage rates, but rising unemployment will reduce wages. A single average wage is estimated for each region and sector. The estimates of average wages are a key input to both the employment equations and the price equations in E3ME. In the absence of growing output, rising wages will increase overall unit costs and industry prices. These prices may get passed on to other industries (through the input-output relationships), building up inflationary pressure.

Hours worked is a simple equation, where average hours worked by industry and region is a function of ‘normal hours-worked ‘ (hours worked in other industries and regions) and technological progress. It is assumed the effects of technical progress gradually reduce average hours worked over time as processes become more efficient. The resulting estimate of hours worked is an explanatory variable in the employment equation (see above). Hours worked is defined as an average across all workers in an industry, so incorporates the effects of higher levels of part-time employment in certain regions and industries.

In the work for CEDEFOP the E3ME model has been extended to include detailed analysis of the demand for and supply of skills (as measured by occupation and qualification). Figure B.1 provides a summary.

Figure B.1: Modelling the Demand for and Supply of Skills – E3ME Extended



Box B.1: The Industrial Employment Equations

THE INDUSTRIAL EMPLOYMENT EQUATIONS

Co-integrating long-term equation:

LN(YRE(.))			[total employment]
	=	BYRE(.,11)	
	+	BYRE(.,12) * LN(YR(.))	[real output]
	+	BYRE(.,13) * LN(YRWC(.))	[real wage costs]
	+	BYRE(.,14) * LN(YRH(.))	[hours worked effect]
	+	BYRE(.,15) * LN(PQRM(.,3))	[real oil price effect]
	+	BYRE(.,16) * LN(YRKC(.) * YRKS(.))	[ICT technological progress]
	+	BYRE(.,17) * LN(YRKN(.))	[non-ICT technological progress]
	+	BYRE(.,18) * RDEU	[German unification]
	+	ECM	[error]

Dynamic equation:

DLN(YRE(.))			[change in total employment]
	=	BYRE(.,1)	
	+	BYRE(.,2) * DLN(YR(.))	[real output]
	+	BYRE(.,3) * DLN(LYLC(.))	[real wage costs]
	+	BYRE(.,4) * DLN(YRH(.))	[hours worked effect]
	+	BYRE(.,5) * DLN(PQRM(.,3))	[real oil price effect]
	+	BYRE(.,6) * DLN(YRKC(.) * YRKS(.))	[ICT technological progress]
	+	BYRE(.,7) * DLN(YRKN(.))	[non-ICT technological progress]
	+	BYRE(.,8) * DRDEU	[German unification]
	+	BYRE(.,9) * DLN(YRE)(-1)	[lagged change in employment]
	+	BYRE(.,10) * ECM(-1)	[lagged error correction]

Identity:

LYLC	=	(YRLC(.) / PYR(.)) / YREE(.)	[real wage costs]

Restrictions:

BYRE(.,2),BYRE(.,12) >= 0	['right sign']
BYRE(.,3),BYRE(.,4) BYRE(.,14) <= 0	['right sign']
0 > BYRE(.,10) > -1	['right sign']

Definitions:

YRE	is a matrix of total employment for 42 industries and 29 regions, in thousands of persons.
BYRE	is a matrix of parameters.
YR	is a matrix of gross industry output for 42 industries and 29 regions, m euro at 2000 prices.
YRH	is a matrix of average hours worked per week for 42 industries and 29 regions.
YRLC	is a matrix of employer wage costs (wages plus imputed social security contributions) for 42 industries and 29 regions, local currency at current prices.
YRKC	is a matrix of ICT technological progress for 42 industries and 29 regions.
YRKN	is a matrix of non-ICT technological progress for 42 industries and 29 countries.
YRKS	is a matrix of skills for 42 industries and 29 regions.
PYR	is a matrix of industry output prices for 42 industries and 29 regions, 2000 = 1.000, local currency.
YREE	is a matrix of wage and salary earners for 29 regions, in thousands of persons.
PQRM	is a matrix of import prices for 42 industries and 29 regions, 2000 = 1.000, local currency.
RDEU	is a dummy matrix for German unification (= 0 for other countries).
(.)	indicates that a matrix is defined across sectors.
LN	indicates natural logarithm.
DLN	indicates change in natural logarithm.
ECM	[error].

Box B.2: The Industrial Hours Worked Equations

THE INDUSTRIAL HOURS-WORKED EQUATIONS

Co-integrating long-term equation:

LN(YRH(.))			[average hours worked]
	=	BYRH(.,9)	
	+	BYRH(.,10) * LN(YRNH(.))	[normal hours worked]
	+	BYRH(.,11) * LN(YRKC(.)*(YRKS(.))	[ICT technological progress]
	+	BYRH(.,12) * LN(YRKN(.))	[non-ICT technological progress]
	+	BYRH(.,13) * RDEU	[German unification]
	+	ECM	[error]

Dynamic equations:

DLN(YRH(.))			[change in average hours worked]
	=	BYRH(.,1)	
	+	BYRH(.,2) * DLN(YRNH(.))	[normal hours worked]
	+	BYRH(.,3) * DLN(YRKC(.) * YRKS(.))	[ICT technological progress]
	+	BYRH(.,4) * DLN(YRKN(.))	[non-ICT technological progress]
	+	BYRH(.,5) * LN(YYN(.))	[actual/normal output]
	+	BYRH(.,6) * DRDEU	[German unification]
	+	BYRH(.,7) * DLN(YRH)(-1)	[lagged change in average hours worked]
	+	BYRH(.,8) * ECM(-1)	[lagged error correction]

Restrictions:

BYRH(.,3), BYRH(.,4), BYRH(.,11), BYRH(.,12) <=0	['right sign']
BYRH(.,2),BYRH(.,6) BYRH(.,10) BYRH(.,13) = 1	[normal hours homogeneity]
0 > BYRH(.,8) > -1	['right sign']

Definitions:

YRH	is a matrix of average hours worked per week for 42 industries and 29 regions.
BYRH	is a matrix of parameters.
ECM	[error].
YRKC	is a matrix of ICT technological progress for 42 industries and 29 regions
YRKN	is a matrix of non-ICT technological progress for 42 industries and 29 regions.
YRKS	is a matrix of skills for 42 industries and 29 regions.
YRNH	is a matrix of normal hours worked for 42 industries and 29 regions.
YYN	is a matrix of the ratio of gross output to normal output, for 42 industries and 29 regions.
RDEU	is a dummy matrix for German unification (= 0 for other countries).
(.)	indicates that a matrix is defined across sectors.
LN	indicates natural logarithm.
DLN	indicates change in natural logarithm.
ECM	[error]

Box B.3: The Industrial Average Earnings Equations

THE INDUSTRIAL AVERAGE EARNINGS EQUATIONS

Co-integrating long-term equation:

LN(YRW(.))			[gross nominal average earnings]
	=	BYRW(.,14)	
	+	BYRW(.,15) * LN(YRWE(.))	[external industry wage rates]
	+	BYRW(.,16) * LN(YRXE(.)	[external regional wage rates
	+	BYRW(.,17) * (LYR(.)-LYRE(.)+LPYR(.) -LAPSC)	[productivity effect]
	+	BYRW(.,18) * LN(RUNR)	[unemployment rate effect]
	+	BYRW(.,19) * LN(RBNR)	[benefit rate effect]
	+	BYRW(.,20) * LAPSC	[adjusted consumer prices]
	+	BYRW(.,21) * ARET	[adjusted wage retention rate]
	+	BYRW(.,22) * RDEU	[German unification]
	+	ECM	[error]

Dynamic equation:

DLN(YRW(.))			[change in gross nominal average earnings]
	=	BYRW(.,1)	
	+	BYRW(.,2) * DLN(LYRWE(.))	[external industry wage rates]
	+	BYRW(.,3) * DLN(LYRXE(.))	[external regional wage rates]
	+	BYRW(.,4) * D(LYR(.)-LYRE(.)+LPYR(.) -LAPSC)	[productivity effect]
	+	BYRW(.,5) * DLN(RUNR(.))	[unemployment rate effect]
	+	BYRW(.,6) * DLN(RBNR(.))	[benefit rate effect]
	+	BYRW(.,7) * D(LAPSC)	[adjusted consumer prices]
	+	BYRW(.,8) * DLN(ARET)	[adjusted wage retention rate]
	+	BYRW(.,9) * DRDEU	[German unification]
	+	BYRW(.,10) * D(DLAPSC)	[change in adjusted consumer price deflator]
	+	BYRW(.,11) * LN(YYN(.))	[normal/actual output]
	+	BYRW(.,12) * DLN(YRW)(-1)	[lagged change in wage rates]
	+	BYRW(.,13) * ECM(-1)	[lagged error correction]

Identities:

LAPSC	=	LN(PRSC) + LYEC + RRET	[log adjusted consumer price deflator]
LYEC	=	LN(1 + (YEC / RWS))	[log employers' social security rate]
ARET	=	RRET * RETR * RITR	[adjusted wage retention rate]
LN(YRWE(.))	=	SUM OVER I (I NE J) (LN(YRW(I) * YRLC(I) / SUM(YRLC(I)) - LAPSC)	[external industry wage rates]
YRXE(.)	=	LN(YRW(.))*RRDD +LN(EX)-LAPSC	[external regional wage rates]
RBNR	=	RBEN / RWS	[the benefit rate]

Restrictions:

BYRW(.,15) + BYRW(.,16) + BYRW(.,17) = 1	[price homogeneity]
BYRW(.,2),BYRW(.,3),BYRW(.,4),BYRW(.,6),BYRW(.,15) BYRW(.,16),BYRW(.,17),BYRW(.,19) > 0	['right sign']
BYRW(.,5),BYRW(.,18) < 0	['right sign']
0 > BYRW(.,13) > -1	['right sign']

Definitions:

YRW	is a matrix of nominal average earnings (contractual wage) for 42 industries and 29 regions, national currency per person-year.
BYRW	is a matrix of parameters.
YRLC	is a matrix of nominal employer costs (wages and salaries plus employers' and imputed social security contributions) for 42 industries and 29 regions, local currency at current price.
RWS	is a vector of the YRW for 29 regions.
RLC	is a vector of the YRLC for 29 regions.
LYRE	is a matrix of the log of total employment for 42 industries and 29 regions, in thousands of persons.
LYR	is a matrix of the log of gross industry output for 42 industries and 29 regions, national currency at 2000 prices.
LPYR	is a matrix of the log of prices of gross output for 42 industries and 29 regions, 2000 = 1.000, local currency
YYN	is a matrix of the ration of gross output to normal output, for 42 industries and 29 regions.
PRSC	is the price deflator for total consumers' expenditure, 2000 = 1.000, local currency.
RRET	is a vector of wage retention rate for 29 regions
RETR	is a vector of 1 + employers social security rate for 29 regions
RITR	is a vector of 1 + indirect tax rate for 29 regions
RUNR	is the standardised unemployment rate.
RBEN	is the social benefit paid to households, m euro at current prices for 42 industries and 29 regions.
RDTX	is the total direct tax payments made by households, meuro at current prices.
YEC	is a matrix of employers' contributions to NIC, m euro at current prices.
REES	is the total of employees' contributions to NIC, m euro at current prices.
RRDD	is a normalised distance indicator matrix for 29 regions with zeros down the leading diagonal and rows summing to one.
EX	is a vector of exchange rates, local currency per euro, 2000=1.000.
RDEU	is a dummy matrix for German unification (= 0 in other countries).
(.)	indicates that a matrix is defined across sectors.
LN	indicates natural logarithm.
DLN	indicates change in natural logarithm.
ECM	[error].

