Assessing the Employment and Social Impact of Energy Efficiency

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Executive Summary

Introduction and scope of the study

- This study assesses the direct and indirect linkages between energy efficiency, labour markets and social welfare, at both the micro and the macro levels, using a mixture of qualitative and quantitative approaches to carry out the analysis. The key research questions addressed in the study are:
  - What is the level of employment currently associated with energy efficiency across Europe, and what is the potential for creating employment related to energy efficiency improvements and/or investments?
  - What instruments can be provided to policy makers to support assessment of the impact of energy efficiency policies on employment?
  - What are the social impacts of energy efficiency?
  - What are the skills that are needed to implement large-scale energy efficiency programmes?

Findings from earlier studies (Chapter 2)

- The study included a detailed literature review. It found that energy efficiency can have a range of benefits to households, businesses and wider society. Some of these benefits may be quantifiable in economic terms, while others, such as health benefits or energy security, are less easy to measure.
- The literature has identified positive effects on GDP and employment of investment in energy efficiency. With only a few exceptions, the studies identified for review report a positive effect on GDP ranging from 0.3% to 1.3% depending on time periods, geography and the scale of the programme being assessed. Studies that use Computable General Equilibrium (CGE) models tend to show results that are less positive, and sometimes negative if they assume that there are no 'no regrets' options for energy efficiency still to be taken up and that the economy's resources are fully employed (given the prevailing prices).
- For comparison, the modelling carried out for the present study examined a range of alternative scenarios for the ambition for the intensity of energy efficiency achievements[1] and used models from the two main theoretical traditions (a CGE model and a macro-econometric model) that have been used in the literature to assess economic impacts. The modelling found that setting a fairly ambitious energy efficiency target for Europe[2] would have a modest impact on GDP (-0.2% in the CGE model and +1.1% in the macro-econometric model) compared to baseline by 2030, similar to the findings in earlier literature. The main reason for the difference is that the CGE model assumed that the investment to implement energy efficiency measures would crowd out other investment, whereas the macro-econometric model allowed the energy efficiency investment to be additional. More summary

[1] Ranging from a reduction of 25% by 2030 in primary energy demand relative to the PRIMES 2007 projection to a reduction of 40%.

[2] A reduction of 30% by 2030 in primary energy demand relative to the PRIMES 2007 projection.

results from the modelling results are discussed in this Executive Summary under the subheading ‘Chapters 4 to 6’ below.

- The literature review also found that the manufacture and installation of energy efficient equipment and materials is a relatively labour-intensive activity that has the potential to boost local labour markets. However, the skills requirements are often quite specific, so there could be a role for active intervention in providing training to local workforces.
- Because of their relatively high levels of labour intensity, energy efficiency measures are widely seen in the literature as creating more jobs than new energy generation, which tends to be much more capital intensive. Per million euros of spend, investment in energy efficiency could create up to twice as many jobs as investment in new energy generation.
- A stimulus to employment may also arise as a result of the export potential of energy efficiency activities and/or the substitution of imported energy.
- The rebound effect (the tendency for behavioural responses to improved energy efficiency to offset partially some of the reductions in energy consumption) is also an important factor to consider when assessing energy efficiency. The rebound effect reflects positive economic outcomes (a higher level of real incomes and hence spending) but may erode the initial energy savings. The scale of the rebound effect varies by sector, location and time period but it can be considerable and should be taken into account by policy makers when estimates are made of the potential savings arising from an intervention. Estimates found in the literature suggest that the rebound effect may reduce savings by between 1% and 50% depending on time period, sector and geography and inclusion of indirect effects (i.e. the knock-on effects of the direct rebound effect on the purchases of goods and services and associated energy requirements).
- It is also interesting to note that there is now some literature reporting increases in building values and rentals as a consequence of improved energy efficiency. US data suggest that values of buildings with certified energy performance are 10-16% higher than similar non-certified buildings.

Estimates of direct jobs related to energy efficiency in 2010 (Chapter 3)

- Our *core* definition of ‘employment in energy efficiency’ is employment in firms whose principal activity is the supply of goods and services for which the main motivation for purchase by the customer is to save energy. We also make estimates for a *broad* definition, which extends the core definition to include employment in firms whose goods and services that have the potential to bring about energy savings, even if they are not purchased primarily for that purpose. By far the largest sector in the latter case is public transport[3].
- Two methods could in principle be used to estimate the number of direct jobs related to energy efficiency. The first uses conventional economic

[3] An alternative definition is to identify workers whose principal function is to manage or promote energy efficiency in their enterprise, regardless of what the enterprise itself does. However, we prefer the definition based on the nature of the firm’s goods and services because this is consistent with the principle followed (for example, by Eurostat) to define the wider Environmental Goods and Services sector.

statistics for employment categorised by sector of activity and seeks to pick out those sectors that could be defined as producing 'energy efficiency' goods and services. The second uses an engineering-based set of coefficients for the number of jobs required to implement and operate specific measures. The first approach suffers from the problem that energy efficiency activity cuts across traditional economic sectors. The second approach suffers from the needs and uncertainties of aggregation across measures when used to estimate overall employment. In both cases there are also issues of boundaries and scope which are highlighted in the main body of the report. Since comprehensive data that classify jobs in a way that distinguishes the provision of energy efficiency goods and services are not available for the EU, our method makes use of estimates made for the US and seeks to apply these with appropriate adjustments to EU employment data.

- Subject to these data limitations, our estimate is that gross EU28 employment in the provision of energy efficiency goods and services sold in 2010 amounted to approximately 0.9m jobs, on the *core* definition (of activities for which the main motivation for the purchase is to save energy). If we include activities that have the potential to bring about energy savings, but are not purchased primarily for that purpose, our estimate of EU28 employment increases to approximately 2.4m jobs (see Table 3.4 for a specification of what is included in the core and broad definitions). That would amount to approximately 1% of total EU employment[4].
- As the basis of comparisons with other sectoral employment estimates, the employment associated with the supply of energy efficiency goods and services should be used; 0.9m jobs in the EU28 using the core definition, or 2.4m jobs in the EU28 using the broad definition.
- A complementary approach to estimating current employment impacts is to estimate the potential future employment effects as a result of energy saving achieved (tonnes of oil equivalent, toe) based on published estimates of the related employment ratio (jobs generated per unit energy saved, (toe)). Two studies were found providing these ratios, which vary according to sector. On the basis of these studies, and available estimates of energy saving potential, by sector, then in 2010, between 100,000 and 300,000 additional jobs could be generated in the EU28 if the savings potentials were realised. This employment effect could increase five-fold by 2030 if the savings potentials were fully realised. Note these are potential future jobs based on energy saving potential. These should not be confused with the estimates of current (2010) employment noted above.
- The necessity for reliance in this study on empirical findings in the US suggests the need for the development and application of a methodology to produce similar statistics for the EU28. Discussion with ESTAT should examine the available options, recognising the difficulties of isolating the relevant activities within currently defined economic sectors.

[4] There are, in addition, people working to support energy efficiency activity within their firm or organisation: if the US position can be extrapolated to the EU, this would represent 0.8m jobs.

- Net employment effects that account for jobs displaced in other sectors as a result of greater energy efficiency would be smaller than the gross employment effects described above, but displaced jobs cannot be observed in historical data: in the modelling exercise described below we have made estimates of the net employment impacts that could arise in future scenarios in which higher levels of energy efficiency are achieved.

Estimates of net jobs created in a future with higher energy efficiency (Chapters 4-6)

- Two macroeconomic models were applied to estimate the impacts of future scenarios of different levels of ambition for improved energy efficiency across the EU in the period up to 2030. Six scenarios were assessed, in which primary energy savings are 25%, 28%, 30%, 32%, 35% and 40% in 2030, relative to the PRIMES 2007 projection. One of the models, GEM-E3, is a Computable General Equilibrium (CGE) model based on neoclassical economic theory, while the other, E3ME, is a macro-econometric model with a post-Keynesian methodology.
- Both models used the same information about the take-up of opportunities for energy saving and the associated costs[5]. This means that the differences between their results arose not from any difference about the scope for energy efficiency measures but from different responses to the raising of finance for the extra investment, the economic activity stimulated by the investment, and the reduction in energy bills and economic activity associated with the supply of energy.
- For all the scenarios except the two with the most ambitious energy saving targets, the impacts on GDP in 2030 are modest: in the range -0.2% to +1.3%. For the scenarios with the two most ambitious targets, the range of impacts widens, reaching -1.2% to 4.4% in the 40% saving case; however, these latter estimates are more uncertain because the most ambitious scenario raises the question of the capacity of the economy to deliver the required investment. In every case, the bottom (negative) end of the range of GDP impacts came from GEM-E3, while the top (positive) end of the range came from E3ME. The principal reason for the difference is that GEM-E3 assumes that the investment to implement energy efficiency measures would crowd out other investment, whereas the E3ME allows the energy efficiency investment to be additional.
- Both models predict an increase in EU employment when more ambitious energy efficiency programmes are implemented. In E3ME this reflects the higher level of GDP; in GEM-E3 it arises because of substitution of labour for capital, which outweighs the effect of lower GDP. The range of impacts in the 30% scenario is 0.3% to 1.9% of EU employment by 2030. In absolute terms, this amounts to a potential increase in EU employment of 0.7-4.2m in 2030.

A series of in-depth case studies (Chapter 7)

- A series of case studies was selected for policy initiatives that had previously been subject to some degree of monitoring and evaluation to enable some assessment of impacts that are not dealt with explicitly in the macroeconomic modelling exercise or are more relevant from the micro

[5] Taken from the results of the PRIMES energy model scenarios that correspond to the various alternative energy efficiency targets.

perspective. These include policy design and evaluation and the skills and related training requirements. Six case studies were carried out, four of which assessed measures designed to address energy efficiency in buildings, one in local industry and one in the transport sector.

- All of the programmes that were covered resulted in significant energy savings. The role of public policy varied quite considerably between the different cases but tended to include a strong element of information provision and public engagement. The public sector also has a role in designing energy efficiency programmes to target low-income households where this is the policy objective.
- The case studies also showed the importance of local authorities working with local businesses and labour groups to ensure that the available workforce is equipped with the skills necessary to implement the programmes successfully. This could include direct training or 'training of trainers'. Finally, in the case of electric vehicles, the public sector has a key role in enhancing R&D activities.
- From a policy development perspective, the case studies demonstrate variable quality in the application of monitoring and evaluation (M&E) methods, making it difficult to draw clear conclusions for improvements in policy. Difficulties noted include: a failure to formulate the purpose of policy clearly enough as the basis of monitoring, the timeliness of data collection and the failure to compare outcomes against what an assessment of would have occurred in the absence of the intervention. To the extent that policy interventions are increasingly funded by EU Structural and Investment Funds (ESIF), the related requirements of ESIF should lead to improvements in M&E of energy efficiency measures.

Social impacts (Chapter 7)

- Investment programmes that improve the energy efficiency of homes offer an important route to tackling fuel poverty, provided that obstacles to implementation (access to finance for poor households; a way to incentivise landlords to implement improvements to privately-rented dwellings) can be overcome. They also help to improve the social and political acceptability of policies to raise the price of carbon-based fuels to curb emissions.
- There are clear health benefits, both physical and mental, from providing homes that are adequately heated. Improvements will be of particular benefit to children.
- Energy efficiency measures that have the co-benefit of reducing pollutants from vehicles or power stations reduce the incidence and severity of respiratory and cardiovascular diseases.

Skills impacts (Chapter 7)

- Transition to a more energy efficient economy does not constitute a wholly distinct skills policy challenge compared to other trends, like technological change and globalisation. Within reasonable limits regarding the scale of ambition for implementing energy efficiency measures, it is likely that existing trends in the occupational structure, and changing demand for skills, will not be shifted much in a future with greater investment in energy efficiency, but there can be more striking impacts at the margin and in particular areas. The impact depends on the pace of change in demand for energy efficiency measures and any related need for new skills, compared to the capacity of the relevant national and local institutions responsible for competence definition and skills training to adjust to changing demands. Where the demand increases rapidly, supporting initiatives are likely to be required.

- Science, Technology, Engineering and Mathematics (STEM) subjects are of particular importance because of the high technological content of at least some of the required occupations. STEM skills are an important foundation for the technical skills, resource management skills and complex problem-solving skills that at least some of the jobs in energy efficiency (and other green jobs) require. Perhaps the most important impact of the transition (from the point of view of skills policy) is likely to be in exacerbating existing skills shortages in STEM subjects, rather than in stimulating demand for 'new' skills.
- Analysis of the gaps between current levels of efficiency of energy use and the technical potential suggests that the opportunities for new jobs and related changes in competencies are greatest in transport and buildings, and to a lesser extent in industry, which points to greater demand for the occupations involved in the identification and implementation of measures and in the development of equipment in the supply chain in the construction and automotive vehicles sectors. In the latter sector, the study finds well developed institutional infrastructure for monitoring and responding to changes in skills driven by the demand for more efficient vehicles. However, in the former sector, institutional infrastructure is less well developed and equipped to respond quickly to significant changes in demand, reflected in a number of national and local initiatives to support training where shortages arise.

Conclusions and recommendations (Chapter 8)

- The macroeconomic benefits of meeting more ambitious energy efficiency targets will be maximised if the energy efficient equipment is produced within the EU and if new energy efficient technologies are developed within the EU. A key sector in this respect is automotive vehicles, which should be a priority for policies to promote innovation, strengthen skills and, in the case of technologies that represent a radical change from the internal combustion engine, encourage consumer take-up.
- The goal of promoting energy efficiency on a substantial scale reinforces the priority of existing plans and actions to improve the supply of workers with STEM skills from school and vocational education.
- Specific labour market responses to particular changes in demand require better forecasting of future trends in employment and skills requirements by the institutions responsible, accelerating the development of occupational profiles and training accordingly. This forecasting would be helped by clearer statistics on employment linked to the demand for energy efficiency related activities, particularly at Member State level. There is a clear role for ESTAT in coordinating the development of common definitions and protocols for the collection of statistics.
- Because of the importance of opportunities for energy saving in buildings, the biggest impact on employment and skills is expected to be in

construction. The fragmented nature of the industry and its high level of self-employment, particularly in the field of housing renovation, make its firms particularly difficult to target for engagement in skills improvement programmes. The quality of services available in this sector could therefore represent a significant bottleneck to the take-up of energy efficiency measures, and this should be targeted by the industry's training bodies. Experience from the best examples of existing programmes (including the development of new competencies and qualifications, and cluster initiatives with sharing of resources and learning) should be diffused more widely.

- The largest potential for energy savings lies in the newer Member States. If policies to close the gap in the level of energy efficiency between these countries and the rest of the EU are to be successful, the STEM and housing renovation skills issues need to be addressed particularly in these countries.
- Take-up of energy saving opportunities tends to be weakest among users with limited resources to acquire the necessary information and for whom energy bills are not so high that they overcome inertia to change. This is most obvious in the case of household use of energy for space heating and hot water, but also in the information failures amongst industrial users of energy, especially smaller businesses. Case studies demonstrate how awareness-raising and targeted technical advice can address these failures and stimulate investment in the take-up of new and existing techniques for energy saving. These measures are often highly cost-effective, not requiring any major capital expenditure but leveraging private expenditure.
- Achieving higher levels of energy efficiency in the homes occupied by poor households offers an important route to improving welfare and health. It also helps to overcome an important social and political obstacle to the use of higher prices as an instrument for curbing energy consumption more broadly. Since the required work is usually labour-intensive, investment programmes will also create jobs in the localities where the funds are spent. Policies to tackle the financial and institutional obstacles to improving the energy properties of these homes should be given priority.
- There is a need for continued EU funding of national and sub-national programmes to provide the initial stimulus and to facilitate replication and modification, recognising that although programmes need to reflect local context and circumstance, there is sufficient common interest and core activity to make use of the demonstration of approaches identified in each case study. Given that energy saving opportunities, social needs and the funding resources available are greatest in the newer Member States, European Structural Investment Funds (ESIF) provide a critical dimension to the policy response. The use of ESIF is likely also to be associated with a more rigorous approach to the monitoring and evaluation of energy efficiency measures in a broad range of contexts, to support the better design of policy responses.