Box B.4: The Participation Rate Equations

THE PARTICIPATION RATE EQUATIONS

Co-integrating long-term equation:

LN(LRP/(1-LRP))			[participation rate, logistic form]
	=	BLRP(12)	
	+	BLRP(13) * LN(RSQ)	[industry output]
	+	BLRP(14) * LN(RWSR)	[real retained wage rates]
	+	BLRP(15) * LN(LRUN)	[unemployment rate by group]
	+	BLRP(16) * LN(RBPR)	[benefit or pension rate]
	+	BLRP(17) * LN(RSER)	[economic structure]
	+	BLRP(18) * LN(RYH)	[average hours worked]
	+	BLRP(19) * LN(LRQU)	[qualifications mix]
	+	BLRP(20) * RDEU	[German unification]
	+	ECM	[error]

Dynamic equation:

DLN(LRP/(1-LRP))			[participation rate, logistic form]
	=	BLRP(1)	
	+	BLRP(2) * DLN(RSQ)	[industry output]
	+	BLRP(3) * DLN(RWSR)	[real retained wage rates]
	+	BLRP(4) * DLN(LRUN)	[unemployment rate by group]
	+	BLRP(5) * DLN(RBPR)	[benefit or pension rate]
	+	BLRP(6) * DLN(RSER)	[economic structure]
	+	BLRP(7) * DLN(RYH)	[average hours worked]
	+	BLRP(8) * DLN(LRQU)	[qualifications mix]
	+	BLRP(9) * DRDEU	[German unification]
	+	BLRP(10) * DLN(LRP / (1-LRP))(-1)	[lagged change in participation rate]
	+	BLRP(11) * ECM(-1)	[lagged error correction]

Identity:

RWSR	=	EX * (RWS) / (PRSC * REEM)	[real retained wage rates]
LRP	=	RLAB / RPOP	[participation rate]
RBNR	=	RBEN / RWS	[benefit rate (15-49 age groups)]
RSER	=	RSERV / NSERV	[economic structure]

Restrictions:

BLRP(.,2),BLRP(.,3),BLRP(.,13),BLRP(.,14) > 0	['right sign']
BLRP(4),BLRP(5),BLRP(7),BLRP(.,15),BLRP(.,16),BLRP(.,18) < 0	['right sign']
0 > BLRP(.,11) > -1	['right sign']

Definitions:

LRP	is a vector of labour force participation rate for 27 age/gender groups and 29 regions, as a proportion.
BLRP	is a matrix of parameters.
RLAB	is a matrix of labour force for 27 age/gender groups and 29 regions, in thousands of persons.
RPOP	is a matrix of population of working age for 27 age/gender groups and 29 regions, in thousands of persons.
RSQ	is a vector of total gross industry output for 29 regions, m euro at 2000 prices.
RWS	is a vector of total nominal wages and salaries (wages and salaries excluding employers' imputed social security contributions) for 29 regions, m euro at current prices.
LRUN	is the standardised unemployment rate for 27 age/gender groups and 29 regions.
PRSC	is a vector of total consumer price deflator for 29 regions, 2000 = 1.000, local currency.
REEM	is a vector of total wage and salary earners for 29 regions, in thousands of persons.
RBEN	is the social benefit paid to households, national currency at current prices.
RBPR	is the social benefit rate paid to households (15-49 age groups) compared to wages, or average pensions in euros pa (50+ age groups).
RSERV	is total gross output of service industries for 29 regions, m euro at 2000 prices.
NSERV	is total gross output of non-service industries or 29 regions, m euro at 2000 prices.
RSER	is the sectoral concentration variable for 29 regions to represent increased female participation rates.
RYH	is the average hours worked per week for 29 regions.
LRQU	is the the qualifications mix for 27 age/gender groups and for 29 regions.
EX	is a vector of exchange rates, local currency per euro, 2000=1.00.
RDEU	is a dummy matrix for German unification (= 0 in other countries).
(.)	indicates that a matrix is defined across sectors.
LN	indicates natural logarithm.
DLN	indicates change in natural logarithm.
ECM	[error].

Box B.5: Reconciling Demand and Supply - BALMOD

The sorting algorithm at the heart of BALMOD is designed to reconcile the projections from the **Stock model** of supply (numbers available by the three qualification levels) with those from the **demand for qualifications model** (number of jobs requiring particular qualification levels). The former provides a view of supply side developments (the overall numbers of people who have acquired qualifications at the three different levels that are actively searching for work), while the latter is more concerned with changing demand for qualifications within occupations (the number of jobs available requiring particular levels of qualifications).

The module also has to deal with differences between the various estimates of employment used in E3ME (based on National Accounts and LFS data) and the so called Labour Market Accounts Residual (LMAR) which arises in part because of such discrepancies but which is also affected by other issues, including measurement error. The main employment measure used in E3ME is a National Accounts based one. This is referred to as ***unconstrained estimates of employment***. All the estimates by sector and occupation are on this basis. A second measure, based on LFS information and Eurostat demographic data is implicit in the modelling of labour supply. This is referred to as ***supply in employment***. The two differ for a variety of reasons, encompassed under the heading of the LMAR. These include:

- Double jobbing (some people have more than one job);
- Distinction between residence and workplace (many people do not live in the same country as they work, this is especially significant for some small countries such as Luxembourg);
- Statistical errors (in measure of employment, unemployment and related indicators).

The **Sorting** model uses an iterative RAS procedure (see main text) to reconcile two sets of estimates of employment, ***changing*** the overall qualification shares from the **demand for qualifications model (QUALMOD)** to match those from the **Stock model** of supply (STOCKMOD), while at the same time maintaining the patterns of occupational deployment, and ensuring a plausible pattern of unemployment rates for the different qualification categories. It is therefore focused upon which occupations the people with different qualifications end up in.

Overall Unemployment levels are taken from E3ME. This is taken as exogenous for these purposes. The overall level of unemployment is shared out between qualification categories, based on an extrapolation of patterns from historical LFS data. In the current versions it is assumed that the relative rates of unemployment for the three broad qualification categories are maintained. Checks are made to see that this results in plausible unemployment levels for the three qualification categories. The implied unemployment levels by qualification are then deducted from the overall supply numbers to get the numbers of people in employment by qualification level (**Supply in employment**). The sorting model then reconciles these estimates with the number of jobs available (unconstrained estimates) by altering the shares of people with the three different qualification levels employed within each occupation until the overall numbers match the numbers of people available.

The final results may show indications of over or under-qualification of people in different occupations, depending on the overall demand supply balance.

The ***constraint*** (matching of numbers by the three qualifications levels) is imposed at the 2 digit occupational level. The key dimensions in the SORT routine are:

- Occupation (27)
- Qualification level (3).
- Sector (41)

(although the results in a number of the summary tables in the ***Imbalances*** workbook where this is undertaken

RAS procedure A RAS procedure (also known as Iterative Proportional Filling Procedure) is a numerical method for scaling disaggregated data sets so that they add up to two published totals. It was originally developed in the 1960s and is used quite commonly in this type of analysis where there are several dimensions to which estimated data points must be fitted. The procedure is iterative and essentially involves putting the data into a matrix and then repeatedly scaling by row and by column until all the elements of the matrix sum horizontally and vertically to the required total.

Projecting the demand for skills

When it comes to modelling the occupational and educational structure of employment, there is often a considerable gap between theory and practice. In theory there are various factors that might be expected to explain changes in occupational and qualifications structure. However, the estimation of complex, behavioural models is limited in practice, due to data restrictions. The methodology utilized for this project is based on simple extrapolation techniques assuming that past trends within sectors will continue into the future.

The models estimated are of the general form shown in equation (1):

Sijt = F(time) (1)

Three main specifications were adopted. These range from simple extrapolation between fixed points, to various methods based on line fitting. The latter includes fitting:

- a linear trend, [S = a + b*Time], (2)
- a log linear trend [Ln(S) = a + b*Time] (3)
- or a logistic equation [Ln(S/(1-S)) = a + b*Time] (4)

These are based on analysis of occupations/qualifications shares in employment extracted from the EU LFS data, and adopting specifications as in equations (1) – (4). In order for all the shares to add to 100% an ad hoc external constraint is imposed in all the above models.

The first method is a linear trend estimated by regressing the occupational/qualifications shares within each sectoral category against time. The drawback of this method is that the projections of proportions can easily go beyond 100% and thus an external constraint needs to be imposed. The problem of the 0-1 restriction can be resolved using the second method, which regresses the natural logarithm of an occupational/qualifications share against time. A problem of this approach is the sigmoid distribution of the dependent variable. In particular, the projected values of the dependent variable may show an exponential growth, which can result in rather implausible projections. This problem, however, can be resolved by the third model, in which the dependent variable goes through a logit transformation. This transformation linearises the sigmoid distribution of the dependent variable. After running the model, predictions of the dependent variable are produced and the reverse logits are estimated. Since the third model overcomes both the 0%-100% constraint and sigmoid distribution of the dependent variable, the results from the third model are set as the default ones.

Alternative specifications, including non-linear effects, were also tested during the development phase of the model. However, the empirical results showed that this did not provide significant benefits in terms of fitting the equation to the data, so the preference was to use the simpler specification shown above.

E3ME's projections of sectoral employment are then used in order to map IER's projections of occupational and qualifications structure and derive projected levels of occupations and qualifications employment. The fact that the modelling exercise does not include links between the structure of occupational and qualification employment and economic indicators (e.g. pay or other economic indicators, such as productivity, investments or R&D) is reflected in the lack of variation in the projections across different scenarios. In particular, projected levels of employment of occupations and qualifications show very little variation across the alternative scenarios. Thus the choice of scenario has only a very small impact on the levels of employment by occupation and qualification.

Appendix C: Detailed Results in 2020

Table 7.1: EU27 Employment (000s), Difference From Base

EU27 EMPLOYMENT (000s), DIFFERENCE FROM BASE						
	Base	**Ref**	**S3**	**S4**	**S5**	**S6**
1 Agriculture etc.	9510.3	19.3	19.8	24.3	41.7	53.5
2 Coal	263.2	0.0	0.0	0.0	0.0	0.0
3 Oil & Gas etc.	94.5	0.0	0.0	0.0	0.0	0.0
4 Other Mining	249.6	-0.1	-0.2	0.0	-0.5	-1.8
5 Food, Drink & Tob.	5000.5	7.2	7.0	8.9	13.8	28.8
6 Text., Cloth. & Leath	2385.1	12.0	10.8	8.1	15.1	12.1
7 Wood & Paper	1918.5	5.2	4.6	6.0	7.7	18.5
8 Printing & Publishing	1879.5	5.0	4.3	5.6	5.8	12.9
9 Manuf. Fuels	154.7	-1.0	-0.9	-1.3	-3.2	-5.7
10 Pharmaceuticals	573.8	0.8	0.7	1.9	2.0	0.4
11 Chemicals nes	1235.9	3.1	3.2	5.1	6.2	13.2
12 Rubber & Plastics	1578.1	8.2	7.4	8.5	9.1	22.7
13 Non-Met. Min. Prods.	1574.2	3.6	2.8	3.4	8.9	3.2
14 Basic Metals	1030.9	3.1	3.1	2.7	3.0	11.3
15 Metal Goods	3938.4	14.9	14.3	17.1	19.9	25.1
16 Mech. Engineering	3248.8	13.3	13.0	16.4	17.0	2.8
17 Electronics	1359.4	1.3	0.9	0.9	0.7	4.0
18 Elec. Eng. & Instrum.	2026.2	4.3	3.2	6.5	4.9	5.4
19 Motor Vehicles	2319.2	4.8	4.2	5.1	9.0	11.5
20 Oth. Transp. Equip.	765.0	0.6	0.6	0.5	0.9	2.0
21 Manuf. nes	2624.2	4.8	3.8	5.9	8.8	10.8
22 Electricity	862.2	-2.6	-1.9	-7.3	-12.4	-15.8
23 Gas Supply	209.7	-15.2	-15.2	-3.8	-20.4	-29.1
24 Water Supply	341.1	0.0	0.0	0.0	0.0	0.0
25 Construction	15085.6	28.7	25.5	42.8	28.4	413.2
26 Distribution	16424.1	9.8	2.8	14.7	5.9	-16.9
27 Retailing	18709.8	4.1	4.7	14.2	24.1	3.8
28 Hotels & Catering	11774.4	11.7	10.8	10.6	21.4	4.5
29 Land Transport etc.	9204.0	1.7	5.5	14.1	17.9	38.0
30 Water Transport	251.5	-0.1	0.1	0.4	0.6	1.8
31 Air Transport	1120.7	2.2	2.1	3.8	7.5	11.7
32 Communications	3163.4	17.7	16.6	17.1	29.7	38.1
33 Banking & Finance	4373.3	1.4	0.6	2.4	1.8	-1.7
34 Insurance	1132.5	0.5	0.3	0.9	1.0	0.6
35 Computing Services	2785.1	5.9	4.8	7.4	2.6	13.9
36 Prof. Services	8581.7	22.9	17.2	15.1	17.4	6.2