1 Introduction

1.1 The benefits to Europe of investments in energy efficiency

Improvements in energy efficiency have the potential to bring about long-term social, economic and environmental benefits to Europe. By using energy more efficiently, businesses become more competitive and households face lower fuel bills. At macroeconomic level, lower fuel imports mean an improvement to the balance of trade (and GDP), reduced exposure to price shocks and greater energy security.

There are also short-term socio-economic costs and benefits from investment in energy efficiency measures. Someone must pay for the investment required to improve buildings and equipment. But the activities stimulated by this spending to improve energy efficiency are often fairly labour-intensive and can provide a short-term boost to local employment, especially in some of the sectors that were most affected by the financial crisis and recession (e.g. construction).

It has been found consistently that households typically do not take up options to improve energy efficiency, even when these options are cost effective or have a short payback period. This is due to various market failures, including a lack of information, the externalities that arise when occupiers are not owners, and restricted access to credit.

These market failures provide the justification for policy intervention. The EU's Energy Efficiency Directive established an energy savings target for 2020 and a target has now been set for 2030 as well.

1.2 Introduction to this report

This is the final report from the study *Assessing the Employment and Social Impact of Energy Efficiency*. In this report we use a combination of qualitative and quantitative techniques to assess the impacts of European energy efficiency policies on Europe's economies, labour markets and on social welfare in the EU. The key research questions are:

- to evaluate the labour market and social impacts of the implementation of energy efficiency policies at European and national scale
- to provide instruments that can be used by policy makers to assess the development of employment in response to energy efficiency policies
- to identify the skills that are needed to implement large-scale energy efficiency programmes

Chapter 2 draws together the evidence from existing studies in the area. Chapter 3 uses micro-level data to estimate the number of direct jobs currently engaged with energy efficiency measures. Chapters 4 and 5 provide estimates of the macroeconomic consequences of meeting energy efficiency targets, using two different modelling approaches to strengthen the robustness of the estimates. Chapter 6 compares the results from the two models, noting common findings and differences and drawing conclusions.

Chapter 7 reports on the social and skills impacts of investment in energy efficiency, drawing together evidence from the literature and from a range of case studies carried out for the project of public policy interventions to promote energy efficiency. Chapter 8 provides a summary of the main conclusions and recommendations from the analysis.

The appendices contain more detailed descriptions of the models used to produce the macroeconomic estimates, a list of the references made in the report, the detailed results of the literature review, background information on EU energy efficiency policy and details of the case studies.

2 Review of the literature on the economic and social impacts of energy efficiency investment

2.1 Introduction

This chapter sets out the findings that emerged from the literature review. The focus of the review reported here is the economic and employment impacts. The literature on the social impacts is presented in Chapter 7, which focuses more broadly on the social impact of energy efficiency policies

2.2 Methodology

The review has identified and extracted summary information from more than 70 sources. The studies range from peer-reviewed journal articles to working papers and published research from academic institutes, international agencies and government departments.

Coverage

The majority of the studies are focused on the EU or its Member States (MS)[6] while a further twelve studies cover the US and Canada or several countries. The studies reviewed cover a range of sectors and technologies, but the primary focus is on buildings and construction, power generation and energy transformation, manufacturing, and transport[7]. A full list of sources is provided in Appendix D to this report.

Review questions

The literature review seeks to answer the following research questions:

1. What are the economic and social impacts of energy efficiency (EE), including employment, occupational and welfare effects?
2. What factors influence the magnitude (and distribution) of these impacts?
3. Are there examples of good practice in the design of effective policies to maximise the positive (or offset the negative) impacts of EE?

The priority has been to create an understanding of the economic and employment outcomes of energy efficiency and energy savings and the relationship between them through potential rebound effects. This assessment has in turn informed the development of a conceptual framework (presented in Chapter 3) for estimating the current level of employment related to energy efficiency.

2.3 The economic impacts of energy efficiency

Measures to increase energy efficiency have a range of social and economic impacts. Appendix D provides an overview of the main findings from the

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[6] The identified studies cover evaluations and research for twelve MS: Austria, Finland, France, Germany, Greece, Hungary, Ireland, Netherlands, Poland, Portugal, Spain and the United Kingdom.

[7] Other sectors covered include: ICT, recycling, household appliances, agriculture, and environmental technologies.

literature review. It describes the evidence of these impacts and summarise the main economic and employment effects of energy efficiency measures, on an economy-wide basis. It distinguishes international studies from Member State studies) and also makes a sectoral / occupational distinction.

GDP

In the majority of studies, the output effects of energy efficiency measures (typically measured in terms of GDP) are positive, irrespective of the modelling approach used (e.g. ACE, 2000 and Cambridge Econometrics et al. 2011). There are several examples of studies that use either Computable General Equilibrium (CGE) or macro-econometric models to estimate the GDP effects of energy efficiency programmes (which are the two approaches applied in Chapters 4 and 5). These studies suggest that there are significant potential impacts on output ranging from 0.8% to 1.3% of GDP, although the scale of the impacts of course depends on the size of the programmes being assessed (IEA, 2012). Studies that use general equilibrium models tend to show results that are less positive, and sometimes negative if they assume that there are no ‘no regrets’ options for energy efficiency still to be taken up and that the economy’s resources are fully employed (given the prevailing prices).

Other modelling approaches have found slightly smaller, positive effects. For example, looking ahead to US energy efficiency opportunities to 2050, Laitner et al. (2012) estimate that energy consumption could be reduced by 42% relative to a business-as-usual (BAU) case. Using an input-output approach, the efficiency savings are estimated to increase GDP in 2050 by 0.3% above the BAU.

In Finland there is evidence of a temporal dimension to the positive economic returns to energy efficiency investments. A rather modest increase in annual construction and renovation investments, which reduces total primary energy consumption by 3.8%-5.3% by 2020 and by 4.7%-6.8% by 2050 compared to a baseline scenario, leads to a projected short-term *decrease* in the level of economic activity (GDP). In the medium to long term, the effects on both GDP and employment are *positive* (Tuominen et al. 2013).

The modelling of energy efficiency measures using a CGE approach (GEM-E3), for this study (see Chapter 4) estimated a small *negative* effect on GDP. This effect stems from the assumption that the additional investment required for energy efficiency improvements crowds out other investment. By comparison the results from the E3ME model, which do not assume crowding out, suggest a small positive effect. The assumptions related to different macroeconomic modelling approaches are discussed in more detail in Chapter 6.

Employment

These GDP impacts translate into positive net employment effects (even in the CGE model used in Chapter 4, because it was assumed in that exercise that unemployed labour was available). For example, based on a multi-sectoral dynamic model (MDM-E3)[8], UK energy efficiency policy is estimated to have raised the annual rate of economic growth by around 0.1 percentage points

[8] MDM-E3 combines time-series econometric relationships and cross-sectional input-output relationships with detailed modelling of the energy sector. It is similar in approach to the E3ME model that is used as part of the modelling exercise for the present study.

between 2000 and 2007. Overall, the cumulative impact of the boost to growth resulting from these energy efficiency policies – together with those policies announced for the period 2007 to 2010 – was estimated to have increased employment by 0.8% (or 271,000 jobs) in the UK in 2010 (Barker and Foxon, 2008).

Reflecting the generally small but positive economic impacts, most studies find that investment in energy efficiency has a small net positive effect on employment. This reflects the tendency for those sectors providing EE goods and services (especially the buildings and construction sector) to employ more people per unit of output than energy-producing sectors. However, while consistently positive, the scale of reported employment impacts varies considerably, according to the intensity of the measures, (for example. the speed and depth of building renovation, see e.g. BPIE, 2011, and Cuchi and Sweatman, 2011).

These findings are supported by an analysis of the employment impacts of deep building renovations in Poland by Uerge-Vorstatz et al. (2012). Based on data collected and scaled-up from a number of case studies, the report estimates that a programme costing between €2.2bn and €7bn in 2010 prices, and saving between €0.6bn and €1.3bn of energy in 2010 prices a year would have a direct labour impact in the construction sector of between 15,000 and 87,000 full-time equivalent (FTE) jobs in 2020 compared to baseline. Most of the new jobs were expected to require skilled labour.

The Polish report also looks at the net effects, using input-output analysis. It distinguishes between three types of induced effects: those generated by the additional jobs created by the investment in construction, job losses in the energy sector from reduced demand, and the induced impacts fuelled by the spending of energy cost savings. On aggregate, the study estimates that between 86,000 and 254,000 additional jobs (FTE) per year could be generated in 2020, depending on the intensity and depth of the buildings renovation scenarios. Manufacturing (through the supply of materials for the renovations) and construction are more labour intensive than energy supply (Uerge-Vorstatz et al. 2012).

For a given level of investment, energy efficiency measures are widely seen in the literature as creating more jobs than new energy generation, which tends to be much more capital intensive – particularly in energy importing countries (Quirion, 2013). Investment in greater energy efficiency creates more jobs than investing in an equivalent level of energy generation.

A recent American Council for an Energy Efficient Economy (ACEEE) study found that investments in energy efficiency create jobs in labour-intensive industries, such as construction, especially in the refurbishment and installation of EE measures in buildings. For example, a $1m investment supports, on average, 20 construction jobs compared to just 14 in the less labour-intensive manufacturing sector (Bell, 2012)[9]. However, Neubauer et al.

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[9] The job metric is equivalent to the resources required to employ a person for 12 months (or 2 workers for 6 months each, or 3 workers for 4 months each) (Bell, 2012)

(2013) report a much lower employment yield for investment in conventional energy generation, with only 10 jobs for every $1m spent.

Pikas et al., (2015) estimate the employment impacts related to renovating apartment buildings in Estonia. The study found that 17 direct and indirect jobs were created for every €1m of investment. Directly, ten jobs were created in on-site construction activities, and between one and six were related to consultancy and manufacturing industries, respectively.

Evidence from other national sources also highlights the importance of considering the export potential of services developed domestically. In Denmark, the Danish Energy Agency (2013) estimates that the growth potential of energy efficiency equipment and advice is around 27bn Danish krone (~€3.6bn)[10] by 2020, supporting 9,000 new jobs. Two-thirds of these new jobs would be due to the export of energy efficient equipment and advisory services to other European and international markets.

A recent report by VHK (2014), which considers the direct employment impacts of ecodesign and energy labelling services in the EU28, suggests that an extra 0.8m *direct* jobs will be created in the industry, wholesale and retail sector in 2020. The direct employment relates strictly to identifiable jobs in the added-value chain of the product. Employment displacement effects are not considered.

In a rare assessment of the employment effects of indirect rebound[11] effects, Roland-Holst (2008) examined the impact of a historical decrease in energy intensity in Californian households between 1972 and 2006. Here, the resulting switch of expenditure to other goods and services is found to have created 1.5m FTE jobs with an average annual salary of $30,000.

Moreover, it is estimated that, as a result of energy efficiency, California also reduced its dependence on imported energy and directed a greater percentage of its consumption to in-state, employment-intensive goods and services, whose supply chains also largely reside within California. The rebound effect in this case thereby created a further ‘multiplier’ effect in terms of job generation. Taking into account the slower growth in the energy supply chains, for every new job foregone in these sectors, the authors estimated that more than 50 new jobs were created across the state.

In summary, the reported literature indicates that as a result of investment in energy efficiency, gross and net positive employment impacts accrue. In the absence of the investment, such employment effects would not be generated. Energy efficiency investment can generate positive net employment impacts, because the measures undertaken and supplied to save energy are more labour intensive than the same investment in new energy generation. No literature was found that specifically commented on the gender of the people taking up these jobs. Neither is there any explicit analysis or comparison of the quality of the jobs generated.

[10] 1 DKK = 0.134011 EUR, based on European Commission annual exchange rates, accessed on 23/06/14

[11] See Section 2.4 for a discussion of the meaning of ‘rebound’ effects.

Energy bills and public finances

In addition, energy efficiency can help to reduce consumers' energy bills. In terms of energy prices and consumer bills, low carbon policies in the UK are estimated by the UK Department of Energy and Climate Change (DECC, 2013) to have accounted for between one-sixth and one-seventh of the overall 13% rise in household energy bills between 2010 and 2012[12]. However, once the potential offsetting savings from energy efficiency policies are taken into account, it is estimated that the average impact is a net *saving* of 5% in 2013 compared to what bills would have been in the absence of the policies.

Copenhagen Economics (2012) estimated that, by achieving the potential for EE renovation in buildings in 2020, EU Member States may achieve total annual benefits worth up to €175bn for public finances with an additional 'one-off' boost to GDP in the range of €153bn to €291bn for the years up to and including 2017.

In an EU-wide assessment of the impacts of fully implementing the Ecodesign Directive, Ecofys (2012) estimated that full implementation could produce net savings for European consumers and businesses of around €90bn per year in 2020. This is calculated to equate to net savings of €280 per household per year. Furthermore, reinvesting these savings in other sectors of the economy results in the creation of an estimated one million jobs.

Impacts on building values/rentals

There is also some preliminary evidence – from non-peer-reviewed sources – that investors may be willing to pay rental and sales premiums for properties with better energy performance. For example, because energy is one of the highest operating costs in most offices, economic theory suggests that the net present value of future energy savings can be added to the resale value (reflecting, in turn, the prospect of higher rental payments by occupiers). Empirical studies based on hedonic regressions from the US (e.g. Eichholtz et al. 2008 and Fuerst and McAllister, 2007) suggest that the market increasingly reflects this reasoning – with sales premiums for Energy Star certified office buildings ranging from 10-16% compared to non-certified buildings nearby.

2.4 The rebound effect

Rebound effects

It is important to make the distinction between energy efficiency and energy savings on the one hand and reductions in energy consumption on the other. An improvement in energy efficiency may lead to an initial reduction in energy consumption, but over time the effective reduction in the unit cost may lead to increased usage and hence higher energy consumption. This is referred to as the rebound effect.

The main types of rebound effect are:

1. Direct rebound effect – The product becomes more cost-effective to use and therefore it is used more (e.g. a more efficient car is cheaper to run and therefore may be driven more).
2. Indirect rebound effects:

[12] Similarly, a recent Commission staff working document (EC, 2014) notes that energy efficiency schemes in the UK – which could be counted as levies – acted to increase energy costs even though wholesale prices fell.

a. Income effect – The money that is saved through energy efficiency is instead spent on other products that may be energy-intensive.

b. Energy price effect – If demand for energy falls, so do energy (or, in the EU, ETS) prices, which encourages consumption elsewhere.

Estimates of the rebound effect

Estimates of the rebound effect vary in the academic literature and it is likely that the size of the effect varies according to geographical area and economic sector, and over time[13].

Although there is some uncertainty, particularly for household heating and cooling, a recent evidence review by ACEEE (2012) indicated that the direct rebound effects (increased consumption) will generally be 10% or less of the savings achieved.

For household heating and cooling, uncertainties about the impact of efficiency measures arise from the influence of technical effects (e.g. retrofitting of buildings makes it easier to achieve the desired internal temperature) and of behavioural effects (e.g. the reduced cost of heating the home on a ‘useful delivered heat’ basis can lead to an increase in desired comfort levels). These combined effects may be more significant in the case of very poorly-insulated homes (where higher retrofitting costs may be incurred) and in the case of low-income households (ACEEE, 2012).

The main findings on the size of the *direct* rebound effect are presented in Table 2.1.

For industrial sectors, ACEEE (2012) predicts that, even where energy costs account for a relatively high proportion of total production costs (i.e. in energy-intensive industries), EE improvements have a negligible impact on production.