EU27 EMPLOYMENT (000s), DIFFERENCE FROM BASE

	Base	Ref	S3	S4	S5	S6
37 Other Bus. Services	20235.3	32.7	23.8	49.5	45.3	44.6
38 Public Admin. & Def.	14394.4	0.0	0.0	0.0	0.0	0.0
39 Education	15778.7	0.0	0.0	0.0	0.0	0.0
40 Health & Social Work	22487.1	0.0	0.0	0.0	0.0	0.0
41 Misc. Services	16652.2	-36.1	-32.3	-44.0	-70.6	-94.8

Note(s): Figures shown for scenarios ref – s6 are difference from Baseline, 000s.
Energy supplies are assumed to be exogenous so employment in the extraction sectors is unchanged.
Public sector employment is also assumed to be exogenous.
Source(s): E3ME, Cambridge Econometrics.

Table 7.2: Labour Force by Country (000s), Difference From Base

LABOUR FORCE BY COUNTRY (000s), DIFFERENCE FROM BASE

	Base	Ref	S3	S4	S5	S6
Belgium	4775.9	1.9	1.9	2.6	1.8	4.7
Denmark	2923.6	-1.4	-1.4	-1.6	-2.8	-4.5
Germany	40776.1	-27.6	-24.2	-39.4	-88.4	-126.1
Greece	4904.0	-1.1	-1.4	-0.4	-3.7	-4.9
Spain	24012.1	6.1	3.8	14.4	10.7	22.3
France	27846.5	-6.6	-7.2	-9.0	-18.0	-21.1
Ireland	2545.4	0.7	0.9	1.9	0.3	3.4
Italy	24311.6	-1.2	-1.9	-7.8	-20.6	1.0
Luxembourg	234.8	0.0	0.0	0.0	0.0	0.1
Netherlands	8752.6	-1.9	-1.3	0.3	-22.0	-4.6
Austria	4277.4	0.6	0.5	2.0	2.1	3.8
Portugal	5702.2	23.6	23.2	20.9	26.5	59.5
Finland	2621.4	0.6	0.6	1.0	1.2	5.8
Sweden	5207.6	3.1	3.2	2.4	2.5	8.9
United Kingdom	32365.9	-5.6	-8.3	-10.4	-24.6	-38.7
Czech Republic	5085.7	0.0	0.1	-1.0	-3.0	8.4
Estonia	667.1	0.7	0.6	0.5	1.0	2.4
Cyprus	488.7	-0.1	-0.1	-0.3	-0.4	-0.1
Latvia	1095.5	0.8	0.8	0.4	0.1	3.2
Lithuania	1584.0	0.0	0.0	0.6	-0.6	1.7
Hungary	4182.6	-0.3	0.3	-0.1	-3.0	7.0
Malta	169.9	-0.1	-0.1	-0.1	-0.2	0.0
Poland	16655.8	-4.4	-6.4	-6.5	-2.5	-13.3
Slovenia	944.6	0.2	0.1	-0.1	-0.6	-0.8
Slovakia	2666.7	-0.4	-0.3	0.5	-1.8	5.0
Bulgaria	3310.3	-1.1	-1.6	-0.7	-1.8	4.7
Romania	9624.6	2.1	0.6	-0.4	-3.3	-14.2
EU27	237732.5	-11.5	-17.7	-30.2	-151.0	-86.5

Note(s): Figures shown for scenarios ref – s6 are difference from Baseline, 000s.
Source(s): E3ME, Cambridge Econometrics.

Table 7.3: EU27 Labour Force by Labour Group (000s), Difference from Base

EU27 LABOUR FORCE BY LABOUR GROUP (000s), DIFFERENCE FROM BASE

	Base	Ref	S3	S4	S5	S6
1 Male 15-19	2992.8	3.4	3.1	2.0	0.7	10.1
2 Male 20-24	9164.6	0.8	1.3	0.2	0.6	11.0
3 Male 25-29	13982.8	6.9	7.9	4.5	6.1	20.6
4 Male 30-34	15902.6	1.4	1.6	0.5	-2.4	0.3
5 Male 35-39	16980.1	3.6	4.4	2.0	2.2	3.5
6 Male 40-44	17296.7	4.6	4.9	2.9	4.0	9.1
7 Male 44-49	16083.5	-1.8	-1.7	0.3	-1.1	7.0
8 Male 50-54	16035.2	-0.7	-1.3	0.1	-3.5	-3.6
9 Male 55-59	12940.0	-7.4	-7.0	-10.7	-26.2	-25.3
10 Male 60-64	6405.8	-18.1	-21.3	-12.6	-48.4	-48.8
11 Male 65+	3192.4	-2.9	-4.3	-6.1	-17.2	-31.4
12 Female 15-19	2464.3	0.9	1.2	-0.3	-3.5	4.8
13 Female 20-24	7596.5	0.7	0.1	0.5	-0.9	6.4
14 Female 25-29	12019.3	7.5	7.9	4.2	6.5	14.0
15 Female 30-34	13031.7	3.1	3.0	3.3	3.9	15.1
16 Female 35-39	14309.4	4.5	4.6	3.0	2.1	4.9
17 Female 40-44	14712.9	5.6	5.7	4.4	1.4	9.7
18 Female 45-49	13749.3	-1.5	-1.3	-2.9	-4.7	0.6
19 Female 50-54	13230.2	-3.0	-3.7	-5.5	-10.8	-11.1
20 Female 55-59	10029.2	-3.7	-5.7	-1.8	-17.6	-7.0
21 Female 60-64	3948.3	-12.8	-14.3	-13.9	-33.9	-51.4
22 Female 65+	1664.9	-2.7	-2.7	-4.3	-8.4	-24.8
23 Total 15-19	5457.2	4.3	4.3	1.7	-2.9	14.8
24 Total 20-24	16761.1	1.4	1.4	0.8	-0.2	17.4
25 Total 25-29	26002.1	14.4	15.8	8.7	12.7	34.6
26 Total 30-34	28934.3	4.6	4.6	3.8	1.6	15.4
27 Total 35-39	31289.5	8.2	9.0	5.0	4.3	8.4
28 Total 40-44	32009.6	10.2	10.5	7.3	5.4	18.8
29 Total 45-49	29832.7	-3.3	-3.0	-2.6	-5.8	7.6
30 Total 50-54	29265.4	-3.6	-4.9	-5.4	-14.3	-14.7
31 Total 55-59	22969.2	-11.1	-12.7	-12.5	-43.9	-32.3
32 Total 60-64	10354.1	-30.9	-35.6	-26.4	-82.3	-100.3
33 Total 65+	4857.4	-5.7	-7.0	-10.5	-25.6	-56.2

Note(s): Figures shown for scenarios ref – s6 are difference from Baseline, 000s.
Source(s): E3ME, Cambridge Econometrics.

Table 7.4: EU27 Employment (000s), Difference From Base

EU27 EMPLOYMENT (000s), DIFFERENCE FROM BASE					
	Base	**Ref**	**SS1**	**SS21**	**SS22**
1 Agriculture etc.	9510.3	19.3	19.9	-151.7	-133.5
2 Coal	263.2	0.0	0.0	0.0	0.0
3 Oil & Gas etc.	94.5	0.0	0.0	0.0	0.0
4 Other Mining	249.6	-0.1	-0.1	-13.8	-13.9
5 Food, Drink & Tob.	5000.5	7.2	7.0	-83.4	-77.0
6 Text., Cloth. & Leath	2385.1	12.0	12.9	-171.8	-160.2
7 Wood & Paper	1918.5	5.2	5.4	-38.9	-33.8
8 Printing & Publishing	1879.5	5.0	5.1	-90.1	-86.3
9 Manuf. Fuels	154.7	-1.0	-1.0	-1.7	-2.4
10 Pharmaceuticals	573.8	0.8	0.6	0.6	1.6
11 Chemicals nes	1235.9	3.1	2.9	-7.8	-4.7
12 Rubber & Plastics	1578.1	8.2	7.8	-46.2	-39.6
13 Non-Met. Min. Prods.	1574.2	3.6	2.6	15.8	17.9
14 Basic Metals	1030.9	3.1	5.1	-29.4	-26.4
15 Metal Goods	3938.4	14.9	16.1	-32.5	-17.9
16 Mech. Engineering	3248.8	13.3	10.3	76.4	90.2
17 Electronics	1359.4	1.3	1.0	-29.1	-27.8
18 Elec. Eng. & Instrum.	2026.2	4.3	3.9	-47.3	-41.9
19 Motor Vehicles	2319.2	4.8	4.3	18.5	23.7
20 Oth. Transp. Equip.	765.0	0.6	0.8	-12.1	-11.7
21 Manuf. nes	2624.2	4.8	3.9	-112.4	-108.3
22 Electricity	862.2	-2.6	-2.7	-13.0	-15.6
23 Gas Supply	209.7	-15.2	-15.2	-4.3	-19.2
24 Water Supply	341.1	0.0	0.0	0.0	0.0
25 Construction	15085.6	28.7	23.8	-291.4	-263.9
26 Distribution	16424.1	9.8	7.2	-138.5	-132.6
27 Retailing	18709.8	4.1	0.4	43.3	45.7
28 Hotels & Catering	11774.4	11.7	11.2	-43.6	-32.5
29 Land Transport etc.	9204.0	1.7	0.2	-50.6	-49.5
30 Water Transport	251.5	-0.1	-0.2	2.7	2.6
31 Air Transport	1120.7	2.2	2.3	-27.8	-25.8
32 Communications	3163.4	17.7	17.6	-57.6	-41.4
33 Banking & Finance	4373.3	1.4	1.1	-32.5	-31.1
34 Insurance	1132.5	0.5	0.4	-17.1	-16.7
35 Computing Services	2785.1	5.9	3.9	-74.2	-67.6
36 Prof. Services	8581.7	22.9	21.7	-390.7	-366.8
37 Other Bus. Services	20235.3	32.7	28.7	282.3	312.3

EU27 EMPLOYMENT (000s), DIFFERENCE FROM BASE

	Base	Ref	SS1	SS21	SS22
38 Public Admin. & Def.	14394.4	0.0	0.0	0.0	0.0
39 Education	15778.7	0.0	0.0	0.0	0.0
40 Health & Social Work	22487.1	0.0	0.0	0.0	0.0
41 Misc. Services	16652.2	-36.1	-39.0	-183.0	-217.4

Note(s): Figures shown for scenarios ref – ss22 are difference from Baseline, 000s.
Energy supplies are assumed to be exogenous so employment in the extraction sectors is unchanged.
Public sector employment is also assumed to be exogenous.
Source(s): E3ME, Cambridge Econometrics.