Only one study has been identified that has quantified the *indirect* rebound effects in any detail. Using a macroeconomic model Barker and Foxon (2008) examined the impact of UK EE policies from 2000 to 2010.The study predicted that the indirect rebound effect for final energy users would be around 11% by 2010, averaged across sectors of the economy. Higher indirect effects (15%) were projected for energy-intensive industries and lower effects for households (10%), road transport (6%) and commerce (5%).

[13]Some of the cited results from these studies, and particularly the high-end estimates, are derived indirectly from evidence about consumer responses to changes in energy prices. It is however possible that price changes driven by efficiencies are a special case and that elasticities for prices and efficiency are statistically different (ACEEE, 2012).

Table 2.1 Overview of study findings of direct rebound effects

Study	Scope	Summary of direct rebound effects
Sorrell (2007)	EU	For household heating and cooling, the direct rebound effect is estimated to be between 10% and 30%. This includes behavioural and technical effects. For personal automotive transport it is estimated to be closer to 10%.
Allan et al. (2006)	UK	A long-term rebound effect of 31% from a 5% improvement in energy efficiency across all UK production sectors, including primary energy supply.
Barker et al. (2009)	Global	Installing EE measures lowers domestic energy bills and results in higher disposable incomes, which can be spent elsewhere in the economy, while businesses see a reduction in running costs and so an increase in productivity. The rebound effect can ultimately be as high as 50%, once indirect effects are taken into account.
DECC (2013)	UK	For any heat consumption reduction measure, or renewable heat pump or insulation measure, the savings are adjusted by 15% to allow for comfort taking (the reduced cost of running appliances means they will be run more often).
Lee and Wagner (2012)	US	Empirical research using US data on fuel efficiency shows that the rebound effect exists. It ranges from 1% to 10% in the short run and 5% to 30% in the long run.
CE et al. (2011)	EU	Vehicle fuel-efficiency reduces the cost of motoring but, in the long run, will lead to an increase in demand, thus offsetting the initial gains.
ACEEE (2012)	US	Consumers moderately increase operating hours after they install efficient lights, with a range of 5-12%. There is limited evidence of rebound effects in industrial sectors.
Jin (2007)	South Korea	Based on estimates of the price elasticity of residential electricity use, the long- and short-term rebound effects were estimated at 30% and 38%, respectively.

Based on the data reported above, combining the direct rebound and indirect income effects leads to the conclusion that, if energy use were reduced by 10%, then the actual energy savings realised would be 7.9%[14].

2.5 Co-benefits of energy efficiency

On the one hand, from an energy perspective, by directly lowering the marginal costs of energy use and freeing up resources that can be invested elsewhere, rebound effects will make it more challenging to achieve targeted reductions in energy use. On the other hand, from a societal perspective, these same rebound effects may be considered welfare enhancing due to a host of multiple 'co-benefits'.

[14] 10% savings * (100% - 10% direct rebound - 11% indirect rebound) = 7.9% savings.

In a study of the multiple benefits of energy efficiency, IEA (2013) highlights that reinvestment of energy savings can act as '*a driver for achievement of other policy goals, including employment, poverty alleviation, health improvements, etc'*. Lee and Wagner (2008) suggested that these positive social effects can be seen as having two parts: enhanced productivity, and widened consumer access. In relation to productivity, a higher level of production can be achieved from the same level of resource input. The reduced production costs free up resources that can be subsequently reinvested, boosting economic development and stimulating employment (see also Roland-Holst 2008). In relation to consumer access, the reduction in the marginal costs of energy use 'lowers the bar' for those who would otherwise be priced out from owning / renting and using energy-consuming appliances. Energy efficiency measures, in this sense, can be seen as enhancing consumer welfare, because they improve an individual's access to energy-using technologies and services.

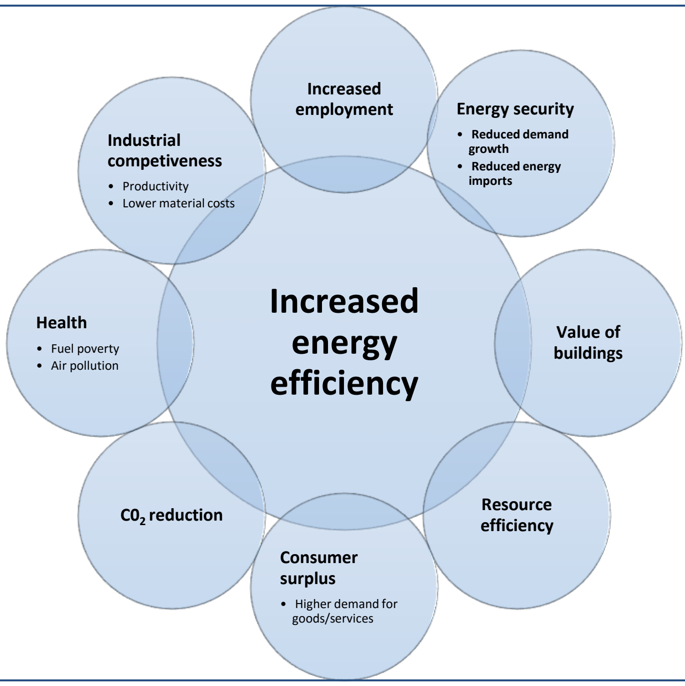
Several studies also highlight wider societal co-benefits from energy efficiency. For example, based on an assessment of the economic effects of energy efficiency improvements in the Finnish building stock, Tuominen et al. (2013) also identify a significant drop in anticipated harmful emissions of pollutants and greenhouse gases.

At the level of the plant or enterprise, Worrell et al. (2003) estimated that in 30% of cases studied the co-benefits of industrial energy efficiency for manufacturers are equivalent to three times the value of the direct energy savings. These co-benefits include: improved worker safety, improved plant reliability, improved product quality, resource efficiency improvements with reduction in materials used, and reduced labour and maintenance costs. The uncertainty in evaluating certain productivity benefits (particularly quantifying, in financial terms, a productivity increase as a result of improved worker welfare) deters some enterprises from implementing energy efficiency measures. Information failure also prevents identified benefits from being widely appreciated by businesses.

There is also some preliminary evidence (based on consultations with the WHO and IEA) to suggest that energy efficiency improvements lead to reduced local air pollution and, in the case of building retrofits, to better indoor climate as a result of reduced dampness and improved indoor air quality. These co-benefits are in turn linked with better health outcomes, higher productivity and welfare (see Figure: 2.1).

The role of energy efficiency policies in supporting wider co-benefits and their impact on health and wellbeing are examined further in Chapter 7.

Figure: 2.1 Co-benefits of energy efficiency policy



3 Direct employment associated with energy efficiency activities

3.1 Introduction

This chapter reviews the different approaches to estimating the current stock of jobs related to activity that promotes energy efficiency and energy savings. Based on these findings, a conceptual framework is set out on the basis of sector and ratio approaches. Making use of the two approaches, worked examples are elaborated to assess the level of employment related to energy efficiency at EU and Member State level[15] and to answer the research questions: what is the level of employment currently associated with energy efficiency across Europe, and what is the potential for creating employment related to energy efficiency improvements and/or investments?

3.2 What are energy efficiency activities?

Defining energy efficiency

It is important to clarify terminology and concepts used before we proceed to the analysis of the level and scale of employment related to energy efficiency activities. The definitions that we give of key concepts and terms are based on the EU Energy Efficiency Directive (EED) 2012/27/EU that forms the legal underpinning of what is understood by 'energy efficiency' in the EU. They also draw on the wider insights gained from the literature reviewed (see Chapter 2).

The EED defines energy efficiency as 'the ratio of output of performance, service, goods or energy, to input of energy'[16]. In the literature, on the other hand, energy efficiency is normally understood only as the production or delivery of a specific service – such as a unit of residential heating – with less energy.

This common understanding of energy efficiency is sometimes interpreted in a limited, technical manner to encompass only the energy saved as a result of technical change (e.g. changing to low-energy light bulbs). In contrast, the EED definition of energy efficiency improvements explicitly captures the non-technical factors contributing to lower energy consumption (e.g. switching off lights as a result of behavioural changes).

Taking this further, the legal definition of the EU energy efficiency target defined in terms of reduced energy consumption[17] can also be seen to take

[15] The underlying datasets have been extended to provide equivalent data for all EU Member States. It is not possible to test the inherent assumptions in the data transfer from the US without detailed empirical research in Member States. Data should be used as providing only broad indicative estimates.

[16] Energy Efficiency Directive 2012/27/EU Article 2 (4).

[17] This target is defined in the EED as EU energy consumption in 2020 of no more than 1,483 Mtoe of primary energy or no more than 1,086 Mtoe of final energy. The recently agreed target for the 2030 framework is an energy saving of at least 27%, to be reviewed in 2020 having in mind a 30% target http://ec.europa.eu/clima/policies/2030/index_en.htm.

account of external conditions (e.g. economic factors like economic growth) that affect energy consumption or savings in energy use.

A further distinction between the EED definition and the common approach is the reference to a ratio that, as well as encompassing the use of less energy for the same output, does not exclude the production or delivery of more services for the same amount of energy[18]. Therefore, there can be an improvement in energy efficiency either when less energy is consumed to provide the same level of output, or when the same amount of energy is used to produce a higher level of output.

The EED definition also includes reference to the source of energy or fuel, in relation to the relative efficiency (or wastage) associated with the transformation of primary energy into electricity and fuels.

This means that energy efficiency is defined both in terms of energy demand foregone ('avoided energy consumption') that reduces the level of energy consumed, and also in terms of reduced energy losses associated with the transformation of primary energy into electricity and fuels, as well as their transmission ('avoided energy losses'). Loss-reductions within power generation and energy transmission are recognised by the EU[19] as an important aspect of energy efficiency.

Table 3.1: Summary of definitions of energy efficiency

Source	Term used	Definition
EU Energy Efficiency Directive (2012/27/EC)	Energy efficiency	The ratio of output of performance, service, goods or energy, to input of energy.
	Energy efficiency improvement	An increase in energy efficiency as a result of technological, behavioural or economic changes.
	Energy savings	An amount of saved energy determined by measuring and/or estimating consumption before and after implementation of an energy efficiency improvement measure, whilst ensuring normalisation for external conditions that affect energy consumption.

The market for energy efficiency

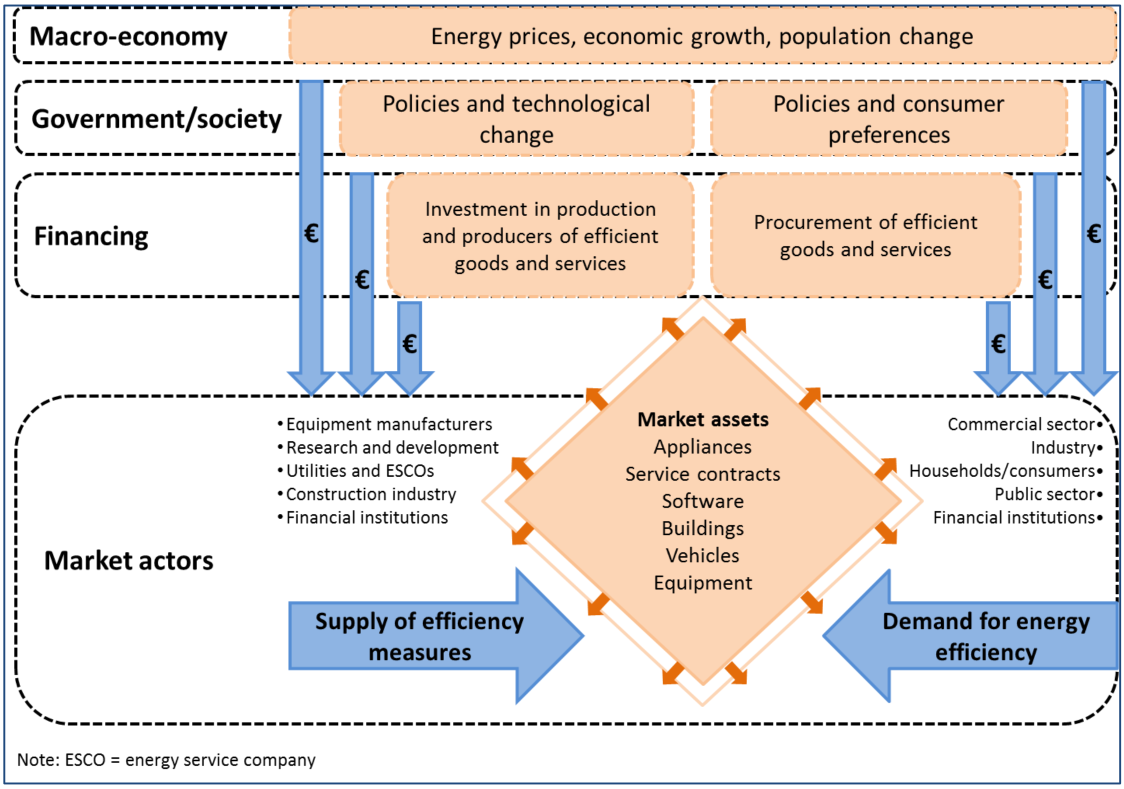
Before examining and developing approaches that define and estimate the economic and employment scale of energy efficiency activities, it is important to operationalise what is understood by the energy efficiency market and its various actors (see Figure 3.1). This conceptualisation of the market for energy efficiency adopts a two-sided definition, because it recognises that the approaches to estimating economic activity need to distinguish between demand-side (purchases of goods and services) and supply-side (sales of goods and services[20]), not least in order to avoid double-counting of jobs relating to energy efficiency market assets.

[18] For example, insulating a home so that it retains heat better, and then keeping the increased temperature for a more comfortable living environment instead of turning down the thermostat.

[19] See Art. 14 and 15 of the EED.

[20] Utilities and financial institutions would conventionally be considered as providers of services. In this context services includes those provided by the construction sector – such as the refurbishment of buildings.

Figure 3.1: The Market for Energy Efficiency



Sources: IEA (2013), *Energy Efficiency Market Report 2013*, International Energy Agency.

Approaches to estimation also need to distinguish between capital expenditures that involve purchases from other parts of the supply chain and thereby also have indirect effects on jobs, and those operational expenditures that directly support jobs.

Factors driving the demand for energy efficiency

The demand for energy efficiency is driven by a number of factors:

- **High energy prices**, which can strongly motivate the uptake of energy efficient technologies and procedures (Fraunhofer et al. 2009)
- **Innovation effects** of technologies and scale effects when widely used (e.g. learning curves)
- **Government policy** to promote energy efficient activities and technologies, and/or the scale of programmes to implement them
- **Consumer preferences**: as well as considering energy costs, consumers also act in accordance with personal preferences about patterns of use; moreover, their purchase decisions may also be based on social, environmental or utility considerations

In this context, a range of studies have been reviewed that use different approaches to defining the economic activity related to energy efficiency. These different approaches highlight the methodological and practical challenges related to the definition of such a diffuse and diverse market and the related difficulties in estimating the jobs associated with it.

Challenges in operationalising a definition of energy efficiency

However, there are several difficulties or challenges in operationalising any definition of energy efficiency in order to assess the current and future levels of employment that can be associated with it.

First, activities to improve energy efficiency are not distinguished in economic accounts – there is a not a discrete ‘energy efficiency’ production sector and it is not possible from published statistics to know what the levels of investment, sales or employment are that result from the demand for energy efficiency.

In economic statistics, industries are usually grouped as establishments that produce similar goods, whereas energy efficiency activities are heterogeneous and therefore difficult to classify together. In addition energy efficiency has a strong transversal dimension because it is often embedded within already existing technologies and practices. As a result, it is challenging to define specific energy efficiency activities that align with national or international systems and conventions for recording and measuring economic activity and employment.

Consequently, estimates of economic activity need to be based on informed judgements about which economic activities are necessary to achieve improvements in energy efficiency; and these judgements must be the basis for interrogating published statistics and/or collecting market data from the grey literature. In other words, the ‘system boundary’ of energy efficiency related industries needs to be specified.