Table 7.5: Labour Force by Country (000s), Difference From Base

LABOUR FORCE BY COUNTRY (000s) – DIFFERENCE FROM BASE

	Base	Ref	SS1	SS21	SS22
Belgium	4775.9	1.9	2.2	-22.6	-20.9
Denmark	2923.6	-1.4	-1.5	-17.8	-19.0
Germany	40776.1	-27.6	-28.3	-245.8	-270.2
Greece	4904.0	-1.1	-1.9	-71.1	-72.3
Spain	24012.1	6.1	5.9	-219.9	-217.0
France	27846.5	-6.6	-5.7	-111.0	-116.9
Ireland	2545.4	0.7	0.5	-14.5	-13.9
Italy	24311.6	-1.2	-3.1	-84.7	-84.4
Luxembourg	234.8	0.0	0.0	-0.5	-0.5
Netherlands	8752.6	-1.9	-1.9	5.4	3.9
Austria	4277.4	0.6	0.2	-22.8	-21.9
Portugal	5702.2	23.6	23.6	-39.6	-15.8
Finland	2621.4	0.6	0.7	-7.5	-7.0
Sweden	5207.6	3.1	3.4	-13.1	-10.3
United Kingdom	32365.9	-5.6	-9.1	-111.5	-115.8
Czech Republic	5085.7	0.0	0.2	-18.5	-18.1
Estonia	667.1	0.7	0.6	-3.4	-2.8
Cyprus	488.7	-0.1	-0.1	1.3	1.2
Latvia	1095.5	0.8	0.9	-5.0	-4.3
Lithuania	1584.0	0.0	-0.4	-7.3	-7.1
Hungary	4182.6	-0.3	-0.5	-26.4	-26.8
Malta	169.9	-0.1	-0.1	-0.2	-0.3
Poland	16655.8	-4.4	-4.9	-126.0	-131.7
Slovenia	944.6	0.2	0.1	-2.7	-2.5
Slovakia	2666.7	-0.4	-0.4	-5.5	-5.8
Bulgaria	3310.3	-1.1	-1.0	-16.7	-17.7
Romania	9624.6	2.1	1.1	-99.6	-97.2
EU27	237732.5	-11.5	-19.4	-1287.2	-1295.0

Note(s): Figures shown for scenarios ref – ss22 are difference from Baseline, 000s.
Source(s): E3ME, Cambridge Econometrics.

Table 7.6 EU27 Labour Force by Labour Group (000s), Difference from Base – Sensitivity Scenarios

EU27 LABOUR FORCE BY LABOUR GROUP (000s), DIFFERENCE FROM BASE

	Base	Ref	SS1	SS21	SS22
1 Male 15-19	2992.8	3.4	3.7	-9.6	-6.4
2 Male 20-24	9164.6	0.8	0.8	-28.2	-27.4
3 Male 25-29	13982.8	6.9	6.9	-34.3	-27.5
4 Male 30-34	15902.6	1.4	1.3	-9.9	-8.7
5 Male 35-39	16980.1	3.6	2.9	-12.7	-9.2
6 Male 40-44	17296.7	4.6	4.1	-30.3	-25.6
7 Male 44-49	16083.5	-1.8	-1.9	-27.8	-29.3
8 Male 50-54	16035.2	-0.7	-1.6	-60.6	-60.8
9 Male 55-59	12940.0	-7.4	-7.3	-106.3	-113.5
10 Male 60-64	6405.8	-18.1	-18.2	-208.1	-224.0
11 Male 65+	3192.4	-2.9	-3.9	-98.4	-101.1
12 Female 15-19	2464.3	0.9	0.5	-14.4	-13.5
13 Female 20-24	7596.5	0.7	0.6	-18.5	-18.0
14 Female 25-29	12019.3	7.5	7.4	-62.6	-54.9
15 Female 30-34	13031.7	3.1	3.1	-27.1	-24.2
16 Female 35-39	14309.4	4.5	3.4	-22.4	-18.2
17 Female 40-44	14712.9	5.6	5.5	-47.9	-41.8
18 Female 45-49	13749.3	-1.5	-1.3	-11.4	-12.6
19 Female 50-54	13230.2	-3.0	-3.9	-82.2	-85.6
20 Female 55-59	10029.2	-3.7	-4.7	-193.3	-196.8
21 Female 60-64	3948.3	-12.8	-13.0	-134.8	-146.9
22 Female 65+	1664.9	-2.7	-3.7	-46.4	-49.1
23 Total 15-19	5457.2	4.3	4.2	-24.0	-19.8
24 Total 20-24	16761.1	1.4	1.4	-46.7	-45.4
25 Total 25-29	26002.1	14.4	14.3	-96.9	-82.4
26 Total 30-34	28934.3	4.6	4.3	-37.0	-32.9
27 Total 35-39	31289.5	8.2	6.2	-35.0	-27.4
28 Total 40-44	32009.6	10.2	9.6	-78.2	-67.4
29 Total 45-49	29832.7	-3.3	-3.2	-39.2	-41.9
30 Total 50-54	29265.4	-3.6	-5.5	-142.8	-146.4
31 Total 55-59	22969.2	-11.1	-11.9	-299.6	-310.3
32 Total 60-64	10354.1	-30.9	-31.2	-342.9	-370.9
33 Total 65+	4857.4	-5.7	-7.7	-144.9	-150.1

Note(s): Figures shown for scenarios ref – ss22 are difference from Baseline, 000s.
Source(s): E3ME, Cambridge Econometrics.

Table 7.7 Baseline Average Annual Employment Growth (%) 2010-20, EU27

BASELINE AVERAGE ANNUAL EMPLOYMENT GROWTH (%) 2010-20, EU27

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
Agriculture	-0.6	-1.0	-1.1	-2.0	0.2	-0.9	-0.7	-3.1	-0.7	-1.6	-1.2	-1.3	-1.6	-1.0
Extraction Industries	-0.6	-1.6	-3.9	-0.9	-0.4	0.5	-4.1	-1.8	0.0	-1.1	-1.9	0.0	1.0	2.9
Basic manufacturing	-1.6	0.7	-1.0	-1.5	1.4	0.1	1.4	-1.1	0.2	-1.1	-0.7	-0.5	-1.1	0.7
Engineering equipment	0.0	1.3	-0.4	0.6	1.8	-0.8	1.4	0.3	2.0	-0.6	-0.5	0.2	1.0	0.0
Utilities	-1.7	-1.0	-0.5	0.3	2.4	0.5	0.7	-1.8	-0.1	-0.3	-2.1	-0.5	-1.1	1.3
Construction	1.2	0.3	0.0	-1.1	-2.0	0.4	3.0	-0.7	0.7	0.4	2.0	1.1	0.5	0.2
Distribution and retail	0.0	-0.3	-0.4	0.6	3.7	0.3	3.3	-0.1	1.2	0.8	0.2	1.4	-0.1	0.5
Transport and communications	1.4	0.9	-0.2	0.1	1.5	0.7	1.8	-1.7	0.8	-0.7	-0.1	0.0	-1.9	3.7
Business services	1.4	0.8	0.6	1.0	1.3	1.1	2.9	2.1	1.4	0.7	2.1	1.6	0.7	2.0
Public services	0.5	0.0	0.3	0.6	2.1	0.3	3.1	0.3	1.0	0.2	0.5	0.2	0.6	1.4

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
Agriculture	-0.8	-2.1	-3.2	-0.5	-0.3	-3.4	-1.8	-1.3	-3.4	-3.1	-1.8	-3.3	-2.5
Extraction Industries	-3.7	-0.2	-4.2	0.0	-2.9	-2.4	-3.1	-2.0	-4.8	-0.8	-2.1	-0.4	-1.0
Basic manufacturing	-1.7	-0.4	-1.1	-0.2	-0.8	-0.4	-1.6	-1.0	-0.4	-1.5	-0.4	-3.1	-0.5
Engineering and transport equipment	-1.0	-0.3	6.7	1.3	3.0	-0.4	-0.3	-2.8	-1.2	-1.1	-0.6	-2.7	-4.0
Utilities	-1.4	-0.7	-1.9	-0.5	-3.0	-3.5	0.0	-2.1	-4.4	-1.0	0.2	1.8	-0.7
Construction	0.6	-1.3	-2.0	5.8	-2.0	2.4	4.1	1.1	0.8	0.9	1.7	1.8	3.2
Distribution and retail	0.7	0.3	0.1	1.4	1.8	1.3	0.2	1.4	0.9	-1.3	1.2	0.6	3.4
Transport and communications	0.5	0.3	2.8	1.5	-0.3	1.0	1.0	0.4	2.1	0.8	0.9	2.1	2.9
Business services	1.8	1.6	1.0	3.2	6.8	4.8	3.5	1.0	3.1	2.2	1.2	4.4	3.1
Public services	0.9	0.5	0.5	3.3	0.0	1.0	0.3	0.7	-0.2	0.2	0.8	0.3	0.4

Source(s): Cambridge Econometrics, CEDEFOP.

Table 7.8 Occupational Change in employment (000s) 2010-2020, Baseline Scenario, EU27+NO+CH

	Total	BE	DK	DE	EL	ES	FR	IE	IT	LX
11 Legislators and senior officials	155	2.4	-1.3	1.3	-0.8	14.0	28.0	7.3	0.1	-0.1
12 Corporate managers	1579	3.0	29.4	15.1	22.7	196.7	244.1	94.7	216.9	1.4
13 Managers of small enterprises	104	9.9	12.3	-172.6	-46.4	161.3	-66.7	-4.8	-57.9	1.4
21 Physical, mathematical and engineering science professionals	972	13.1	28.5	56.6	4.2	150.2	162.0	24.2	127.0	-3.7
22 Life science and health professionals	157	-14.0	8.4	-28.3	-1.5	-29.7	-33.2	-9.1	-5.1	0.2
23 Teaching professionals	-464	-52.8	-4.3	-13.3	8.9	29.9	26.5	4.6	-111.1	4.3
24 Other professionals	2583	57.9	7.5	508.5	-9.8	190.0	18.2	36.6	242.8	25.9
31 Physical and engineering science associate professionals	868	53.2	21.1	-153.6	21.8	209.0	-43.4	14.4	506.3	1.5
32 Life science and health associate professionals	40	-9.9	-6.5	-125.5	18.2	37.7	9.9	6.6	104.1	-0.8
33 Teaching associate professionals	464	59.4	-10.4	47.0	7.5	19.3	78.4	31.5	137.8	-0.6
34 Other associate professionals	3671	25.9	50.5	315.2	115.4	859.8	202.0	23.4	320.6	0.9
41 Office clerks	-1615	-84.6	-50.1	-636.4	-41.7	83.2	-197.9	43.5	-288.4	4.3
42 Customer services clerks	740	10.6	-9.7	342.7	44.3	193.6	-13.6	-8.7	-56.5	3.8
51 Personal and protective services workers	1851	80.0	-0.9	270.5	37.5	524.0	94.7	106.8	-11.0	3.8
52 Models, salespersons and demonstrators	972	5.9	-17.2	-187.1	19.0	372.9	112.2	32.9	107.1	2.7
61 Skilled agricultural and fishery workers	-1821	6.3	-15.3	12.9	-90.1	-67.5	-80.3	2.0	-158.9	0.3
71 Extraction and building trades workers	337	-7.0	10.1	-17.0	-18.6	8.1	-41.0	27.3	-23.2	-1.4
72 Metal, machinery and related trades workers	-1252	-12.3	-7.4	-134.1	-24.0	-53.1	-145.1	22.2	-330.5	-1.3
73 Precision, handicraft, craft printing and related trades workers	-172	-6.3	-0.3	-52.0	-6.4	-27.0	-5.1	1.4	-38.6	-0.2
74 Other craft and related trades workers	-669	-10.1	1.1	-74.9	-12.7	-56.6	-34.2	-3.3	-149.1	1.0
81 Stationary plant and related operators	102	-3.1	0.0	10.3	4.5	48.7	-53.6	-0.2	159.5	0.2
82 Machine operators and assemblers	-236	12.0	9.4	96.1	7.2	-13.2	-35.3	4.0	-146.9	0.8
83 Drivers and mobile plant operators	169	-4.3	4.6	-93.0	5.8	72.6	50.8	28.1	-194.8	0.6
91 Sales and services elementary occupations	1518	22.2	-9.1	92.0	36.7	311.8	237.6	22.5	366.5	3.1
92 Agricultural, fishery and related labourers	-28	0.4	13.4	-38.2	-5.9	69.1	0.0	-3.6	-48.8	0.0
93 Labourers in mining, construction, manu. and transport	1077	9.4	27.7	2.3	1.9	260.2	215.8	4.5	47.1	2.1

	NL	AT	PT	FI	SW	UK	CZ	EN	CY	LV
11 Legislators and senior officials	4.5	-0.6	-0.4	8.0	0.0	-17.5	-2.8	4.1	0.0	7.5
12 Corporate managers	3.0	3.7	30.6	3.6	83.3	466.6	42.4	6.0	3.5	12.0
13 Managers of small enterprises	76.6	-3.7	-48.6	14.4	2.8	122.8	-8.3	7.7	0.4	-4.6
21 Physical, mathematical and engineering science professionals	-19.2	53.0	11.0	24.9	39.8	35.3	19.2	-3.2	4.7	0.4
22 Life science and health professionals	18.5	-10.0	-7.4	6.6	34.3	152.4	14.4	4.2	2.0	-1.7
23 Teaching professionals	-65.7	-19.9	-21.8	-10.9	-13.2	-180.9	7.2	-4.2	5.8	-6.3
24 Other professionals	224.1	11.3	106.0	24.8	179.8	425.1	48.2	0.1	7.9	-1.1
31 Physical and engineering science associate professionals	21.7	24.8	51.4	-4.0	-15.2	65.3	3.5	1.5	2.8	-2.7
32 Life science and health associate professionals	9.1	-28.4	9.2	3.6	21.8	-1.3	13.1	-3.5	0.5	3.1
33 Teaching associate professionals	1.7	-3.3	-6.2	-0.1	26.8	82.9	1.4	-0.4	0.2	-0.8
34 Other associate professionals	26.8	17.7	2.7	48.6	68.2	1087.8	62.5	14.4	7.8	35.5
41 Office clerks	-68.2	-13.0	35.0	-32.6	-15.9	-359.4	-26.7	-1.4	16.9	-0.2
42 Customer services clerks	52.3	11.0	23.0	-0.2	20.7	17.0	21.1	0.4	7.1	1.0
51 Personal and protective services workers	61.0	65.1	4.0	-7.4	16.6	265.5	25.3	-5.6	0.7	46.2
52 Models, salespersons and demonstrators	-32.8	43.1	11.1	-23.2	28.6	320.8	-31.4	-3.1	2.6	-1.4
61 Skilled agricultural and fishery workers	-17.5	-37.3	-33.1	-20.2	-3.7	30.4	-11.8	-4.6	-0.5	-16.9
71 Extraction and building trades workers	16.8	33.4	20.8	-0.4	-6.0	223.4	-35.0	-5.9	6.0	-11.1
72 Metal, machinery and related trades workers	-31.1	-47.7	-1.3	3.4	4.6	-212.4	-52.7	3.4	1.6	-15.1
73 Precision, handicraft, craft printing and related trades workers	-3.2	-4.6	-2.0	-1.6	4.0	-43.2	12.4	-0.2	-0.2	-0.7
74 Other craft and related trades workers	-9.6	0.8	-11.2	2.1	9.9	-28.8	-9.1	0.0	-0.3	-4.0
81 Stationary plant and related operators	4.6	-2.6	12.6	-0.8	-2.0	5.6	-7.2	-2.0	0.2	-1.0
82 Machine operators and assemblers	-23.2	21.7	15.3	2.4	-6.5	-32.9	1.7	16.1	0.0	-2.3
83 Drivers and mobile plant operators	-28.4	-30.4	-2.9	-20.2	-10.2	193.4	-0.1	-1.3	1.0	-12.3
91 Sales and services elementary occupations	8.7	91.5	89.5	1.8	-19.6	19.7	-3.7	8.1	22.6	8.9
92 Agricultural, fishery and related labourers	-1.7	12.8	-9.1	-0.2	2.5	-27.9	-2.1	0.8	1.4	-4.9
93 Labourers in mining, construction, manufacturing and transport	100.3	17.4	30.0	7.2	29.9	198.7	-9.9	5.7	0.8	-9.0

	LT	HU	MT	PL	SI	SK	BG	RO	NO	CH
11 Legislators and senior officials	6.8	-2.1	0.0	0.6	-0.5	-1.5	0.6	3.0	-2.0	96.5
12 Corporate managers	31.8	17.2	0.6	11.4	5.6	4.6	-6.2	23.7	-4.2	15.9
13 Managers of small enterprises	9.3	57.1	0.8	24.3	-5.8	7.4	4.9	19.5	-3.9	-5.3
21 Physical, mathematical and engineering science professionals	28.6	35.3	-0.3	76.5	1.9	-2.0	8.0	-3.8	22.3	77.5
22 Life science and health professionals	-1.6	2.9	0.1	29.8	0.7	0.7	-3.3	17.2	7.5	2.6
23 Teaching professionals	-8.3	-11.5	0.4	-28.3	-2.9	0.5	-6.8	-2.2	-13.1	25.6
24 Other professionals	39.4	36.6	0.0	86.4	7.8	-3.2	25.8	92.5	71.6	122.2
31 Physical and engineering science associate professionals	-1.2	50.5	0.3	13.6	-1.3	-2.3	-2.1	-21.7	11.1	41.5
32 Life science and health associate professionals	-2.7	-27.0	0.1	0.0	-5.7	-13.5	-2.6	25.3	23.4	-18.4
33 Teaching associate professionals	-1.4	9.6	0.4	-2.5	8.5	-4.4	-1.9	-0.2	-10.5	-6.1
34 Other associate professionals	21.5	33.8	0.6	14.1	19.4	53.4	20.0	115.5	110.0	-2.5
41 Office clerks	-2.1	10.7	0.6	10.6	-11.7	-8.4	13.9	47.1	5.7	-47.9
42 Customer services clerks	-1.1	18.2	0.5	31.1	-1.9	6.7	1.8	15.7	10.0	-0.9
51 Personal and protective services workers	18.8	31.9	0.5	153.7	-9.3	30.1	29.8	83.5	-31.5	-33.3
52 Models, salespersons and demonstrators	1.6	-13.6	0.4	124.8	-10.9	-3.3	-0.8	78.4	1.3	31.4
61 Skilled agricultural and fishery workers	-31.5	-22.3	-0.3	-652.2	-33.2	-5.1	-155.4	-381.0	-15.6	-18.6
71 Extraction and building trades workers	11.4	22.8	0.4	21.3	-2.7	14.2	12.7	102.3	-16.5	-8.0
72 Metal, machinery and related trades workers	-6.4	-61.3	-0.6	-18.9	-7.8	-8.5	-4.1	-145.9	9.2	25.5
73 Precision, handicraft, craft printing and related trades workers	2.2	10.1	0.0	-1.6	-1.3	-4.2	-4.2	-11.8	-0.7	13.2
74 Other craft and related trades workers	-7.9	-24.6	0.1	-85.7	-0.3	-9.1	-39.2	-116.6	3.6	-0.7
81 Stationary plant and related operators	0.4	-3.9	-0.1	-28.8	1.1	4.1	-8.3	-38.9	-5.5	8.2
82 Machine operators and assemblers	-0.4	16.3	-1.6	-3.0	-14.9	3.5	-45.5	-131.6	-0.5	15.1
83 Drivers and mobile plant operators	-5.4	31.8	-0.4	43.6	0.9	7.4	-0.7	129.9	3.1	-0.3
91 Sales and services elementary occupations	16.4	10.0	2.4	19.8	12.6	6.3	45.0	90.3	-30.9	35.5
92 Agricultural, fishery and related labourers	-4.9	1.8	0.0	-28.6	5.1	-0.3	-21.9	51.6	0.9	10.3
93 Labourers in mining, construction, manu. and transport	8.8	5.2	0.8	6.1	7.2	12.8	4.4	63.3	4.8	21.7

Note: The categories in Figure 3.3 are aggregated into 9 groups based on the first digit in the codes above.

Table 7.9 Reference scenario, Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	0.0	0.1	0.0	0.0	0.1	-0.2	0.1	-0.2	0.1	0.4	0.1	1.0	0.1	0.3
Expenditure Groups														
First quintile	0.0	0.1	0.0	-0.1	0.1	-0.2	-0.1	-0.4	0.0	0.4	0.1	1.0	0.1	0.3
Second quintile	0.0	0.0	0.0	0.0	0.1	-0.2	0.0	-0.3	0.0	0.4	0.1	1.0	0.1	0.3
Third quintile	0.1	0.0	0.0	0.0	0.1	-0.2	0.1	-0.3	0.0	0.4	0.1	1.0	0.1	0.3
Fourth quintile	0.1	0.1	0.0	0.1	0.1	-0.2	0.1	-0.2	0.1	0.4	0.1	1.0	0.2	0.3
Fifth quintile	0.1	0.0	0.0	0.1	0.1	-0.1	0.2	0.0	0.1	0.4	0.1	1.0	0.2	0.3
Socio-economic groups														
Manual workers	0.1	0.1	0.0	0.1	0.1	-0.1	0.1	-0.1	0.0	0.4	0.1	1.2	0.2	0.3
Non-manual workers	0.0	0.0	0.0	0.0	0.1	-0.1	0.1	-0.1	0.1	0.4	0.1	1.1	0.1	0.3
Self-employed	0.0	0.0	0.0	0.0	0.1	-0.1	0.1	-0.2	0.1	0.3	0.1	1.0	0.1	0.4
Unemployed	-0.1	0.1	-0.2	-0.1	0.1	-0.2	0.0	-0.3	0.0	0.3	0.0	1.0	0.0	0.4
Retired	0.0	0.0	-0.1	-0.1	0.1	-0.3	0.1	-0.4	0.0	0.4	0.1	0.9	0.0	0.4
Inactive	0.0	0.0	-0.2	-0.2	0.0	-0.3	0.0	-0.4	0.0	0.4	0.1	0.9	0.1	0.3
Population Density														
Densely-populated	0.1	0.1	0.0	0.0	0.1	-0.2	0.1	-0.1	0.1	0.4	0.2	1.0	0.1	0.3
Sparsely-populated	0.0	0.1	0.0	0.0	0.0	-0.1	0.1	-0.2	0.0	0.4	0.1	1.0	0.2	0.3

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	0.1	0.3	1.2	0.0	0.2	0.3	1.0	0.0	0.3	0.1	0.5	-0.5	1.0
Expenditure Groups													
First quintile	0.0	0.3	0.8	-0.1	0.2	0.2	0.8	-0.1	-0.3	-0.1	0.4	-0.5	1.0
Second quintile	0.0	0.2	0.8	-0.1	0.0	0.1	0.9	-0.1	-0.4	0.0	0.4	-0.5	0.9
Third quintile	0.1	0.2	1.0	0.0	0.0	0.2	1.0	-0.1	-0.1	0.1	0.5	-0.6	0.9
Fourth quintile	0.1	0.3	1.2	0.0	0.2	0.3	1.1	0.1	0.3	0.2	0.5	-0.6	1.0
Fifth quintile	0.1	0.4	1.4	0.0	0.3	0.3	1.2	0.2	0.7	0.3	0.6	-0.5	1.0
Socio-economic groups													
Manual workers	0.1	0.4	0.9	0.0	0.1	0.2	1.1	-0.1	-0.1	0.1	0.4	-0.4	0.9
Non-manual workers	0.1	0.4	1.1	0.0	0.2	0.2	1.1	0.0	0.3	0.2	0.5	-0.4	0.9
Self-employed	0.1	0.3	1.1	0.0	0.2	0.3	1.0	0.0	0.2	0.2	0.5	-0.5	1.0
Unemployed	0.0	0.1	0.9	0.0	-0.3	0.1	1.0	-0.1	-0.2	-0.2	0.3	-0.5	1.1
Retired	0.0	-0.1	0.8	-0.1	-0.5	0.0	0.8	-0.3	-0.7	-0.1	0.3	-0.8	0.8
Inactive	0.1	-0.1	0.5	-0.1	-0.6	-0.1	1.0	-0.3	-0.7	-0.3	0.0	-0.6	-
Population Density													
Densely-populated	0.1	0.3	1.2	0.0	0.1	0.2	1.1	0.1	0.3	0.2	0.6	-0.7	0.9
Sparsely-populated	0.0	0.4	1.2	0.0	0.2	0.3	1.0	0.1	0.2	0.1	0.5	-0.4	1.0

Source(s): E3ME, Cambridge Econometrics.