It is also worth emphasising that the judgements required in order to specify the system boundary are not straightforward, because they presuppose that the purpose of the economic activity is energy efficiency. For example, is public transport in and of itself an energy efficiency activity? In the first instance, public transport systems operate to provide mobility to users. The fact that they are more energy efficient than, say, personal road based systems was not the rationale for their construction and operation. However, it might be argued that new investments in public transport are at least in part informed by the energy efficiency saving compared to some alternative transport option, and would constitute an energy efficiency investment.

There is also the issue of ‘mainstreaming’ or the integration of what was originally a distinctive activity designed to improve energy efficiency but which has become a standard activity over time. For example, investment in energy efficient lighting produced alternatives to the standard incandescent light bulb, and thus allowed market regulation to phase out the incandescent light bulb. Since the replacements are now the market standard, are their sales to be considered an expenditure on energy efficiency; and, if so, is it just the difference in cost that should be taken into account? Where there is additional expenditure incurred by, say, an industrial plant to replace older lighting systems and install more energy efficient lighting, then this would be more clearly definable as an energy efficiency activity.

3.3 Classifying energy efficiency market activities

All approaches to classifying energy efficiency market activities have one thing in common – they use some definition of activities that are undertaken *because* they improve energy efficiency.

However, establishing that the purpose of some activity is to support energy efficiency is often a matter of judgment about which there may be different levels of agreement or disagreement. Such problems could be mitigated if there were a widely accepted core definition and a non-core definition that included additional activities about which there is less agreement. Such an approach was adopted in the early stages of defining the environmental goods and services sector in the EU[21].

Classification of EE activity

We summarise recent approaches to the classification of energy efficiency activity in Table 3.2:.

Table 3.2: Definitions of energy efficiency related jobs

Study	Definition
Environmental Goods and Services Sector (EGSS), Eurostat	Identifies purchases of goods and services that are deemed to have the specific purpose of providing environmental protection. The EGSS includes reference to a Classification of Resource Management Activities (CReMA)[22]. This categorises activities in relation to the management of energy resources disaggregated by a) The production of energy from renewable resources; b) Heat/energy saving and management; and c) Minimization of the use of fossil energy as raw materials. However, no disaggregated data on employment or production are available across these categories, while the aggregate data are only available for intermittent years over the period (2000-2010) across a few Member States.
US Green Goods and Services (GGS) Survey (BLS, 2011a)	Products and services that improve energy efficiency. Included in this group are energy efficient equipment, appliances, buildings and vehicles, as well as products and services that improve the energy efficiency of buildings and the efficiency of energy storage and distribution, such as Smart Grid technologies.
US Green Technologies and Practices (GTP) survey (BLS, 2011b)	Jobs in which workers' duties involve making their establishment's production processes more environmentally friendly or reducing their use of natural resources. There are six categories of green technologies and practices, three of which are most relevant to energy efficiency: improve energy efficiency within the establishment (B); reduce or eliminate the creation of waste materials (E); and conserve natural resources (F).
US Clean Economy, Brookings (2011)	EE is a sub-category of the clean economy and includes the following segments: appliances, battery technologies, electric vehicles, energy-saving building materials, energy-saving consumer products, fuel cells, green architecture and construction services, heating, ventilation and air conditioning (HVAC) and building control

[21] OECD/Eurostat (1999): The Environmental Goods and Services Industry: manual for data collection and analysis. Paris, OECD

[22] No internationally agreed standard classification for resource management activities exists yet.

	systems, lighting, professional energy services, public mass transport, smart grid, water efficient products.
ECO Canada (2011)	Energy efficiency is defined as a sub-sector of the green economy (entitled ‘energy efficiency or green buildings’). The definition Includes the following two segments: (1) green building activities: architectural and construction services, building inspection and audit, deconstruction of inefficient systems or structures, resource-efficient landscaping, energy-saving building materials, energy efficient HVAC and building control systems, energy efficient lighting, resource-conserving water systems, other professional energy services. (2) other energy efficiency technologies and applications: energy storage and battery technologies, use of ‘smart grid’ technologies, energy saving consumer products and appliances, energy consulting, software and services, fuel cell technologies.
EU Construction Sector, Ecorys (2010)	Energy efficiency encompasses all changes that result in a reduction in the energy used for a given energy service (heating, lighting, etc.) or level of activity. This reduction in energy used for energy services is not necessarily associated with technical changes, but also results from better organisation and management or improved economic efficiency in the sector (e.g. overall gains in productivity).

The definitions outlined above show that there is relatively broad agreement on the types of sector or industry associated with energy efficiency.

Review of sector approaches

The European EGSS statistics are defined to be consistent with standard national economic accounting systems. However, the data cannot be extracted from the accounts but are collected separately through a bi-annual survey of economic actors that identifies purchases of goods and services that are deemed to have the specific purpose of providing environmental protection. Although resource efficiency and energy management activities are included, survey returns are incomplete for the majority of Member States, and disaggregated data by category of activity are not available.

In an EU study on sustainable construction, Ecorys (2010) draws on two previous studies (Ernst and Young, 2006 and Ecorys, 2009), to arrive at an estimate that the sustainable (or eco-) construction sector accounted for 5-10% of the total construction sector in 2006, and that the share will rise to 20% in 2015. Recognising that sustainable construction should include both the use of technologies and improved approaches to the management of construction projects, the study then identifies four specific occupational profiles (installers, technicians, inspectors and auditors) working in the sustainable construction sector for which to estimate employment. There is, however, little underpinning empirical evidence to support these judgements/assumptions on the share of the construction industry that is sustainable and its market share in the future.

Alternative sources Given the lack of EU data, available evidence on the share of energy efficient employment from other developed countries was considered.

In the US, the Bureau of Labor Statistics (BLS) conducts two surveys on green goods and services (GGS) and green technologies and practices (GTP). Like the EGSS, the GGS identifies 325 detailed industries (6-digit NAICS) as potential producers of green goods and services. Within these industries, the survey then identifies establishments that produce green goods and services and estimates the number of jobs associated with this production based on revenue data (Sommers, 2010). It is, however, not possible to differentiate between goals related to energy efficiency and wider environmental purposes.

In the BLS (2012) GTP survey, the aim is to collect data on establishments' use of green technologies and practices (i.e. those that lessen the environmental impact of an establishment's production processes) and the occupations of workers who spend more than half of their time involved in such GTPs. Here, activities related to energy efficiency were identified through a specific set of questions which divide GTPs into six categories, including energy efficiency, waste management and resource conservation. Workers were considered to be involved in GTPs if they were: a) Researching, developing, maintaining, using, or installing technologies or practices to lessen the environmental impact of their establishment; or b) Training the establishment's workers in these GTPs.

Brookings (2011) uses a similar approach to the EU EGSS and US GGS classifications by defining energy efficiency activities in terms of outputs (rather than processes). This study identified a set of firms, establishments and jobs deemed to be exclusively part of the 'clean economy'. Energy efficiency and EE-related jobs are defined as a sub-category of the clean economy.

Similarly ECO Canada (2011) defines occupational profiles based on existing industry classification systems and energy efficiency is treated as a sub-sector of the whole economy. Brookings (2011) goes further by applying non-standard market information on goods and services in its examination of employment in standard sector classifications.

Summary The production of energy efficiency goods and services cannot be considered as a distinct sector of the economy. Its extent is intimately linked to economic structure and to the potential for energy savings (IEA, 2013).

The approaches identified in this review of previous attempts to classify current jobs in relation to energy efficiency tend to adopt a sector-based approach, which uses standard industrial classifications but seeks to estimate the share of sector output and employment associated with energy efficiency (construction / transport services / vehicles), based on industry surveys of users of energy efficiency goods and services to define expenditure levels (including ancillary activities) and/or related employment.

3.4 Current levels of employment related to energy efficiency in Europe

Applying sector approaches

Since secondary data on energy efficiency related jobs in the EU are not available, and primary research is not the focus of this study, the approach adopted here has been to develop a range of estimates in line with the underlying definitions used in the classification of existing data from other non-EU regions.

The review of approaches has identified two datasets from Brookings (2011) and the US GTP survey that can provide a starting point for analysing current employment levels related to energy efficiency in the EU. These datasets provide sufficient detail to allow us to identify and map analogous data about energy efficiency activities and employment in Europe. The datasets are also in broad agreement about the types of activity to include in core and non-core definitions of energy efficiency activities. However, the two studies differ significantly in the relative weight give to the demand and supply sides. The GTP survey seeks to identify establishments engaged in increasing their energy efficiency and workers who spend more than half of their time in making their own establishments more energy efficient. This is effectively a measure of the demand side, and activity will take place across all sectors of the economy. The establishments will be purchasing goods and services that help to improve energy efficiency. The Brookings study is a more conventional supply-side analysis, seeking to identify the production of goods and services used to secure energy efficiency. As a supply-side analysis it seeks to identify the sectors responsible for the production, and will therefore be concentrated in a smaller number of sectors, especially manufacturing. These sectors are difficult to identify because, as with green goods and services more generally, energy efficiency is not specified as an activity for the purposes of industrial classification.

Throughout the analysis, we continue to explore and develop an understanding of the sectors most associated with the supply and use of goods and services that enable improvements in energy efficiency, and we set out the steps to provide a rigorous analysis of employment in specific sectors of interest.

Because of the difference in focus and approach, the two studies are not comparable; the employment associated with own-use EE activity is different to that associated with the production of EE goods and services. In the context of this study, examining the employment implications of investment in energy efficiency, it is the results of the Brookings research that is of most interest.

In order to use the results of US studies specified at sector level, account should be taken of the different industrial structure between the US and the EU and the relative size of the sector in the US compared to the EU. Since the US and the EU both use the same international standard industrial classification (ISIC), there is no need to adjust for any differences in the classification. The EU NACE classification is based on the ISIC and is the same as the NAIC classification used in the US.

Data from the GTP Survey

The GTP survey in the US[23] identifies workers within their establishments that spend time carrying out energy efficiency activities – defined as employees who use technologies or practices to improve energy efficiency[24].

In providing information on the number of workers that spend more than half of their time using energy efficiency technologies or practices, the survey can provide useful information on the degree to which energy efficiency practices are present across industry sectors. However, it does not indicate employment associated with the production of EE goods and services.

In order to apply the US survey data in the EU context, it is necessary to reweight the survey values by taking account of the different composition of industrial structures[25] and working populations (see Figure 3.2 for a methodological note on the underpinning methodology).

The results of Step 1 in Figure 3.2 indicate that, of the total US GTP employment of 855,000 in 2010, some 57% (471,000) is related to energy efficiency. Assuming that the EU has a similar level of activity as recorded in the GTP survey, by sector, there were approximately 774,000 jobs related to energy efficiency activity in the EU28 in 2010.

Although the procedure described in Figure 3.2 takes some account of differences in economic structure between the US and EU economies by estimating EE weightings by sector, it seems likely that there will be discrepancies between the identified US data and the real values that one would observe in the EU – if such data existed – due to the differences between the two regions in their approaches to energy efficiency and in the underlying energy efficiency policy context.

The principal difference in energy efficiency policy between the EU and the US is the prevalence of voluntary approaches in the US. Whereas EU policy focuses on legislation driven by Directives such as the Energy Efficiency Directive, the US prioritises voluntary efforts to improve energy efficiency in buildings, products, industry and transport, as well as energy-using products.

However, for the purposes of this analysis the patterns observed in broad industries in both regions are assumed to be similar.

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[23] Further information on the US GTP survey is available at: http://www.bls.gov/gtp/, accessed on 26/06/14.

[24] For example, EE appliances and lighting, EE certified buildings, programmable thermostats, cogeneration (combined heat and power), etc.

[25] Industrial classification in the US uses the International Standard Industrial Classification of All Economic Activities, (ISIC, Revision 4). This is consistent with the European Statistical Classification of Economic Activities (NACE, Revision 2). NACE is a derived classification of ISIC: categories at all levels of NACE are defined either to be identical to, or to form subsets of, single ISIC categories. The first level and the second level of ISIC Rev. 4 (sections and divisions) are identical to sections and divisions of NACE Rev. 2. For more details see: http://ec.europa.eu/eurostat/documents/3859598/5902521/KS-RA-07-015-EN.PDF/dd5443f5-b886-40e4-920d-9df03590ff91?version=1.0

Figure 3.2: Methodology to transfer GTP data

To apply the US survey data in the EU context, a stepwise approach was adopted:

Step 1: Estimate the number of EE jobs for each US sector (at 2-digit ISIC), using GTP data. Because the published data only indicate the number of establishments in which EE activity is going on, and not the number of workers engaged in that activity, the US sector EE employment needs to be estimated. This is based on total sector GTP employment divided by the share of EE establishments in total GTP establishments in the sector.

Example:

GTP employment in construction = 134,100

EE establishments in construction (291,100) as a share of all GTP establishments in construction (570,200) = 51.1%

Estimated EE employment in construction = 134,100 * 51.1% = 68,461

Step 2: Estimate the share of total US sector employment related to EE activity (as the basis of weights to be applied to EU sector employment estimates) to estimate EU sector level EE employment).

Example:

US employment in construction = 7,466,000

Estimated EE employment in US construction = 68,461

Estimated share of total construction sector employment associated with EE activity = 68,461 / 7,466,000 = 0.9% = EE construction sector weighting

Step 3: Estimate the share of total EU sector employment related to EE activity.

Example:

Construction sector EE weighting = 0.9%

EU employment in construction (NACE) = 16,022,000

Estimated EE employment in EU construction = 16,022,000 * 0.9% = 147,000

Data from Brookings

This US study by the Brookings Institute (2011)[26] sought to estimate the employment associated with establishments providing products that provide environmental benefits. The estimate was built up using pre-defined 'clean economy' categories from various company and establishment databases. Because activities do not fall into standard industrial classifications, the standard classifications were not used.

Figure 3.3: Identifying clean economy companies and establishments

[26] http://www.brookings.edu/research/reports/2011/07/13-clean-economy - Sizing the clean economy: The basic definition of the clean economy used in this study is 'economic activity measured in terms of establishments and the jobs associated with them—that produces goods and services with an environmental benefit or adds value to such products using skills or technologies that are uniquely applied to those products'.

Two approaches were taken in Brookings (2011) to identify clean economy firms. First, a set of industries deemed exclusively part of the clean economy was identified using the eight-digit SIC (Standard Industrial Classification) system developed by Dun & Bradstreet (D&B) and maintained as a time series by Walls & Associates as the National Establishment Time Series (NETS). In performing research on the clean economy for the Pew Charitable Trusts, Collaborative Economics developed a list of industries that could be considered completely embedded in the clean economy, in that each establishment in that listing produces goods or services that have an environmental benefit as defined above. More recently, Berkeley researchers worked off that list and added over 100 new SICs to it. This study used the Berkeley list as a starting point and incorporated almost every company, establishment, and job in those industries and added relevant SICs for air, water, waste management and treatment. This industry-based approach yielded 49 percent of all jobs and 69 percent of all establishments included in this study.

The second approach employed for identifying clean economy firms and establishments was to create a validated master clean economy list to catalogue every known industry association, certification, federal grantee, venture capital recipient, patent assignee, and product list that is relevant to the clean economy. In this fashion, over 60 lists of clean economy companies were compiled to create a substantial list of firms. The team also considered and incorporated listings from market research organizations and proprietary industry data sources, such as the Environmental Business Journal and Plunkett's Renewable, Alternative and Hydrogen Energy Industry Almanac. All of the lists were carefully validated. Lists were rejected if the team discovered that non-clean economy companies were allowed to join. The companies from the master list were incorporated into the study, and duplicate establishments were removed. With the industry codes identified and firm lists assembled, the next step was to find statistics on the companies and their relevant establishments using Dun & Bradstreet. Establishment history and other characteristics were added through the use of NETS. For companies that produce both 'green' and 'nongreen' products an effort was made to include only establishments that specialize in the clean economy production. This task was facilitated by Dun & Bradstreet and NETS because they employ detailed industry classification schemes that distinguish activities across establishments of the same company and even within single locations.