Table 7.10 Regulation scenario (S3), Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	0.0	0.0	0.0	0.0	0.0	-0.2	0.1	-0.3	0.0	0.4	0.1	1.0	0.1	0.3
Expenditure Groups														
First quintile	-0.1	0.0	0.0	-0.1	0.0	-0.3	-0.1	-0.5	0.0	0.4	0.1	1.0	0.1	0.3
Second quintile	-0.1	0.0	0.0	0.0	0.0	-0.2	0.0	-0.4	0.0	0.3	0.1	1.0	0.1	0.3
Third quintile	0.0	0.0	0.0	0.0	0.0	-0.2	0.1	-0.3	0.0	0.4	0.1	1.0	0.1	0.3
Fourth quintile	0.0	0.1	0.1	0.0	0.0	-0.2	0.1	-0.3	0.0	0.4	0.1	1.0	0.1	0.3
Fifth quintile	0.0	0.0	0.1	0.0	0.0	-0.2	0.2	-0.1	0.0	0.4	0.1	1.0	0.1	0.3
Socio-economic groups														
Manual workers	0.0	0.1	0.1	0.1	0.0	-0.2	0.1	-0.2	0.0	0.4	0.1	1.1	0.1	0.3
Non-manual workers	0.0	0.0	0.0	0.0	0.0	-0.1	0.1	-0.2	0.0	0.3	0.1	1.1	0.1	0.3
Self-employed	0.0	0.0	0.0	-0.1	0.0	-0.2	0.1	-0.2	0.0	0.3	0.1	0.9	0.0	0.3
Unemployed	-0.2	0.0	-0.2	-0.2	0.0	-0.3	0.0	-0.4	0.0	0.3	0.0	0.9	0.0	0.3
Retired	-0.1	0.0	-0.1	-0.2	-0.1	-0.4	0.0	-0.5	0.0	0.3	0.1	0.9	0.0	0.3
Inactive	-0.1	0.0	-0.2	-0.2	-0.1	-0.4	0.0	-0.5	0.0	0.3	0.1	0.9	0.0	0.2
Population Density														
Densely-populated	0.0	0.1	0.0	0.0	0.0	-0.3	0.1	-0.2	0.0	0.4	0.1	0.9	0.1	0.2
Sparsely-populated	0.0	0.0	0.0	0.0	-0.1	-0.2	0.1	-0.3	0.0	0.4	0.0	1.0	0.1	0.3

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	0.0	0.2	1.2	-0.2	-0.1	0.2	1.0	0.0	0.2	-0.1	0.4	-0.8	0.9
Expenditure Groups													
First quintile	-0.1	0.2	0.8	-0.3	0.0	0.1	0.9	-0.2	-0.4	-0.6	0.3	-0.7	0.9
Second quintile	0.0	0.2	0.8	-0.2	-0.5	0.1	0.9	-0.2	-0.4	-0.4	0.3	-0.7	0.8
Third quintile	0.0	0.2	1.0	-0.2	-0.7	0.1	1.0	-0.1	-0.2	-0.2	0.4	-0.8	0.8
Fourth quintile	0.0	0.3	1.2	-0.2	-0.3	0.2	1.1	0.0	0.2	-0.1	0.5	-0.8	0.9
Fifth quintile	0.1	0.3	1.4	-0.2	-0.1	0.3	1.1	0.1	0.7	0.1	0.5	-0.8	1.0
Socio-economic groups													
Manual workers	0.0	0.3	0.9	-0.2	-0.3	0.1	1.1	-0.1	-0.1	-0.2	0.4	-0.6	0.9
Non-manual workers	0.0	0.3	1.1	-0.2	-0.1	0.2	1.1	-0.1	0.2	0.0	0.5	-0.6	0.9
Self-employed	0.0	0.3	1.1	-0.2	-0.1	0.2	1.0	0.0	0.2	0.0	0.5	-0.7	0.9
Unemployed	0.0	0.0	0.8	-0.3	-1.3	0.0	1.0	-0.2	-0.3	-0.7	0.1	-0.7	1.0
Retired	-0.1	-0.2	0.7	-0.3	-2.1	-0.1	0.8	-0.3	-0.8	-0.7	0.2	-1.0	0.8
Inactive	0.0	-0.2	0.4	-0.5	-1.8	-0.2	1.0	-0.3	-0.8	-0.7	-0.2	-0.9	-
Population Density													
Densely-populated	0.0	0.2	1.1	-0.2	-0.4	0.2	1.1	0.0	0.3	0.0	0.5	-1.0	0.9
Sparsely-populated	-0.1	0.3	1.1	-0.2	-0.1	0.3	1.0	0.0	0.1	-0.2	0.5	-0.6	1.0

Source(s): E3ME, Cambridge Econometrics.

Table 7.11 MBI scenario (S4), Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	0.3	0.2	0.1	0.1	0.2	0.0	0.5	0.0	0.2	0.6	0.3	1.1	0.2	0.3
Expenditure Groups														
First quintile	0.4	0.3	0.1	0.0	0.2	0.0	0.2	-0.1	0.2	0.8	0.3	1.1	0.3	0.4
Second quintile	0.3	0.3	0.1	0.1	0.2	0.0	0.3	-0.1	0.2	0.6	0.3	1.1	0.2	0.3
Third quintile	0.3	0.2	0.1	0.1	0.2	0.0	0.4	-0.1	0.2	0.6	0.3	1.1	0.2	0.3
Fourth quintile	0.4	0.3	0.2	0.1	0.3	0.0	0.5	0.0	0.3	0.6	0.3	1.1	0.3	0.3
Fifth quintile	0.3	0.2	0.1	0.1	0.3	0.0	0.6	0.1	0.3	0.6	0.3	1.1	0.2	0.3
Socio-economic groups														
Manual workers	0.4	0.3	0.1	0.2	0.3	0.0	0.4	0.1	0.2	0.7	0.3	1.2	0.3	0.2
Non-manual workers	0.2	0.1	0.1	0.1	0.3	0.0	0.5	0.0	0.2	0.5	0.2	1.2	0.2	0.3
Self-employed	0.1	0.2	0.1	0.0	0.2	0.0	0.4	-0.1	0.2	0.5	0.2	1.0	0.1	0.5
Unemployed	0.1	0.3	-0.1	-0.1	0.2	-0.1	0.3	-0.1	0.1	0.6	0.1	1.0	0.1	0.8
Retired	0.3	0.2	0.0	0.0	0.2	-0.2	0.4	-0.2	0.3	0.7	0.2	1.0	0.1	0.7
Inactive	0.2	0.2	-0.1	0.0	0.2	-0.1	0.3	-0.2	0.2	0.6	0.1	1.0	0.2	0.3
Population Density														
Densely-populated	0.3	0.2	0.1	0.1	0.3	-0.1	0.5	0.0	0.3	0.6	0.4	1.1	0.2	0.3
Sparsely-populated	0.3	0.3	0.1	0.1	0.2	0.0	0.3	0.0	0.2	0.6	0.2	1.1	0.3	0.3

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	0.2	0.5	1.3	0.0	0.3	0.6	1.3	0.2	0.4	0.3	0.4	-0.8	1.4
Expenditure Groups													
First quintile	0.1	0.4	0.9	0.0	0.3	0.4	1.1	0.0	-0.1	-0.4	0.3	-0.7	1.5
Second quintile	0.1	0.4	0.9	0.0	0.1	0.4	1.2	0.0	-0.2	-0.2	0.3	-0.8	1.2
Third quintile	0.2	0.4	1.1	0.0	0.0	0.4	1.2	0.0	0.0	0.0	0.4	-0.8	1.2
Fourth quintile	0.2	0.5	1.3	0.0	0.2	0.6	1.3	0.2	0.4	0.3	0.5	-0.9	1.3
Fifth quintile	0.3	0.6	1.5	0.1	0.4	0.7	1.4	0.3	0.9	0.6	0.6	-0.9	1.5
Socio-economic groups													
Manual workers	0.2	0.5	0.9	0.0	0.1	0.4	1.3	0.0	-0.1	0.0	0.3	-0.7	1.4
Non-manual workers	0.2	0.6	1.2	0.0	0.3	0.5	1.4	0.1	0.3	0.3	0.4	-0.7	1.3
Self-employed	0.2	0.5	1.2	0.0	0.3	0.6	1.3	0.1	0.2	0.4	0.4	-0.8	1.4
Unemployed	0.2	0.2	1.0	0.0	-0.3	0.3	1.2	0.1	0.0	-0.6	0.2	-0.8	1.5
Retired	0.1	-0.1	0.9	-0.1	-0.7	0.2	1.0	-0.1	-0.6	-0.6	0.2	-1.1	1.2
Inactive	0.2	0.1	0.6	-0.1	-0.6	0.0	1.2	0.0	-0.4	-0.5	-0.2	-1.0	-
Population Density													
Densely-populated	0.2	0.5	1.3	0.0	0.2	0.5	1.3	0.2	0.5	0.5	0.5	-1.0	1.3
Sparsely-populated	0.1	0.5	1.2	0.0	0.3	0.6	1.2	0.2	0.3	0.1	0.4	-0.7	1.5

Source(s): E3ME, Cambridge Econometrics.

Table 7.12 30% Target scenario (S5), Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	0.2	0.1	-0.1	0.0	0.1	-0.2	0.3	-0.4	0.2	0.4	0.3	1.2	0.2	0.4
Expenditure Groups														
First quintile	0.2	0.2	-0.2	0.0	0.1	-0.2	-0.1	-0.8	0.1	0.6	0.3	1.3	0.3	0.6
Second quintile	0.2	0.2	-0.1	0.0	0.1	-0.2	0.1	-0.6	0.1	0.4	0.2	1.2	0.2	0.4
Third quintile	0.2	0.1	-0.1	0.0	0.1	-0.2	0.2	-0.6	0.2	0.4	0.2	1.2	0.2	0.4
Fourth quintile	0.3	0.2	0.0	0.2	0.1	-0.2	0.3	-0.4	0.2	0.5	0.2	1.3	0.3	0.3
Fifth quintile	0.3	0.1	-0.1	0.2	0.2	-0.1	0.5	0.0	0.3	0.4	0.3	1.3	0.2	0.4
Socio-economic groups														
Manual workers	0.4	0.2	-0.1	0.2	0.1	-0.1	0.2	-0.2	0.2	0.5	0.2	1.4	0.3	0.3
Non-manual workers	0.1	0.0	-0.1	0.0	0.1	-0.1	0.4	-0.3	0.2	0.3	0.2	1.4	0.2	0.4
Self-employed	0.0	0.1	-0.1	-0.1	0.0	-0.2	0.2	-0.4	0.1	0.3	0.1	1.2	0.1	0.6
Unemployed	-0.2	0.3	-0.5	-0.3	0.0	-0.3	0.1	-0.6	-0.2	0.3	-0.1	1.1	0.0	1.0
Retired	0.1	0.2	-0.3	-0.2	0.1	-0.4	0.2	-0.8	0.2	0.4	0.1	1.2	0.1	1.0
Inactive	0.0	0.1	-0.4	-0.2	0.0	-0.4	0.1	-0.8	0.1	0.4	0.0	1.1	0.2	0.5
Population Density														
Densely-populated	0.3	0.2	-0.1	0.1	0.2	-0.3	0.4	-0.3	0.2	0.5	0.4	1.3	0.2	0.5
Sparsely-populated	0.2	0.2	-0.1	0.1	0.0	-0.1	0.0	-0.5	0.2	0.4	0.1	1.3	0.3	0.4

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	0.1	0.4	1.8	-0.2	0.1	0.6	2.3	0.1	0.3	0.1	0.4	-1.7	2.4
Expenditure Groups													
First quintile	-0.1	0.4	1.2	-0.3	0.1	0.4	1.7	-0.1	-0.7	-0.7	0.2	-1.5	2.5
Second quintile	-0.1	0.3	1.2	-0.3	-0.4	0.2	1.9	-0.2	-0.9	-0.5	0.2	-1.6	2.1
Third quintile	0.0	0.3	1.5	-0.2	-0.6	0.3	2.2	-0.1	-0.5	-0.2	0.3	-1.7	2.0
Fourth quintile	0.1	0.5	1.8	-0.1	-0.1	0.6	2.3	0.2	0.4	0.1	0.5	-1.8	2.2
Fifth quintile	0.2	0.5	2.1	-0.1	0.2	0.8	2.7	0.3	1.3	0.5	0.7	-1.8	2.5
Socio-economic groups													
Manual workers	0.1	0.6	1.3	-0.2	-0.3	0.3	2.3	-0.1	-0.5	-0.4	0.2	-1.5	2.3
Non-manual workers	0.1	0.6	1.6	-0.2	0.0	0.5	2.5	0.0	0.2	0.2	0.4	-1.5	2.2
Self-employed	0.0	0.5	1.5	-0.2	0.1	0.6	2.3	0.0	0.1	0.2	0.3	-1.6	2.4
Unemployed	0.0	0.0	1.3	-0.3	-1.2	0.1	2.1	-0.1	-0.4	-1.1	0.0	-1.6	2.6
Retired	-0.1	-0.5	1.1	-0.4	-2.1	-0.1	1.5	-0.4	-1.6	-0.9	0.0	-2.1	2.0
Inactive	0.1	-0.2	0.6	-0.5	-1.7	-0.1	2.1	-0.4	-1.3	-1.2	-0.4	-1.9	-
Population Density													
Densely-populated	0.1	0.4	1.8	-0.1	-0.2	0.4	2.4	0.1	0.5	0.4	0.6	-2.1	2.2
Sparsely-populated	-0.2	0.5	1.7	-0.2	0.1	0.7	2.2	0.2	0.2	-0.2	0.4	-1.5	2.6

Source(s): E3ME, Cambridge Econometrics.

Table 7.13 Energy-Efficiency scenario (S6), Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	0.0	0.0	-0.7	-0.9	-0.3	-0.4	0.3	-0.8	0.2	1.5	-0.4	2.6	0.3	1.1
Expenditure Groups														
First quintile	-0.1	0.1	-0.9	-1.0	-0.4	-0.6	-0.4	-1.3	-0.1	2.1	-0.4	2.8	0.4	1.5
Second quintile	-0.1	0.1	-0.7	-0.9	-0.3	-0.5	-0.1	-1.2	0.1	1.6	-0.5	2.6	0.3	1.2
Third quintile	0.0	-0.1	-0.7	-0.9	-0.3	-0.4	0.2	-1.1	0.2	1.5	-0.5	2.6	0.3	0.9
Fourth quintile	0.1	0.1	-0.5	-0.7	-0.2	-0.4	0.4	-0.9	0.3	1.6	-0.5	2.6	0.4	0.8
Fifth quintile	0.2	0.0	-0.6	-0.7	-0.1	-0.2	0.7	-0.4	0.4	1.5	-0.4	2.7	0.3	1.3
Socio-economic groups														
Manual workers	0.2	0.0	-0.7	-0.7	-0.2	-0.2	0.2	-0.7	0.2	1.7	-0.5	3.0	0.5	0.7
Non-manual workers	-0.2	-0.1	-0.7	-0.8	-0.2	-0.3	0.6	-0.8	0.2	1.1	-0.5	2.9	0.2	1.0
Self-employed	-0.5	-0.1	-0.7	-0.9	-0.4	-0.4	0.2	-0.9	0.0	1.2	-0.9	2.5	0.0	2.0
Unemployed	-0.8	-0.1	-1.6	-1.3	-0.5	-0.8	0.0	-1.3	-0.9	1.3	-1.1	2.3	-0.3	3.3
Retired	-0.2	-0.1	-1.2	-1.1	-0.4	-1.0	0.1	-1.6	0.2	1.9	-0.8	2.4	-0.2	3.2
Inactive	-0.4	-0.3	-1.5	-1.1	-0.5	-0.9	0.0	-1.6	0.0	1.6	-0.9	2.3	0.0	1.1
Population Density														
Densely-populated	0.0	0.1	-0.6	-0.7	-0.1	-0.7	0.6	-0.7	0.3	1.6	-0.2	2.6	0.3	1.2
Sparsely-populated	-0.1	0.0	-0.6	-0.8	-0.5	-0.1	-0.2	-1.0	0.2	1.6	-0.8	2.7	0.4	1.2

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	0.0	-0.2	2.6	-0.8	0.1	2.2	3.0	-0.9	-0.3	-0.4	-0.2	-4.4	3.4
Expenditure Groups													
First quintile	-0.2	-0.2	1.6	-1.1	0.4	1.6	2.1	-1.0	-1.6	-1.0	-0.4	-3.9	3.7
Second quintile	-0.2	-0.5	1.8	-1.0	-0.7	1.3	2.6	-0.9	-1.9	-1.0	-0.3	-4.1	3.0
Third quintile	-0.2	-0.5	2.2	-0.9	-1.0	1.5	2.9	-1.0	-1.4	-0.7	-0.1	-4.4	2.8
Fourth quintile	0.0	0.0	2.7	-0.8	-0.1	2.2	3.1	-0.9	-0.3	-0.5	-0.1	-4.5	3.1
Fifth quintile	0.3	0.0	3.1	-0.7	0.4	2.7	3.6	-0.9	0.9	0.1	0.1	-4.6	3.4
Socio-economic groups													
Manual workers	0.0	0.2	1.9	-0.9	-0.5	1.5	3.0	-0.9	-1.5	-1.0	-0.3	-3.9	3.4
Non-manual workers	0.0	0.0	2.3	-0.8	0.0	2.0	3.3	-0.9	-0.5	-0.3	-0.1	-4.0	3.1
Self-employed	-0.1	0.2	2.3	-0.8	0.2	2.3	3.0	-0.8	-0.7	-0.3	-0.4	-4.3	3.6
Unemployed	0.0	-1.4	1.4	-1.4	-2.3	0.4	2.7	-1.4	-1.6	-2.4	-1.1	-4.2	3.9
Retired	-0.3	-2.0	1.3	-1.2	-3.5	0.3	2.1	-1.2	-3.0	-1.4	-0.7	-5.0	3.0
Inactive	0.0	-2.2	-0.9	-2.1	-4.8	-1.4	3.0	-2.1	-3.5	-3.4	-2.7	-4.6	-
Population Density													
Densely-populated	0.1	-0.4	2.7	-0.8	-0.3	1.7	3.2	-0.9	0.0	0.1	0.2	-5.1	3.0
Sparsely-populated	-0.5	0.1	2.5	-0.9	0.3	2.4	2.9	-0.8	-0.5	-0.7	-0.1	-4.1	3.8

Source(s): E3ME, Cambridge Econometrics.

Table 7.14 Benefits scenario (S38b), Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	0.4	0.1	0.8	0.6	0.2	0.1	0.5	0.2	0.6	0.5	0.3	0.0	0.2	0.3
Expenditure Groups														
First quintile	1.4	0.4	1.8	1.7	0.8	0.6	2.2	0.8	1.1	1.4	1.1	0.6	1.1	0.7
Second quintile	0.7	0.2	1.2	1.0	0.4	0.3	1.0	0.3	0.7	0.8	0.6	0.2	0.5	0.5
Third quintile	0.6	0.2	1.0	0.9	0.3	0.2	0.6	0.3	0.7	0.7	0.5	0.1	0.4	0.4
Fourth quintile	0.2	0.0	0.7	0.4	0.1	0.1	0.5	0.1	0.5	0.4	0.2	0.0	0.1	0.3
Fifth quintile	0.2	0.0	0.6	0.4	0.1	0.0	0.3	0.1	0.5	0.4	0.2	-0.1	0.1	0.1
Socio-economic groups														
Manual workers	0.1	-0.1	0.7	0.3	0.0	0.0	0.6	0.0	0.4	0.3	0.1	-0.1	-0.1	0.3
Non-manual workers	0.4	0.2	0.8	0.5	0.1	0.1	0.4	0.2	0.5	0.5	0.3	0.0	0.2	0.2
Self-employed	0.4	0.2	0.8	0.6	0.1	0.1	0.5	0.2	0.5	0.6	0.3	0.0	0.2	0.2
Unemployed	2.1	1.5	1.1	1.9	1.1	0.7	0.9	1.9	1.6	2.4	0.6	0.8	1.5	0.5
Retired	3.3	1.6	2.0	3.1	2.4	1.2	1.7	1.5	2.4	3.9	1.5	1.9	2.6	0.6
Inactive	3.3	1.7	1.9	3.1	2.4	1.2	0.7	1.5	2.4	3.9	0.7	1.9	2.6	0.5
Population Density														
Densely-populated	0.4	0.1	0.8	0.6	0.2	0.1	0.5	0.2	0.6	0.6	0.4	0.0	0.2	0.3
Sparsely-populated	0.5	0.1	1.0	0.8	0.3	0.2	0.5	0.3	0.7	0.6	0.4	0.1	0.4	0.4

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	0.4	0.7	1.1	-0.1	0.2	0.2	0.9	0.2	0.9	0.2	0.4	-0.3	0.9
Expenditure Groups													
First quintile	1.2	1.4	1.7	-0.1	0.5	0.5	1.1	0.4	2.0	0.6	0.8	0.1	1.3
Second quintile	0.8	1.1	1.5	-0.1	0.5	0.5	1.2	0.4	2.0	0.5	0.7	0.0	1.1
Third quintile	0.5	1.1	1.6	0.0	0.5	0.5	1.1	0.4	1.9	0.5	0.7	-0.1	1.1
Fourth quintile	0.4	0.7	1.4	0.0	0.4	0.4	1.1	0.4	1.4	0.4	0.7	-0.3	1.1
Fifth quintile	0.3	0.1	0.6	-0.3	0.0	-0.1	0.4	-0.1	-0.3	-0.1	-0.1	-0.5	0.6
Socio-economic groups													
Manual workers	0.2	0.2	0.6	-0.3	0.2	0.1	0.5	0.1	0.9	0.2	0.0	-0.3	0.6
Non-manual workers	0.3	-0.3	0.2	-0.4	0.0	-0.1	0.3	-0.1	-0.1	-0.1	-0.3	-0.4	0.4
Self-employed	0.4	0.1	0.2	-0.4	0.0	-0.2	0.5	-0.1	-0.2	-0.1	-0.3	-0.6	0.4
Unemployed	0.9	2.3	2.1	-0.7	0.5	0.4	2.3	0.0	1.8	0.6	0.7	-0.3	2.1
Retired	2.3	8.4	9.4	2.1	3.8	3.8	5.3	3.0	10.0	3.6	5.5	0.4	5.5
Inactive	2.3	0.9	-0.2	-1.8	-0.3	-0.5	2.7	-1.2	-0.9	-0.5	-0.8	0.5	-
Population Density													
Densely-populated	0.4	-0.2	1.1	-0.2	0.2	0.2	0.7	0.1	0.7	0.2	0.3	-0.4	0.9
Sparsely-populated	0.4	0.2	1.2	0.0	0.3	0.3	1.1	0.3	1.2	0.3	0.5	-0.5	0.9

Source(s): E3ME, Cambridge Econometrics.