For cases where large establishments were known to produce both green and conventional products, information from companies, including their websites, was used to allocate a percentage of the site's employees to the clean economy based on the relative importance of its clean products compared to all of its products. Because of the nature of the Dun & Bradstreet database, many of the smaller establishments of less than five employees were a mix of independent contractors and field offices rather than stand-alone establishments. In order to ensure consistency within the establishment and job count, those very small establishments were excluded from the Brookings-Battelle database. This resulted in a roughly five percent reduction in the total number of clean economy jobs and a larger reduction in the number of establishments as most of them had zero jobs.

Classifying the establishments

Once the company, establishment, and job information was compiled, the next step was to classify it. The goal was to make the data as analytically useful as possible to facilitate research at various geographic levels and especially for regional economic development planning. There were a number of options, and ultimately this study reports the data in three ways.

First, through Dun & Bradstreet and NETS, the data is organized by NAICS categories, (e.g. for manufacturing, construction, financial services, and so on). Second, because only a small fraction of NAICS categories reside within the clean economy, a second scheme was adopted that divided establishments into five high-level categories (largely adopted from the BLS). Finally, to provide finer-grained categorization, 39 segments designed by the Brookings-Battelle team were used to further narrow the class of business activity and allow detailed analysis.

Establishments were assigned to segments based on their industry code, the list used to identify them, or, in some cases, information provided by the company's website.

Source: Brookings (2011), p15.

The resulting database provides estimates of the current employment levels and recent trends in the clean economy, with a sub-category defined to capture activity related to 'energy and resource efficiency' and yields an initial typology comprising different segments of market activities providing goods and services for the purpose of improving energy efficiency.

Based on this Brookings (2011) typology, the largest single segment of energy efficiency is in Public Mass Transit, which accounted for almost half of all energy efficiency jobs in the US in 2010 (see Table 3.3: below).

Table 3.3: Estimates of energy efficiency related employment in the US, 2010

Brookings defined segment		2010 jobs	Absolute change in jobs 2003-2010 (%)	Annual average change in jobs 2003-2010 (%)
Energy-saving building materials		161,896	25,985	2.5
HVAC and building control systems		73,600	14,946	3.3
Green architecture and construction services		56,190	19,678	6.4
Professional energy services		49,863	18,702	6.9
Appliances		36,608	-9,063	-3.1
Energy-saving consumer products (e.g. smart meters)		19,210	-4,405	-2.9
Battery technologies		16,129	1,524	1.4
Lighting		14,298	-1,971	-1.8
Public mass transit		350,547	82,601	3.9
Smart grid		15,987	7,001	8.6
Electric vehicle technologies		15,711	5,447	6.3
Fuel cells		7,041	3,499	10.3

Sources: Brookings-Battelle Clean Economy Database, 2011.

As explored above, the production of goods and services not considered to be driven by energy efficiency should arguably be excluded from a 'core' definition of EE related employment. However, where the activity does result in energy savings – such as public transport – this can be considered for inclusion in a *broad* category of activity based on the interpretation of the EU definition of energy efficiency[27]. We have therefore sought to divide the classification provided by the Brookings study into core and broad definitions.

The *broad* category of activity is activity that has the potential for energy savings, but is not purchased with the savings in mind (recognising it is a matter of judgement). We have also included jobs related to activities that produce goods or services that may be considered as being more energy efficient or jobs related to the energy efficient production of products that is itself driven by other environmental concerns such as products manufactured from recycled content and green building materials (non-core activities). Here, the Brookings database also includes categories on environmental regulation, compliance and training; these categories include other clean economy activities unrelated to energy efficiency (partial activities). These we have chosen to add to the Brookings classification of energy and resource efficiency under the 'Broad' definition.

Finally, the Brookings classification also includes considerations of energy efficiency in terms of reduced energy losses associated with the transformation of primary energy into electricity (supply-side) and changes in fuel inputs or energy source (or fuel switch).

This approach to interpreting the Brookings classification for application to the EU is based on the sum of employment related to the production of energy efficient products or services and purchased with these savings in mind (the 'core' estimate). A 'broad' estimate is also calculated, adding employment to the 'core' estimate in other activities that might be considered to improve energy efficiency but are not purchased with this benefit in mind.

Energy efficiency activities and their definition, captured in Brookings, and used as the basis of the job estimates in the EU in the present study are presented in Table 3.4: below.

Table 3.4: Estimates of energy efficiency related employment in the US, 2010

Brookings defined Segment	ICF defined category of energy efficiency activity	Judgment on allocations to core / broad categories of energy efficiency activity	2010 jobs – Energy Efficiency
Energy-saving building materials* (Manufacturing)	Core	Energy saving materials including insulation, glazing, VIPs, composite doors.	161,896
HVAC and building control systems* (Construction)	Core	HVAC relevant as EE if BMS which are fitted alongside it controls the HVAC effectively (this includes CHP).	73,600

[27] 'An increase in energy efficiency [the ratio of output of performance, service, goods or energy, to input of energy] as a result of technological, behavioural or economic change.' EU Energy Efficiency Directive, 2012/27/EC.

Green architecture and construction services* (Construction)	Core	Green architecture/construction assumed to cover more energy efficient buildings (not just less water usage; better materials). For example, to passive house standards or near zero energy buildings etc.	56,190
Professional energy services* (Services)	Core	ESCOs and facilities management staff, for example energy auditors (likely to be more developed in the USA than the EU).	49,863
Appliances* (Manufacturing)	Broad	Appliances are often higher specified goods with a price premium, but some consumers will be drawn to them for ethical reasons and due to energy labelling.	36,608
Energy-saving consumer products (e.g. smart meters)* (Manufacturing)	Core	Consumer products purchased with the explicit intention to save energy.	19,210
Battery technologies* (Manufacturing)	Broad	Batteries are not yet used exclusively for EE related applications, hence broad (although relative usage in hybrids and EVs would need examination). Ultracapacitors on the other hand would be core EE.	16,129
Lighting* (Manufacturing)	Broad	Lighting is assumed not to be purchased primarily for its EE function.	14,298
Public mass transit* (Services)	Broad	Too difficult to determine EE component unless specific fleets of buses for example are classified as hybrid vehicles etc.	350,547
Smart grid* (Utilities)	Core	Smart grid investments are designed to save energy. They enable utilities (and consumers such as industry / householders) to have greater insights on energy usage and hence allow for behavioural change and justification for further EE investments.	15,987
Electric vehicle technologies* (Manufacturing)	Core	EV technologies are assumed to be core given the purpose of EVs is to achieve more EE transport.	15,711
Fuel cells* (Manufacturing)	Broad	Fuel cells assumed not to have a core EE function since many help to achieve cost-effective back up power supplies in times of power failure.	7,041
Recycled content products** (Manufacturing)	Broad	Recycled-Content Products can reduce material inputs but primarily for EE reasons.	59,712

Green building materials** (Manufacturing)	Broad	Green Building Materials can produce less offgassing during their lifetime and less waste at their end of life, but are not purchased explicitly for EE.	76,577
Regulation and compliance** (Services)	Broad	Enforcement of building standards/regulations likely to have an EE effect.	141,890
Training to a clean economy** (Services)	Broad	Hard to determine how specialist the training for EE would be.	266

Sources: Brookings-Battelle Clean Economy Database – * indicates segments included in 'energy and resource efficiency' category; ** indicates segments added by ICF from other Brookings Clean Economy categories Additional definitions by ICF: Core= EE activity purchased with the explicit intent to save energy. Broad= EE activity that results in energy savings, but not generally purchased with this end in mind.

Unfortunately the Brookings study does not reclassify the employment in the energy efficiency category by standard industrial classification (although it does so for the clean economy in aggregate).

To provide the basis for a transfer of the results to the EU at sector level, each of the segments in Table 3.4: has been allocated to one of the 2-digit NACE sectors. The transfer to the EU employs the same method as for the GTP results; the share of total sector employment related to EE activity in the US is applied to total EU sector employment estimates.

Employment in energy efficiency in the EU

The Brookings research provides a basis for estimating the indicative total energy-efficiency related employment in the EU presented in Table 3.5:.

Based on the conversion method described above, it is estimated that in 2010 approximately 900,000 jobs were generated in the EU28 by the sale of energy efficiency goods and services, using the core definition. Adding those activities defined to be part of a broader definition of energy efficiency activity increases the estimate of employment to approximately 2.4m jobs.

The major difference between the core and broad estimates is the estimated shares of EE-employment across manufacturing and transport sectors.

The table also includes the results of the GTP survey. As previously noted the survey is more a measure of demand-side activity and not directly comparable to the results from the Brookings research. This analysis identifies 0.8m jobs associated within businesses undertaking their own energy efficiency activity.

Table 3.5: Estimates of EU28 employment in the energy efficient economy by sector, 2010

Industry sector	Jobs from the production of EE goods and services in the EU		Jobs in establishments undertaking own use EE activity
	Employment in EE, as per Brookings (core)	Employment in EE, as per Brookings (broad)	Employment in EE, as per GTP
Agriculture, forestry, etc.	-	-	52,000
Extraction industries	-	-	1,000
Manufacturing	539,000	1,114,000	89,000
Utilities and waste services	39,000	39,000	24,000
Construction	279,000	279,000	147,000
Distribution and retail	-	-	57,000
Transport and warehousing	-	758,000	33,000
Business services[28]	73,000	74,000	259,000
Non-Market services[29]	-	153,000	113,000
Total Employment	929,000	2,416,000	774,000

Sources: ICF calculations based on Brookings (2011), GTP Survey, BLS (2011), ESTAT EU28 employment data by sector, STAN Database for Structural Analysis for US employment data by ISIC.

The EU estimates for manufacturing, construction, etc. can be further broken down to the same Brookings market segments using the US to EU sector coefficients used in the previous table (see Table 3.6). These segment specific estimates facilitate discussion of the employment weight of different energy efficient technologies in the context of EU technology development.

Table 3.6: Estimates of energy efficiency related employment in key market segments in the EU28, 2010

Brookings defined segment	ICF defined category of energy efficiency activity	2010 jobs
Energy-saving building materials (Manufacturing)	Core	443,000
HVAC and building control systems (Construction)	Core	158,000
Green architecture and construction services (Construction)	Core	121,000

[28] Finance and insurance; real estate and rental and leasing; professional, scientific, and technical services; arts, entertainment, and recreation; accommodation and food services; and other business services.

[29] Education services; health care and social assistance; and public administration.

Professional energy services (Services)	Core	73,000
Appliances (Manufacturing)	Broad	100,000
Energy-saving consumer products (e.g. smart meters) (Manufacturing)	Core	53,000
Battery technologies (Manufacturing)	Broad	44,000
Lighting (Manufacturing)	Broad	39,000
Public mass transit (Services)	Broad	729,000
Smart grid (Utilities)	Core	39,000
Electric vehicle technologies (Manufacturing)	Core	43,000
Fuel cells (Manufacturing)	Broad	19,000
Recycled content products (Manufacturing)	Broad	163,000
Green building materials (Manufacturing)	Broad	210,000
Regulation and compliance (Services)	Broad	153,000
Training to a clean economy (Services)	Broad	0

Sources: Tables 3.4 and 3.5.

Estimates at the Member State level can be produced using the same approach (although none have been identified), but using MS rather than EU sector employment, shown in Table 3.6. These results are more likely to be in error than the EU estimate because the analysis assumes that levels of demand match those of the US and that the supply chains providing energy efficiency goods and services (EEGS) are located within the Member State to the same extent as the US (or that the international trade in EEGS by a MS results in similar level of demand), since international and intra-EU trade is not accounted for.

This assumption is likely to result in an underestimate of jobs in countries which are high exporters of EE products, and an overestimate of jobs in countries which do not produce energy efficient goods and services. For example, jobs in Denmark will be underestimated, as Denmark has a high share of EE manufacturing for exports (DEA, 2013), while jobs in Member States that are importers of EE products may be overestimated. The estimates should therefore be treated with extreme caution.

Table 3.6: Estimates of employment associated with the supply and the undertaking of energy efficiency activity by EU28 Member State, 2010

Member State	Jobs from the production of EE goods and services in the EU		Jobs in establishments undertaking own use EE activity
	Employment in EE, as per Brookings (core)	Employment in EE, as per Brookings (broad)	Employment in EE, as per GTP
AT	17,000	45,000	14,000
BE	17,000	47,000	16,000
BG	16,000	41,000	13,000
CY	1,000	4,000	1,000
CZ	31,000	76,000	18,000
DE	179,000	461,000	137,000
DK	9,000	27,000	9,000
EE	3,000	8,000	2,000
ES	72,000	191,000	66,000
FI	11,000	29,000	8,000
FR	94,000	260,000	94,000
GR	15,000	42,000	15,000
HR	8,000	19,000	6,000
HU	20,000	56,000	14,000
IE	7,000	17,000	6,000
IT	119,000	282,000	82,000
LT	6,000	16,000	5,000
LV	4,000	12,000	3,000
LX	1,000	4,000	1,000
MT	1,000	2,000	1,000
NL	26,000	73,000	29,000
PL	79,000	220,000	55,000
PT	22,000	50,000	17,000
RO	43,000	104,000	35,000
SE	18,000	46,000	15,000
SI	5,000	13,000	4,000
SK	12,000	31,000	8,000
UK	93,000	241,000	102,000
EU28	**929,000**	**2,416,000**	**774,000**

Sources: ICF calculations based on ESTAT EU AND MS employment by sector), GTP Survey, BLS (2012), Brookings (2012).

The Member State results based on the GTP survey also assume similar levels of establishment level activity in undertaking energy efficiency as the US. Since no comparable survey in the EU has been found, these estimates should only be used in full recognition of the severe assumptions made.

Areas for further research

Further development of the sector approach would require market research in order to establish the share of sector output associated with each of the market segments associated with energy efficiency in the EU. In the current context, the relative shares of energy efficiency activities in each industry are assumed to be the same as those in the US market; and that levels of domestic demand and international trade are similar in the EU as the US. The table in Appendix D summarises the range of market research sources that might be available at the EU level.

Moreover, although it is possible to calculate the relative industry or country shares of energy efficiency employment based on sector approaches – in the absence of costly data collection processes, this calculation can only provide a static picture of the current level of employment. Energy efficiency and its related employment are dynamic processes, which evolve with the development of new technologies and (public and private) measures that stimulate investment in energy efficiency.

In order to gauge the potential for job creation related to EE in the future, there are other approaches available that focus on the relative labour intensity of energy savings or their related investments (jobs per unit energy saved or jobs per unit of investment in energy efficiency - ratio approaches), where labour intensity is measured not at the level of the economy but rather from discrete analysis of the employment effects of energy savings investment at project, technology or sector levels.

While such measures of labour intensity are largely the outputs from the macroeconomic modelling reported in Chapters 4 and 5, empirical or bottom-up approaches are explored below in Section 3.5, since these can inform the configuration and/or underlying assumptions of the models, and they also provide ways of developing working tools to assess the impacts of future investments in energy efficiency.

3.5 The potential for employment related to energy efficiency activities in Europe

Review of ratio approaches

The literature review also identified studies that used a ratio approach to estimate employment effects based on employment factors (i.e. labour intensities of different technologies or practices). These ratios are based on a number of sources, including industry surveys and insights from specific enterprises or project experiences.

Two ratios tend to be used for comparing the job creation potential of different technologies:

- the number of jobs generated for a given level of output (such as jobs generated per unit of energy production, or per unit of energy saved based on the energy efficiency measures produced for a given technology/type of intervention)

- the number of jobs generated for a given level of spending on a particular technology (Kammen, 2004; Wei et al, 2011)

The estimated ratios in one geographic area are then transferred over or scaled up to the geography of interest. The ratios should be defined with respect to a given geography and technology(-ies).