Table 7.15 Social Security scenario (S38c), Real income in 2020 (% difference from baseline)

	BE	DK	DE	EL	ES	FR	IE	IT	LX	NL	AT	PT	FI	SW
All households	-0.5	-0.5	-0.4	-0.6	-0.5	-0.1	-0.6	-0.4	-0.4	-1.0	-0.3	-0.5	-0.6	-0.3
Expenditure Groups														
First quintile	-0.6	-0.7	-0.4	-0.6	-0.5	-0.1	-0.5	-0.5	-0.5	-1.3	-0.4	-0.5	-0.8	-0.4
Second quintile	-0.5	-0.6	-0.4	-0.6	-0.5	-0.1	-0.5	-0.4	-0.5	-1.1	-0.4	-0.5	-0.7	-0.4
Third quintile	-0.5	-0.5	-0.4	-0.5	-0.5	-0.1	-0.5	-0.4	-0.4	-1.0	-0.3	-0.5	-0.6	-0.3
Fourth quintile	-0.5	-0.6	-0.4	-0.6	-0.5	-0.1	-0.5	-0.5	-0.4	-1.0	-0.4	-0.5	-0.7	-0.3
Fifth quintile	-0.4	-0.5	-0.4	-0.6	-0.5	-0.1	-0.6	-0.4	-0.4	-0.9	-0.3	-0.5	-0.6	-0.4
Socio-economic groups														
Manual workers	-0.6	-0.6	-0.4	-0.7	-0.5	-0.1	-0.5	-0.5	-0.5	-1.0	-0.3	-0.5	-0.7	-0.2
Non-manual workers	-0.2	-0.3	-0.2	-0.4	-0.4	0.0	-0.6	-0.3	-0.3	-0.7	-0.2	-0.4	-0.5	-0.2
Self-employed	-0.2	-0.3	-0.2	-0.4	-0.4	0.0	-0.5	-0.3	-0.3	-0.7	-0.2	-0.4	-0.4	-0.3
Unemployed	-0.2	-0.6	-0.2	-0.3	-0.4	0.0	-0.5	-0.3	-0.4	-1.1	0.0	-0.4	-0.5	-1.1
Retired	-0.4	-0.6	-0.4	-0.4	-0.6	-0.1	-0.7	-0.4	-0.5	-1.4	-0.2	-0.5	-0.7	-1.1
Inactive	-0.3	-0.5	-0.4	-0.3	-0.5	-0.1	-0.6	-0.3	-0.4	-1.2	-0.1	-0.5	-0.5	-0.3
Population Density														
Densely-populated	-0.4	-0.5	-0.4	-0.6	-0.5	-0.1	-0.6	-0.4	-0.4	-1.0	-0.3	-0.5	-0.6	-0.3
Sparsely-populated	-0.6	-0.6	-0.4	-0.6	-0.5	-0.1	-0.5	-0.5	-0.5	-1.1	-0.3	-0.5	-0.7	-0.4

	UK	CZ	EN	CY	LV	LT	HU	MT	PL	SI	SK	BG	RO
All households	-0.5	-1.9	-2.1	-0.2	-0.7	-0.8	-1.9	-0.5	-2.0	-0.5	-0.9	0.1	-2.3
Expenditure Groups													
First quintile	-0.5	-1.7	-1.9	-0.2	-0.5	-0.6	-1.7	-0.3	-1.1	-0.3	-0.8	0.1	-2.1
Second quintile	-0.4	-1.9	-1.7	-0.1	-0.4	-0.5	-1.7	-0.2	-0.6	-0.2	-0.6	0.0	-2.0
Third quintile	-0.5	-1.9	-1.8	-0.2	-0.5	-0.6	-1.8	-0.3	-1.1	-0.3	-0.6	0.0	-2.1
Fourth quintile	-0.5	-2.0	-2.0	-0.2	-0.7	-0.8	-1.8	-0.5	-2.1	-0.6	-0.9	0.0	-2.3
Fifth quintile	-0.5	-2.3	-2.3	-0.3	-0.8	-1.0	-2.1	-0.6	-2.8	-0.8	-1.0	0.0	-2.4
Socio-economic groups													
Manual workers	-0.5	-2.0	-1.5	-0.1	-0.4	-0.5	-1.9	-0.2	-0.6	-0.1	-0.5	0.0	-2.0
Non-manual workers	-0.4	-2.2	-1.8	-0.2	-0.5	-0.6	-2.0	-0.3	-1.3	-0.3	-0.6	0.0	-2.1
Self-employed	-0.4	-1.8	-1.8	-0.2	-0.5	-0.6	-1.7	-0.3	-1.3	-0.3	-0.6	0.1	-2.1
Unemployed	-0.4	-1.8	-2.2	-0.3	-0.5	-0.6	-1.7	-0.5	-1.4	-0.5	-1.0	0.2	-2.2
Retired	-0.6	-1.3	-1.8	-0.2	-0.5	-0.5	-1.4	-0.2	-0.4	-0.2	-0.7	0.2	-2.0
Inactive	-0.5	-2.2	-2.3	-0.5	-0.4	-0.5	-1.6	-0.5	-1.2	-0.5	-1.0	0.2	-
Population Density													
Densely-populated	-0.4	-2.1	-2.2	-0.2	-0.7	-0.8	-2.0	-0.5	-2.0	-0.6	-0.8	0.0	-2.3
Sparsely-populated	-0.5	-1.9	-2.0	-0.2	-0.7	-0.8	-1.8	-0.5	-1.9	-0.5	-0.9	0.0	-2.2

Source(s): E3ME, Cambridge Econometrics.

Table 7.16 Unemployment in the revenue recycling scenarios in 2020 (000s)

UNEMPLOYMENT IN THE REVENUE RECYCLING SCENARIOS IN 2020 (000s)

	Baseline	Invest Tran	Invest Mach	Invest Build	Invest Renew	Invest All	Social Benefits	Emp'rs Soc Sec
Belgium	406.4	408.6	412.1	409.5	407.5	417.9	419.3	403.2
Denmark	128.4	127.5	126.9	127.6	129.0	123.3	127.5	126.2
Germany	3016.5	3028.8	3023.4	3027.3	3036.4	3057.1	3053.9	3074.9
Greece	479.1	475.6	479.5	480.0	479.8	473.9	464.9	479.2
Spain	2178.2	2139.3	2168.6	2175.0	2181.0	2130.7	2197.8	2155.1
France	2463.9	2488.2	2472.8	2471.3	2474.2	2509.9	2500.3	2466.6
Ireland	103.3	103.0	103.0	103.3	104.0	103.5	102.5	102.7
Italy	1770.3	1760.2	1749.4	1768.5	1777.1	1740.2	1755.2	1796.8
Luxembourg	11.9	11.9	11.9	11.9	11.9	11.9	11.9	11.9
Netherlands	411.8	393.4	412.5	402.0	412.6	379.7	382.4	396.4
Austria	228.8	230.7	230.2	230.1	230.0	233.4	223.9	228.9
Portugal	450.1	447.7	447.3	446.6	451.0	442.1	459.3	446.2
Finland	215.9	217.6	218.5	216.4	216.8	221.0	218.5	216.3
Sweden	381.7	381.8	384.9	382.1	382.0	385.1	385.1	382.2
UK	1584.6	1591.8	1600.5	1587.4	1592.0	1615.7	1618.6	1587.2
Czech Rep.	280.7	278.6	278.1	281.9	283.4	278.6	316.3	269.9
Estonia	52.3	52.9	50.5	53.0	53.1	52.5	56.6	53.0
Cyprus	35.7	35.7	35.8	35.7	35.7	35.9	35.5	35.7
Latvia	103.1	102.7	102.9	103.2	103.5	102.7	104.7	101.5
Lithuania	140.1	138.5	140.7	138.0	139.5	136.7	140.8	138.2
Hungary	299.5	300.8	298.4	298.9	299.4	299.2	297.1	296.4
Malta	11.4	11.4	11.4	11.4	11.4	11.4	11.3	11.4
Poland	1382.3	1399.8	1384.2	1393.6	1391.7	1423.8	1450.4	1353.3
Slovenia	65.8	65.5	65.1	64.8	66.3	64.3	65.5	61.3
Slovakia	256.8	256.2	260.5	256.1	257.3	258.6	265.3	253.1
Bulgaria	203.3	204.0	203.2	202.4	206.3	196.5	220.1	203.3
Romania	620.8	623.2	628.4	621.0	625.6	634.6	612.4	612.7
EU27	17282.6	17275.5	17300.7	17298.9	17358.4	17340.1	17497.1	17263.7

Note(s): The baseline reflects revenue recycling from income tax reductions (S4). Note also that baseline values have changed slightly from the main scenario analysis due to updated data becoming available during the project. Due to scale and rounding effects unemployment is not modeled for Luxembourg, Cyprus and Malta.
Source(s): E3ME, Cambridge Econometrics.

Appendix D: Measuring the Quality of Jobs

Measuring Job Quality

The Laeken indicators provide a means of measuring the quality of jobs. The is a broadly defined approach to measuring job quality which provides a theoretical starting point for understanding what constitutes a 'good' or 'bad' quality job. The IER team have used the Laeken indicators as a guide in selecting variables from the EU-LFS which provide insights into job quality. For the whole of EU, the EU-LFS allows the quality of jobs to be measured with respect to:

- educational attainment (high medium or low)
- permanency of job (temp/permanent)
- type of Job (full time/part time)
- hours worked (up to 47/ 48 or more, derived variable)
- non-standard hours of work
- atypical Work (yes/no – never)
- receipt of education / training over the past four weeks

These data can be disaggregated by sector, gender, and by Member State.

The general approach taken by the IER research team to addressing job quality is as follows:

- The EU-LFS provides data which can provide information about job quality. It is not comprehensive with respect to standard measures of job quality described in the literature, but it provides a number of useful indicators. It is possible to derive a simple index of job quality based on the above indicators.
- Using the EU-LFS it is possible to look at the quality of jobs at the ISCO 2-digit level in cross-section for 2009.
- Using the EU-LFS it is also possible to identify the extent to which those occupations which are expected to show employment increase or decrease (i.e. expansion demand) over the projection period are relatively good or bad quality jobs. This can be done by looking at the percentage of the workforce in those 2-digit occupations which report positive or negative features of their job in the EU-LFS. This provides an indication of the extent to which the scenarios result in an overall increase or decrease in job quality.

A More Conceptual Approach to Job Quality and Green Jobs

From a more conceptual perspective, an occupational classification has been developed, using EU-LFS data, which categorises jobs into three broad categories: (i) green increased demand; (ii)green enhanced skills; and (iii) 'dirty' jobs. This categorisation is based on the O*NET classification of green jobs, supplemented by the 'dirty jobs' category which is defined with reference to relatively low skilled occupations which are dependent upon energy intensive / high polluting sectors (and which are mutually exclusive of the green jobs categories).

From the 3-digit occupational groups in the EU-LFS data (available for 2009 only) a typology of occupations has been created based on the O*Net classification of:

- Green Increased Demand
- Green Enhanced Skills
- Dirty Jobs
- Other Jobs

Dirty Occupations are defined as such are classified all Plant and Machine Operators and Assemblers (ISCO = 800) in the following industries: Mining and Quarrying (Nace: C), Manufacturing (Nace: D), Construction (Nace: E), and Electricity, Gas & Water Supply (Nace: F).