These ratios often indicate the ‘gross’ direct job generation effect; these ratios generally take no account of the possible displacement effects on other economic activity (such as reduced spending on energy sources as a result of lower levels of energy consumption). Where there is consideration of the displacement effect, such as the loss of employment in energy generation that would otherwise have been produced, the ratios indicate the *net* job generation effect.

Some ratios relate only to the jobs associated with *direct* activities to save and produce energy, taking no account of the *indirect* supply chain effects or *induced* effects resulting from the spending of energy savings elsewhere in the economy.

In cases where the ratios are used to generate national data, these displacement and multiplier effects could be substantial, although they are difficult to measure without the application of input-output methodologies and the use of reference or counterfactual analyses. In reviewing the available literature we have sought to distinguish whether the ratios relate to gross/net and direct/indirect effects.

A distinction is also required between jobs generated as a result of capital investment, where the employment effects are limited to the duration of the investment period (and typically counted in job years), and revenue or operating expenditure, which is assumed to continue on a regular annual basis for the duration of the impact assessment. Almost all ratios relate to the capital investment.

This section presents the findings that come from a review of studies and surveys using ratio approaches.

Employment ratios relating to energy savings

To calculate the number of jobs produced for a given level of energy savings achieved, the activities required to achieve a unit reduction (e.g. a kWh or GWh) in energy consumption are specified in relation to economic sectors. These activities will vary according to the type of energy efficiency measures (e.g. targeted at building refurbishment or transport improvements). Based on the level of output (€m) required from different sectors to produce the goods and services required to implement the energy saving, and using the average jobs per unit of output per sector, the jobs supported by activities that save the unit of energy can be estimated. This provides a ratio of gross impact. It is also possible to estimate the jobs lost per unit of energy saved in energy producing sectors (assuming a given energy mix). These can be subtracted from the gross effect to provide a ratio of the net impact.

Table 3.7: provides an overview of the employment factors estimated in studies on energy efficiency. These include an EU (OECD) study as well as national studies in Europe and elsewhere. These tend to be measures of the net direct employment impacts.

This overview shows that employment factors tend to vary greatly across studies. They range from 0.17 jobs/GWh estimated by Laitner and McKinney (2008) to 0.60 jobs/GWh considered by Dupressoir et al (2007).

The most comprehensive estimation of EE related jobs is provided by Rutovitz and Atherton (2009), who calculated net job creation in the energy sector associated with two different scenarios. They treated as energy efficiency jobs only those additional to the jobs created in the reference scenario[30]. The employment factors are estimated for 2010[31], and adjusted for 2020 and 2030, and there are other regional multipliers that adjust different productivity levels across regions. Overall, the [R]evolution scenario estimates an increasing number of jobs created in OECD Europe in 2010 (16,000), 2020 (105,000) and 2030 (179,000), as production shifts from capital or carbon-intensive activities to those with relatively higher labour intensities. It does not appear to include any estimates of multiplier effects and our working assumption is that the data relate to direct impacts.

A study carried out by Access Economics in 2009 was based on programmes and actions planned in Australia between 2009 and 2020. This also considers a counterfactual situation where investment would otherwise have been spent on energy production, and takes account of this to estimate the net employment effect. Again multiplier effects are not included and the estimates relate to direct effects.

[30] While there are jobs in energy efficiency in the Reference Scenario, this calculation takes the Reference as a base line, and only considers additional energy efficiency employment over and above what would occur in the Reference scenario. This is not based on a model simulation.

[31] The weighted average and sectoral employment factors are based on efficiency premium employment and energy savings in GWh, calculated based on spending data from Ehrhardt-Martinez and Laitner (2008) cited in Table 3.7.

Table 3.7: Review of studies based on the jobs generated for given energy savings (geographic context varies according to study)

Study	Employment Factor (labour intensity of energy activities) in Jobs/GWh saved	Estimated impact on employment
Rutovitz and Atherton (2009)	Employment factors (OECD Europe) • 0.23 jobs/GWh for 2010 **net direct** • 0.15 jobs/GWh in 2020 **net direct** • 0.13 jobs/GWh in 2030 **net direct** Employment factors from savings in the following sectors: (OECD Europe) • Residential: 0.49 jobs/GWh **net direct** • Commercial: 0.62 jobs/GWh **net direct** • Industrial: 0.27 jobs/GWh **net direct** • Appliances and electronics: 1.02 **net direct** • Transport: 0.06 jobs/GWh **net direct** • Utilities 0.03 jobs/GWh **net direct** • Weighted average: 0.19 jobs/GWh **net direct**	Net employment in energy efficiency (i.e. revolution cf. reference scenario): • 2010: 0.06 m **net direct** • 2020: 0.72 m **net direct** • 2030: 1 .13 m **net direct**
Access Economics (2009)[1]	Employment factors (Australia) • Residential: 0.16 jobs/GWh **net direct** • Commercial: 0.36 jobs/GWh **net direct** • Industrial: 0.07 jobs/GWh **net direct** • Weighted average: 0.19 jobs/GWh **net direct**	n/a
Dupressoir et al. (2007)	Employment factors (Germany): • All sectors: 0.60 jobs/GWh	n/a
Wei et al. (2009)	Employment factors (US) • 0.38 jobs/GWh (based on average of estimates between 0.17 and 0.59) **net direct and indirect**	n/a
Laitner and McKinney (2008)	Employment factors (US) • 0.17 jobs/GWh **net direct and indirect**	n/a

[1] Based on programmes and actions planned in Australia between 2009 and 2020.

Potential employment impacts of future energy savings

These ratios of jobs generated per unit of energy saved (Table 3.7) can be used, together with estimates of future potential energy savings, to calculate, in approximate terms, the employment consequences of implementing energy savings activities. The calculation is simply based on the number of jobs per unit of energy saved, multiplied by the expected volume of energy saved.

However, the estimation assumes that the costs per unit of energy saving and related levels of investment implicit in the employment ratios continues into the future. Future trends are uncertain. Expansion of energy savings activity may result in economies of scale with lower costs per unit of energy saved with a smaller associated employment effect. However, expansion may also require more difficult technological challenges to be addressed, with higher costs per unit of energy saved and a larger associated employment effect.

The estimated volume of potential future energy savings is shown in Table 3.8:, and the ratios (using a range from low to high[32]) are taken from Table 3.7:. The results are summarised in Table 3.9: and Table 3.10. These estimates are taken from the EU database on EU potentials[33]. These in turn are largely based on the MURE simulation tool (Measures d'Utilisation Rationnelle de l'Énergie), which describes end-use technologies in order to describe the impact of the penetration of energy efficient technologies at a detailed level.

Table 3.8: Final energy consumption by end-use sector in the EU27, 2011-2030

Sector	Final energy saving potential (ktoe)	Share of total (%)
Industry	48,500	16%
Residential	105,500	34%
Tertiary	46,600	15%
Transport	107,400	35%
Total	**308,000**	**100%**

Sources: Data on end-use energy savings potentials http://www.eepotential.eu/description.php (accessed 22nd January 2015)

On the basis of this calculation it is estimated that between 97,000 (Table 3.9) and 275,000 (Table 3.10) additional jobs could have been supported in 2010 in the absence of barriers to realising energy savings potential. The range in estimates is a direct reflection of the range in reported jobs per unit of energy saved in the two studies used. To the extent that the Rutovitz (2012) study is EU based and the Access Economics (2009) study is Australian based, the results in Table 3.10 may be the most appropriate indication of the EU impact.

[32] Low-end estimated ratios on jobs per unit of energy saved from Access Economics (2009) and high-end estimated ratios from Rutovitz et al. (2012) except for transport, where the sources are reversed. Note, given potential differences in the Australian and EU transport systems, there is likely to be some degree of error in taking this ratio to be indicative of the EU situation.

[33] http://www.eepotential.eu/description.php

Looking ahead to 2030, there is the potential for between 0.5m (low end estimate) and 1.3m jobs (high end estimate) to be created as a result of avoided energy consumption assuming no productivity improvements in the energy saving activity.

Table 3.9: Estimates of additional employment based on savings potential, low

Sector	Jobs per unit energy saved	2010	2012	2020	2030
Industry[34]	0.07	8,720	12,185	25,886	39,457
Residential	0.16	29,643	41,090	95,870	196,309
Tertiary[35]	0.36	24,916	41,052	106,680	195,101
Transport	0.16	33,991	37,479	52,102	74,945
Total	**-**	**97,269**	**131,806**	**280,538**	**505,812**

Sources: Calculated by ICF based on Access Economics (2009), except Rutovitz (transport).

Table 3.10 Estimates of additional employment based on savings potential, high

Sector	Jobs per unit energy saved	2010	2012	2020	2030
Industry	0.27	33,634	47,001	99,846	152,191
Residential	0.49	90,780	125,839	293,603	601,196
Tertiary	0.62	42,910	70,700	183,726	336,007
Transport	0.19	107,637	118,683	164,989	237,326
Total	**-**	**274,961**	**362,223**	**742,164**	**1,326,720**

Sources: Calculated by ICF based Rutovitz et al. (2012), except Access Economics (transport).

Employment ratios of investment spending on energy efficiency

The second type of ratio used to estimate the job creation potential of different energy efficiency technologies is formed by calculating the number of jobs produced for a given level of investment (in total, government and private) in energy efficiency, based on the sectors producing the goods and services to meet investment demand, and the labour employed in the sector for a given level of output (measured in sales).

The jobs to output ratio by sector is multiplied by the level of investment spend received by the sector to estimate the total jobs in the sector supported by the investment. Employment is then aggregated across sectors[36].

[34] According to the International Standard of Industrial Classification of economic activity, the industry sector is split into four branches: mining, manufacturing, electricity, gas & water, and construction. Final energy consumption in industry excludes the consumption of energy transformation industries. The energy transformation industries (i.e. energy production and transformation) appear at different levels: in mining (NACE 10 and 11), manufacturing (NACE 23), and in electricity, gas and water (NACE 40 and 41).

[35] Tertiary: hotels, restaurants, health, education, commerce, public and private offices.

[36] This was the method employed in the 'bottom-up analysis' of the employment impact of the climate-energy package, presented in the Commission's Impact Assessment, see later section.

Table 3.11: (below) summarises the results of the studies reviewed here. Ehrhardt-Martinez and Laitner (2008) provides the most comprehensive study of the energy efficiency industry in the US. The study provides sector-specific estimates based on the number of jobs produced for a given level of spending and seeks to estimate the net employment effect (the efficiency premium), comparing the gross employment generated from energy efficiency investment against a reference scenario where the investment is spent in a business as usual case. The employment levels from the business as usual case are subtracted from the gross estimate to provide the net impact.

Based on this analysis, the study found that approximately 1.6m jobs in the supply of energy efficiency investment were created through total efficiency investment (the gross impact), while the net impact (the efficiency premium) amounted to an estimated 234,000 jobs in 2004.

Another study using a ratio approach based on spending data was carried out by ICF GHK to estimate the employment effects of the 2030 Climate and Energy framework on behalf of DG CLIMA[37]. The accompanying study to the Impact Assessment draws on expected expenditures on energy efficient buildings, and detailed cost breakdowns drawn from secondary evidence. In addition, the ratios include an allowance for supply-side multiplier effects.

In total the Impact Assessment study estimated that, on average, an additional 273,000 jobs[38] could be created by 2030, from energy efficiency investments for the retrofitting of residential and tertiary buildings over the period 2011-2030 relative to the 2013 PRIMES reference scenario[39].

[37] The Impact Assessment is available at: http://ec.europa.eu/energy/2030_en.htm

[38] The jobs generated relate to the timing of expenditure, and are generally defined as job-years. Dividing job-years by the period of time over which investment takes place provides an estimate of jobs for the period of the investment. See Table 24 in the Impact Assessment.

[39] Details of the 2013 PRIMES reference scenario are available at: http://ec.europa.eu/energy/observatory/trends_2030/doc/trends_to_2050_update_2013.pdf

Table 3.11: Review of studies based on the jobs produced for a given level of spending

Study/report	Employment factors (Jobs per €m or per $m) estimated by study	Employment impacts of EE estimated by study
ICF GHK and CE (2014)	Number of job per €m investment in EE measures: • Domestic retrofit: 12.4[40] • Tertiary retrofit: 11.6	Average annual employment related to EE investments (cf. reference scenario): • Residential: 133,000 • Tertiary: 140,000 • Total: 273,000
Janssen and Staniazszek (2012)	Number of jobs per €m expenditure to improve energy performance of buildings: • Quality and compliance requirements: 7.5 • Lowering the renovation threshold to 200m^2: 10.5 • Lowering the renovation threshold to 500m^2: 10.0 • Abolishing the 1,000m^2 threshold: 9.4	n/a
ACEEE (2011)	Number of jobs per $m revenue by key sector of the US economy: • Manufacturing: 9.9 • Construction: 20.3 • Trade Services: 18.8 • Government: 21.0 • All-sector average: 17.3	n/a
Ehrhardt-Martinez and Laitner (2008),	Number of Jobs per $m revenue by key sector of the US economy (weighted average[41]): • Residential buildings: 8.1 • Commercial buildings: 5.9 • Appliances: 4.2 • Industry: 4.6 • Transport: 4.7 • Utilities: 8.8 • Total: 5.4	Total EE-related employment: 1,630,600 Efficiency premium-related jobs (cf. alternative investments): • Residential: 47,500 • Commercial buildings: 45,200 • Appliances: 44,700 • Industry: 52,700 • Transport: 22,700 • Utilities: 20,800 • Total: 233,500

[40] This indicates that 12.4 jobs are generated from spending €1m on capital expenditure over the period of investment in the domestic building retrofit sector.

[41] Sector specific estimates were created by identifying primary and secondary types of work associated with each efficiency sector. For example, in the residential sector the rate of employment per million dollars of output ranged from an average of 9.3 for the primary jobs to 5.3 for the secondary jobs. The final weighted average for the residential building sector was 8.1 jobs per million dollars (Ehrhardt-Martinez and Laitner, 2008). This includes direct and indirect jobs.

3.6 Summary of findings

This chapter has set out the challenges of establishing indicators for employment related to energy efficiency: including the lack of European data on energy efficiency activities, as well as more fundamental issues over defining the boundaries of what is, what is not, and what may in future be considered to be classed as an energy efficiency activity.

The review of the available approaches adopted in the literature identified three distinct approaches. These estimates do not take account of jobs that would have been displaced (for example, in energy supply), which cannot be observed in historical data and hence for which a modelling exercise is required (as reported below for future scenarios).

The current EU28 employment generated in the supply of goods and services for energy efficiency is estimated to be 0.9m (core definition) and 2.4m (broad definition).Under the core definition, key segments of energy efficiency related economic activity supporting current employment is in the production of energy saving building materials, supporting some 443,000 jobs in the EU28.

Additional employment is possible assuming that investment is taken to exploit the potential identified for energy savings to 2030. These additional future jobs could total between 0.5m (low-end estimate) and 1.3m jobs (high-end estimate) by 2030. The most significant employment potential is related to energy savings in buildings.

4 Results of modelling the economic impact of investment in energy efficiency with the GEM-E3 model

4.1 Introduction

This chapter discusses the macroeconomic impacts of increasing EU energy efficiency that were estimated using the GEM-E3 model. The results and methodology detailed here are the same as those presented in the Impact Assessment accompanying the communication from the Commission to the European Parliament and the Council on Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy[42]. The policy scenarios represent different degrees of promoting energy efficiency in the EU28 Member States, in the time period from 2020 to 2030. The full set of scenarios includes some cases with modest savings and some cases with ambitious reduction targets. The focus is mainly on buildings and appliances, but the efficiency improvement is also discussed in industries and the transport sector.

The time horizon for this analysis is 2050, using 5-year steps. The full results, available in separate Excel files, show data for each EU28 member state, G20 country and the rest of the world, grouped into regions and into activity by sector (splitting the economy into more than 20 sectors).

GEM-E3 was used to estimate only the impact of the energy efficiency policies and not of decarbonisation. The energy scenarios quantified using the PRIMES energy model have assumed that the energy efficiency policies for 2030 take place in the context of decarbonisation targets until 2050. The macroeconomic models, however, were required to assess the macroeconomic effects (and particularly the employment effects) of specific energy efficiency policies up to 2030 and not to assess general decarbonisation pathways up to 2050. Quantifying the macroeconomic impacts of decarbonisation until 2050 is therefore out of the scope of the assessment of impacts of energy efficiency policy until 2030. It should be noted, however, that the restructuring and investment effort towards decarbonisation which has to be undertaken after 2030 requires a much larger shift of resources than the energy efficiency policies up to 2030.

4.2 Definition of the reference case and policy scenarios

Reference case

The GEM-E3 reference case incorporates demographic and macroeconomic assumptions that are consistent with major studies and publications of international organisations and institutes (including the OECD *Economic Outlook*). They have been updated to include:

- more recent data/projections of financial constraints and the recovery of European countries from the recent economic crisis, as published by DG-ECFIN

[42] See http://ec.europa.eu/energy/efficiency/events/doc/2014_eec_ia_adopted_part1.pdf

- a bottom-up assessment of the most important energy and climate policies for Europe and other parts of the world combined with an extrapolation of recent trends and expert judgments (e.g. for clean energy technological learning)

The reference scenario is the same as the reference scenario of the Impact Assessment accompanying the communication from the Commission to the European Parliament and the Council on Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy[43].

The treatment of market imperfections in a CGE model

In CGE models the performance of policy scenarios is evaluated against a reference scenario. The construction of the reference case is thus a key determinant in the evaluation of the counterfactual scenarios. Under strict general equilibrium conditions in a reference scenario of a CGE model agents' choices are optimal given the purchasing and operation costs that prevail (e.g. households will buy an A+++ energy efficiency standard appliance only if the household regards that appliance as beneficial in economic terms). This optimality is the result of the assumption of complete and perfect markets (consumers have access to the full information set). Any counterfactual scenario then would lead to lower welfare effects as there is no room for Pareto-improving resource allocations.

However reference scenarios can include market failures and frictions which can be incorporated in a CGE setting. For the present analysis the GEM-E3 reference scenario has been developed so as to replicate for the EU28 the evolution of the main energy and emissions variables as projected by the Reference plus PRIMES scenario. The GEM-E3 reference scenario implicitly includes market imperfections as these are already captured by the PRIMES reference case.

Similarly, the counterfactual scenarios implemented in GEM-E3 take the PRIMES results for the take-up of energy efficiency measures as assumptions: to the extent that these results for take-up reflect, implicitly, a reduction in sub-optimal choices arising from market imperfections, it is possible for the GEM-E3 results of the scenarios to yield an improvement in welfare compared to the reference case. However the additional energy efficiency investments incorporated in the PRIMES scenarios also result in additional pressure on capital markets (increasing financing requirements that may lead to crowding out). The net outcome calculated by the GEM-E3 model is the joint result of these effects which differ in magnitude and may move in opposite directions.

[43] See: http://ec.europa.eu/energy/efficiency/events/doc/2014_eec_ia_adopted_part1.pdf.

Differences to the Reference PRIMES 2013 scenario

The reference case energy system projections for the EU28 replicate the evolution of the main energy and emissions variables as projected by the Reference plus PRIMES scenario. The Reference Plus PRIMES scenario is an updated version of the Reference PRIMES 2013 scenario[44]. The Reference plus PRIMES scenario includes all the assumptions of the Reference PRIMES 2013 scenario as well as the policy measures and relevant acts proposed by the Commission that were adopted before the end of 2013. These updates include a few additional policy assumptions for the transport sector (additional transport initiatives adopted by the Commission at the end of 2012 and in 2013[45]) and several measures at Member State level[46]. The Reference plus PRIMES scenario also makes provisions for new eco-design and labelling legislation along with an updated assessment of potential savings from the existing legislation. It includes the recent update of the F-gas regulation[47] and revisions of assumptions for the assessment of the national obligation schemes and alternative measures that the Member States provided under article 7 of the EED[48].

The Reference Plus PRIMES scenario is a projection very similar to the Reference PRIMES 2013 scenario. The only noticeable change is a small reduction in energy demand. By 2020 the Reference plus PRIMES scenario achieves energy savings of 5.1% of 2010 consumption, compared to 5.0% in the Reference PRIMES 2013 scenario. On the rate of primary energy consumption savings relative to the PRIMES 2007 projections, the Reference Plus PRIMES scenario achieves 17% in 2020 and 21% in 2030, almost the same as in the Reference PRIMES 2013 scenario (16.8% in 2020 and 21% in 2030). With regards to the share of RES in final consumption, the Reference Plus PRIMES scenario achieves 20.96% by 2020, very close to the 20.88% achieved in the Reference PRIMES 2013 scenario. The impact on the ETS sector is small and so the equilibrium ETS prices have been maintained as in the Reference PRIMES 2013 scenario.

Updated F-gas regulation in the Reference Plus PRIMES scenario results in a higher reduction of non-CO_2 emissions post 2020 relative to the Reference PRIMES 2013 scenario. In 2030 the non-CO2 emissions reduction relative to 1990 is 42% in the Reference Plus PRIMES scenario and 32% in the Reference PRIMES 2013 scenario. However, the differences in total GHG emission reductions in 2030 are small, a 33% reduction compared to 1990

[44] See: http://ec.europa.eu/energy/observatory/trends_2030/doc/trends_to_2050_update_2013.pdf.

[45] These are new EU rules for safer and more environmental lorries, Clean Power for Transport package regarding the infrastructure for alternative fuels, Forth railways package and Single European Sky.

[46] These include road charging for Hungary, Belgium and the UK and a bonus system for silent wagons for rail freight in the Netherlands and Denmark.

[47] Additional F-gas emission reductions in 2030 have been estimated for every Member State based on GAINS marginal abatement cost curves and kept constant afterwards. For 2025 it is assumed that half of the 2030 effect occurs.

[48] Energy Efficiency Directive. These regard Sweden which does not exclude the energy consumption of the transport sector while calculating the energy savings for 2014-2020 and Denmark that does not use the 25% exception and even goes beyond the obligations of art. 7 EED. France intends implementing 75% of the 10.5%.

instead of a 32% reduction, as non-CO_2 emissions account for a small fraction of total emissions.

Policy scenarios

The energy efficiency policy scenarios simulated with the GEM-E3 model reflect escalating levels of energy saving efforts after 2020. Table 4.1 lists the six quantified scenarios of energy efficiency policy, simulating a stepwise increase in the intensity of energy efficiency achievements from the most modest (EE25) to the most ambitious (EE40). Measured as savings in primary energy demand up to 2030, relative to the PRIMES 2007 projection, the six scenarios were defined so as to achieve reductions in primary energy demand by 2030 within a range of 25-40%. The quantification of the scenarios simulated with GEM-E3 has been based on the energy savings achieved in each scenario as derived from the PRIMES model. As the levels of energy consumption in the PRIMES and GEM-E3 models differ, for the quantification of the GEM-E3 policy scenarios the shares of energy saved in the policy scenarios compared to the reference case in the PRIMES model have been used as input.

With regards to the energy efficiency scenarios simulated with PRIMES the following assumptions apply: in all energy efficiency scenarios it is assumed that the enabling settings prevail. This implies that economic agents (i.e. households and firms) anticipate strong commitments to cut emissions and that the effectiveness of the available decarbonisation instruments (i.e. infrastructure, technology, learning, etc.) is maximized. By 2030, the most modest scenario (EE25) achieves a 25% saving in primary energy consumption, whereas the most ambitious scenario (EE40) reaches a 40% saving in primary energy consumption.

In the policy scenarios in PRIMES the assumed structure of energy efficiency policies follows the current set of legislation including the Energy Efficiency Directive. It is assumed that, in the context of the energy efficiency scenarios, the legislation continues after 2020 and further intensifies in terms of saving obligations, peaking in 2030. Afterwards and up to 2050 the ambition of energy efficiency policies increases at low pace. The energy efficiency assumptions imply reduced energy demand by end users and reduced demand for energy used to generate electricity.

Table 4.1: Primary energy savings in the policy scenarios, 2030

	Primary energy consumption savings - excluding consumption for non-energy purposes (% change from PRIMES 2007 reference case projection)
EE25	-25.0
EE28	-28.0
EE30	-30.0
EE32	-32.0
EE35	-35.0
EE40	-40.0

Sources: E3M Lab ‘Study for DG ENER/C3 Modelling of Energy Efficiency Scenarios’ using PRIMES.

How energy savings are modelled in PRIMES

Energy savings, as simulated in PRIMES, represent changes in certain control mechanisms that drive energy efficiency. The latter include energy efficiency regulations for residential and other buildings, reduced interest rates in response to energy efficiency policy implementation, eco-design regulations, implementation of the best possible techniques, horizontal possibilities to save energy through new investment in the industrial sector, the promotion of district heating (DH) and highly efficient combined heat and power (CHP) as part of the energy efficiency policy package, more efficient grids and transport related measures (CO_2 standards, efficiency improvements, eco-driving etc.). The main changes assumed in PRIMES with regards to these control mechanisms are summarised below. For a detailed analysis the reader is referred to the Impact Assessment accompanying the communication from the Commission to the European Parliament and the Council on Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy[49].

The energy efficiency measures vary in the different PRIMES policy scenarios; they drive investments in renovation as well as increase the quality of renovation (from an energy perspective)[50]. It is assumed that the discount rates used by consumers to evaluate energy efficiency measures decrease in a stepwise fashion due to the energy efficiency policies. Lower discount rates increase the profitability of investments in energy efficiency and allow for additional investment that otherwise would have been rejected by energy end users. In the PRIMES model eco-design measures are assumed to increase energy performance beyond 2020.

The policy context encourages increasing consumer confidence in advanced technology and a perception of lower costs. It also leads to a lower regard for risk factors, which intensifies across scenarios from the Reference case to the most ambitious energy efficiency scenario. The early uptake of advanced technology accelerates learning, making it cheaper and more efficient as it matures commercially. Thus the dynamic uptake of advanced technologies by consumers impacts their progress. As higher volumes of advanced technologies are chosen by consumers, their production moves further along the learning curve and hence efficiency improvements occur faster. At the same time the investment cost in advanced technologies increases with increasing efficiency performance.

District Heating, CHP and grid losses

Promotion of DH and highly efficient CHP are assumed (in PRIMES) to continue in the long term. For DH the policies consist of investments that allow more users to have access to networks. Increasing energy efficiency reduces the volumes of heat or steam and electricity demand going against the economics of CHP projects (lower returns to scale). In PRIMES the energy

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[49] See http://ec.europa.eu/energy/efficiency/events/doc/2014_eec_ia_adopted_part1.pdf

[50] Energy efficiency values in PRIMES are model parameters that are used to simulate energy saving obligations in the sectors of houses and office buildings. They reflect the shadow cost of energy savings and influence the rate of energy efficiency improvements in the economy. Energy efficiency values act as a threshold, determining the profitability of energy efficiency projects. Higher values imply higher ambition on energy efficiency targets and induce higher investments on energy saving projects.

efficiency policy scenarios assume the implementation of policies which target the limitation of grid losses. Specific parameters are modified in PRIMES so as to represent the improvement of the grid loss rate due to a smother load factor in electricity demand enabled by smart metering and demand response measures in general. Energy efficiency implies lower electricity demand and thus a lower electrical charge in power grids and consequently lower losses. The rate of reduction of grid losses in PRIMES across the policy scenarios is assumed to be small due to the limited potential for reducing grid losses through smoothing the load curve.

The transport sector

The PRIMES model has further included assumptions on transport-related measures. These are: CO_2 standards, efficiency improvements for heavy-duty vehicles, internalization of local externalities and internalization of GHG emissions, better alignment of taxation, intelligent transport systems and eco-driving. CO_2 emissions are lower stepwise in the policy scenarios in the 2020-2050 period. Internalization of local externalities, intelligent transport systems and eco-driving employ the same level of charges and assumptions as in the Impact Assessment on the 2011 White Paper on Transport[51]. Vehicle taxation assumptions are based on the 2005 Commission proposal[52].

4.3 GEM-E3 modelling method

In order to assess the economic effects of the energy efficiency policies the GEM-E3 model has been used. GEM-E3 is a Computable General Equilibrium (CGE) model. It is widely used for the analysis of European policy. A short description of the model is provided in Appendix B.

Energy consumption

The GEM-E3 model endogenously computes energy consumption, depending on energy prices, realised energy efficiency expenditures and autonomous energy efficiency improvements. Each agent decides how much energy it will consume in order to optimise its behaviour (i.e. to maximise profits for firms and utility for households) subject to technological constraints (i.e. a production function).

At a sectoral level, energy consumption is derived from profit maximization under a nested CES (Constant Elasticity of Substitution) specification. Energy enters the production function together with other production factors (capital, labour, materials). Substitution of energy and the rest of the production factors is imperfect (energy is considered an essential input to the production process) and it is induced by changes in the relative prices of each input.

The energy part of GEM-E3 has been calibrated to match PRIMES in terms of energy consumption, energy intensity and the power generation mix. The GEM-E3 results therefore reflect the results of the PRIMES model, including the shares of energy consumption across different sectors, sectoral and household energy intensities and the shares of different technologies and fuels in power generation mix. While the PRIMES model provides figures on energy statistics and balances in energy units, the GEM-E3 model makes use of monetary values and is based on monetary Input-Output tables (for

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[51] See: http://ec.europa.eu/transport/themes/strategies/2011_white_paper_en.htm

[52] See: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2005:0261:FIN:en:PDF

instance in PRIMES the production of the power sector is given in energy units-ktoe while in GEM-E3 activity of the sector is given in monetary values i.e. base year euros). In order to render inputs obtained from PRIMES compatible with GEM-E3 a specific routine has been developed that combines the prices and volumes from the energy statistics and balances them with the monetary transactions on energy from the Input Output table. The dynamic calibration of energy consumption in GEM-E3 to PRIMES results is performed by adjusting the autonomous energy efficiency improvements and energy efficiency expenditures in the GEM-E3 model.

Residential energy consumption is derived from the utility maximization problem of households. Households allocate their income between different consumption categories and savings to maximize their utility subject to their budget constraint. Consumption is split between durable (i.e. vehicles, electric appliances) and non-durable goods. For durable goods, stock accumulation depends on new purchases and scrapping. Durable goods consume (non-durable) goods and services, including energy products. The latter are endogenously determined depending on the stock of durable goods and on relative energy prices.

Energy efficiency

Energy efficiency in the GEM-E3 model can result from three factors:

- An increase in the amount agents spend to improve energy intensity in response to regulations, for example, by mirroring energy saving obligations or a minimum performance of energy efficiency (endogenous mechanism based on cost-potential curves for energy efficiency by sector).
- A change in energy prices that triggers the substitution of relatively less expensive inputs for more expensive energy, along the frontiers of substitution possibility.
- A change in the rate of energy-embodied technological progress (based on exogenous projections that reflect technological progress).

In the current version of GEM-E3, the endogenous mechanism of energy efficiency expenditures (the first option mentioned above) is used, which employs energy efficiency cost curves that describe the relationship between the energy efficiency expenditures and energy efficiency improvements relative to the benchmark. The energy efficiency cost curves are calibrated according to data provided by the PRIMES model, taking advantage of the granularity and the engineering information of PRIMES. The energy efficiency cost curve represents a mapping between energy saving expenditures and energy savings. Once this mapping has been established then the additional energy saving expenditures (as calculated from the PRIMES model) to the reference scenario were introduced into the GEM-E3 model (the energy saving expenditures are presented in Table 4.3).

Expenditures in energy saving technology are treated as spending that economic agents undertake so as to reduce their energy consumption (e.g. purchases of more energy efficient appliances, insulation of buildings and retrofit etc.). For firms, expenditures in energy saving impact on their energy intensity and do not add to their capital stock (as opposed to investments). As energy saving expenditures do not add to the capital stock of firms, the productive capacity of the firms remains unchanged (i.e. energy saving expenditures of a firm reduce energy consumption per unit produced but they do not affect its productive capacity, that is the number of units that a factory can produce). Energy efficiency expenditures reduce energy consumption one period after they take place and continuously for a period of at least 20 years. Households' expenditures in energy efficiency improvements do not have a direct impact on their utility. The impact is indirect through the reduced energy costs that households have to pay.

Expenditures in energy efficiency improvements generate additional demand for goods and services (ferrous and non-ferrous metals, non-metallic goods, chemical products, electrical goods, construction and market services) which provide inputs to energy efficiency projects (see Table 4.2).

Energy efficiency improvements exhibit decreasing marginal returns (saturation effect). Energy savings potential is inter-temporally limited (differently by sector) and higher energy saving entails an increase in marginal costs.

Estimating levels of energy efficiency expenditure

Expenditures in energy efficiency imply the accumulation of energy saving stock that is more energy efficient than the benchmark. Thus, specific rates of energy consumption (of equipment) and energy requirements are reduced, which contributes to savings of energy consumption following their installation. The higher upfront expenditures for energy efficiency imply funding requirements that need to be drawn from savings and from other borrowing. The additional funds are drawn from the entire economy (the sum of the economic agents' savings and general financing from financial institutions), eventually stressing capital supply in the economy. Energy efficiency expenditures have no direct impact on the capital stock as they are used by the agents to purchase goods and services that reduce energy consumption and are not used to increase directly productive capacity. The sectors that provide the energy saving goods and services need to increase their productive capacity in order to meet the increased demand for their products and to this end compete for capital resources with all the other sectors in the economy. This leads to a crowding out effect, the magnitude of which depends on the assumptions about capital market flexibility worldwide and financial resources overall; to that respect we have performed sensitivity analysis, as explained below. Spending on energy efficiency stimulates demand for sectors that produce the required goods and services, such as construction, industrial materials, equipment and certain market services. The modelling takes into account that the demand for, and expenditure on, energy decreases permanently in the periods that follow energy efficiency expenditures. For the modelling of the energy saving expenditures the basic assumption is that institutional authorities at national and/or EU level define, by sector, obligations that target pre-specified rates of energy efficiency improvements (as defined by the scenarios quantified with the PRIMES model). The amount of energy efficiency expenditure that is required to reach the pre-specified rate of reductions of energy intensity (obtained from PRIMES) is determined by the energy efficiency cost curves.

Energy efficiency projects generate demand for inputs from several sectors. Technical coefficients are used to determine the share that each sector delivering inputs to the energy efficiency projects has on the final expenditure made, i.e. for every expenditure made on energy efficiency projects what percentage of it is spend on each of the different sectors providing inputs to energy efficiency projects. Table 4.2 shows which sectors contribute to the realisation of the energy savings projects and at what shares. These sectors then generate demand for the output of all other sectors through Leontief's Input-Output system, based on technical coefficients that are endogenously projected by the model.

Table 4.2: Sectoral breakdown of expenditures on energy efficiency projects

Sector	Share of expenditure (in equipment goods and services used to implement energy efficiency investment) as received by production sector, in % of overall expenditure in energy efficiency
Ferrous metals	4
Non-ferrous metals	4
Chemical Products	7
Non-metallic minerals	8
Electric Goods	2
Construction	60
Market Services	15

Sources: E3M Lab estimations.

Table 4.3 summarizes the total EU expenditure on energy efficiency in the policy scenarios. The total expenditure figures for households and firms are derived from the PRIMES model results for each scenario.

Full capital mobility within the EU and no change in the EU's external current account of the balance of payments (as a proportion of GDP) across the scenarios have been assumed.

Table 4.3: EU28 energy efficiency expenditures in the energy efficiency policy scenarios

EU28	2030	2040	2050	2030	2040	2050	2030	2040	2050
	Total efficiency expenditures, in % of GDP			Households' efficiency expenditures, in % of GDP			Firms' efficiency expenditures, in % of GDP		
REF	0.013	0.011	0.009	0.000	0.001	0.001	0.012	0.010	0.008
EE25	0.17	0.20	0.12	0.03	0.07	0.07	0.14	0.13	0.05
EE28	0.63	0.37	0.40	0.26	0.13	0.17	0.37	0.24	0.23
EE30	1.15	0.54	0.62	0.66	0.29	0.43	0.49	0.25	0.19
EE32	1.62	0.52	0.61	0.66	0.29	0.43	0.96	0.23	0.18
EE35	2.83	0.69	0.92	1.19	0.46	0.70	1.64	0.23	0.22
EE40	6.63	0.71	1.15	2.98	0.59	0.96	3.65	0.12	0.19
	Total efficiency expenditures, (in bn 2010€)			Households' efficiency expenditures, (in bn 2010€)			Firms' efficiency expenditures, (in bn 2010€)		
REF	2.1	2.1	2.0	0.1	0.2	0.3	2.0	2.0	1.8
EE25	27.9	38.6	27.6	5.3	13.8	16.3	22.7	24.9	11.3
EE28	105.1	70.7	88.0	44.0	25.2	37.8	61.1	45.4	50.2
EE30	192.2	103.4	136.5	110.6	55.5	95.5	81.6	47.9	41.1
EE32	271.1	100.4	134.6	110.6	55.5	95.5	160.5	44.9	39.1
EE35	472.1	132.0	203.1	199.3	89.2	155.0	272.9	42.8	48.1
EE40	1,098.6	136.2	254.8	493.3	113.5	212.0	605.4	22.7	42.7

Sources: E3M Lab estimations based on PRIMES model projections.

Financing the energy efficiency expenditure

Energy efficiency expenditures are financed by agents (households and firms) and the financial sector. Households finance energy saving expenditures with funds drawn from their savings and from bank borrowing. For firms, financing is also based on equity and bank borrowing. Depending on capital for capital market closure (for which we performed sensitivity analysis), fund raising for energy efficiency eventually leads to higher interest rates which increases the operating expenses of firms and reduces gross operating surplus as a gross return on productive capital. Similarly, households' finances are affected by the increase in interest rates. Overall, part of the investment financing in the economy is taken up by financial resources dedicated to funding energy efficiency; this part corresponds to self-financing of energy efficiency investment by firms and households, which acts to the detriment of self-financing of productive capital investment overall in the economy through pressure on capital markets. It is also important to gauge whether capital markets are sufficiently flexible and internationally mobile to the resulting crowding effects. For this purpose we conducted sensitivity analysis assuming that capital markets will have to close either at EU level or alternatively at world level; the latter assumption corresponds to maximum mobility and flexibility of the market. As a result of the energy efficiency expenditures undertaken, the funds available in the economy for other investments are restricted (crowding out effect, the magnitude of which depends also on the assumption about capital mobility and closure).

A part of the energy efficiency expenditures is assumed to be financed by the financial sector; we close accounts of financial institutions also intertemporally. Households and firms are obliged to pay back borrowed funds in the long term (from 2035 onwards) which implies crowding out effects in the long term that do not stem from equity/savings financing but from the long-term indebtedness of the sectors.

The extent of the crowding out effects is in reality uncertain, as it depends on the level of unused financial resources in the economy, the conditions under which actors have access to capital markets and the possibility of capital transferring from the rest of the world. The model endogenously projects interest rates as needed to balance capital markets in each scenario.

Within the real economy, in the time periods after the implementation of the energy efficiency expenditures, variable costs (including expenditure on energy) decrease in all sectors that undertake the energy efficiency investment. This allows individuals to increase consumption (a rebound effect on both non-energy and energy-related consumption, and the purchase of equipment goods) and also their savings, and it allows firms to reduce variable costs and increase gross operating surplus. Both these changes increase the supply of capital to the economy in the years after the implementation of the energy efficiency expenditures and this supply drives higher investment in the economy.

Depending on the degree of leverage available, it may be possible to mitigate capital market pressure when the energy efficiency investment is made (i.e. close to 2030) and undertake interest payments in subsequent time periods when variable costs savings provide sufficient margins. Such an arrangement smooths out capital market pressures and mitigates the adverse effects on the economy that stem from crowding out at times of high levels of energy efficiency expenditures. Similarly, the reduced variable costs mitigate the crowding out effect of the repayment of debts in the long term. Overall, the net impact on the economy is uncertain.

As a computable general equilibrium model, GEM-E3 imposes at all times strict closure between savings and investment, which implies that reorienting or increasing expenditures or investment means that lower funds are available for other purposes. However, the strictness of closure is not static as the model setup assumes borrowing and debt servicing over time, as well as various degrees of capital flexibility at world level. If strict closures were applied in static terms or for single countries, the impacts on the economy would be very sensitive to crowding out effects.

The scenarios have assumed a very large increase in expenditure for energy efficiency purposes, especially up to 2030. If it is assumed that full funding of the energy efficiency expenditures occurs through the closure with savings, the macroeconomic impacts are large and negative, and increasingly negative as the level of ambition increases.

Instead, a more realistic approach has been adopted, and it has been assumed that financing of the energy efficiency expenditures from saving resources in the economy is effectively leveraged, allowing smooth closure until 2050; this implies less pressure until 2030 and a smaller crowding out effect. Beyond 2030 the economy is influenced by the repayment of the debt accumulated for energy efficiency investment before 2030.

GEM-E3 allows for the recycling of additional public revenues through a reduction in social security contributions by employers, lump-sum payments to households, subsidies to renewables, etc. Recycling of the additional public revenues is applied in cases where the simulated policies generate additional public funds compared with the reference case. This is particularly the case in decarbonisation scenarios where carbon taxes increase so as to drive lower GHG emissions. In all the energy efficiency policy scenarios simulated using GEM-E3, the carbon tax revenues are retained by government and used to reduce debt. However, in the energy efficiency policy scenarios, the increased energy efficiency leads to lower energy consumption, and revenues from carbon taxes are lower than in the reference case: thus, no recycling takes place in the energy efficiency scenarios (as revenues from carbon taxes are lower than in the reference scenario).

GEM-E3 is an open economy model and the EU's external current account of the balance of payments can change across scenarios. In the scenarios modelled here, it was assumed that the current account for the EU28 as a percentage of GDP remains unchanged compared with the reference scenario, to avoid the emergence of a persistent current account deficit or surplus. The GEM-E3 model uses relative interest rates as a balancing instrument: the EU-wide interest rate adjusts endogenously in the model, to keep the current account as a percentage of GDP unchanged (this is a proxy for current account re-balancing through exchange rate re-adjustment. For example, interest rates may increase when a change in prices in the EU has the effect of worsening the current account). Interest rates impact on the cost of capital in the energy efficiency policy scenarios. The endogenous adjustment of the interest rates in the model takes into account the expenditures in energy efficiency realized by each agent (the expenditures are set exogenously in each of the policy scenarios simulated). Interest rates impact on the cost of capital in the energy efficiency policy scenarios.

4.4 Results from the GEM-E3 model

Key channels of effect

GEM-E3 captures all the interactions between the energy and economic systems. Table 4.4 provides a theoretical summary of the induced changes, and the expected effects and outcomes.

Table 4.4: Changes and effects from energy efficiency expenditures

<table>
<tr><th>Change simulated</th><th>Trigger effects</th><th>Outcome</th><th>Total effect on the economy</th></tr>
<tr><td>Expenditures in energy efficiency</td><td>Increase in demand for sectors providing inputs to energy efficiency improvement projects.</td><td>Positive effect on activity and employment rate in sectors providing inputs to energy efficiency projects.</td><td rowspan="3">Depend on the net effect of offsetting factors: economic expansion (Keynesian multiplier) and negative effects stemming from crowding out and pressures on primary factor markets.</td></tr>
<tr><td>Increase in energy savings</td><td>Reduced energy demand and energy related imports.</td><td>Negative effect on activity and employment rate in energy sectors. Reduction of energy imports dependence. Positive effects on all sectors that see lower variable costs when purchasing energy commodities.</td></tr>
<tr><td>Financing scheme</td><td>Increase in energy efficiency related expenditures.</td><td>Crowding out effects due to equity-based funding. Crowding out effects due to funding from borrowing, possible increases in interest rates, higher cost of capital, slowdown of productive investment, loss of competitiveness, consumption reduction, etc.</td></tr>
</table>

Sources: E3M Lab notes.

The energy efficiency policies bring about higher expenditure by firms, the public sector and households, in order to implement investment in building insulation and renovation or in industrial processing towards less energy consumption per unit of output. In addition, they promote the purchase of more expensive equipment, appliances or vehicles that are more energy efficient than existing cheaper varieties. The main macroeconomic effects of these policies on the EU economy are summarized below:

a) Keynesian multiplier effect: additional energy efficiency expenditure, relative to the reference scenario implies: i) higher demand for goods and services that are used to implement energy efficiency policies and ii) lower demand for energy commodities. Higher demand for goods and services providing inputs to energy efficiency projects implies higher demand for the sectors producing these goods and services. These sectors are characterised by a high rate of labour intensity (like market services), limited exposure to foreign competition and strong backwards and forward linkages with other sectors in the economy (like the construction sector). Higher output from labour-intensive sectors (like market services) leads to an increase in employment. Limited exposure to foreign competition implies that an increase in demand for inputs to energy efficiency projects is satisfied with higher production from the respective domestic sectors, as opposed to higher imports of possibly cheaper substitutes. This contributes further to domestic labour market and aggregate demand outcomes. There are also supply chain impacts, as sectors that supply the sectors that provide energy efficiency improvements may see multiplier effects. The lower demand for energy products, as a result of the implementation of energy efficiency policies, is associated with lower production of the domestic energy sectors and lower energy imports. Lower demand for energy products reduces production levels in domestic energy sectors, but this has only a limited impact on employment and income as the energy sectors are capital intensive rather than labour intensive. Lower energy imports imply an increase in disposable income for the purchase of goods and services from non-energy sectors, implying further multiplier effects in the economy.

b) Crowding out effects due to primary production factors: incremental activity generated by the energy efficiency expenditures requires more finance and labour than is used in the reference case. Depending on how tight conditions are in capital and labour markets, upward pressure on capital and labour prices may result, which implies greater scarcity of primary production factors as used in other sectors of the economy. Assuming favourable financing conditions, financial closure can be managed at a broad geographical scale and not only at country level. It also implies that appropriate leverage can accommodate financing over a long period of time at low interest rates. In contrast, unfavourable financing conditions imply that a country will have to draw funding for energy efficiency projects to the detriment of other investments and probably well before the energy efficiency project is implemented. So, the degree of crowding out due to capital market tightness varies depending on what is assumed for conditions in the reference case. Labour market conditions also influence the impact of energy efficiency expenditures on labour costs. If the rate of unemployment is high and the labour market is sufficiently flexible, higher labour demand will have a small impact on labour costs and the impact on wages will be limited. Conversely, tightness in labour supply or rigidities in the labour market may cause real wage rates to increase as a result of energy efficiency expenditures, which would undermine competitiveness in foreign markets and act to offset the boost to employment. Crowding out effects due to changes in the costs of primary production factors can vary in intensity depending on assumptions, and would be experienced in all sectors of the economy.

c) Income effects due to higher costs: implementing energy efficiency measures is essentially a trade-off of lower variable operating costs with higher upfront investment costs. Depending on the technical parameters of the energy efficiency expenditure by sector, and also on the intensity of energy efficiency ambition, the present value of costs of the energy efficiency cash flow may be less or more than an alternative that keeps variable operating costs unchanged. The energy efficiency potential exhibits decreasing returns to scale i.e. beyond a certain level, incremental energy efficiency requires increasing marginal expenditures per unit of energy savings. Thus, the cost-effectiveness of energy efficiency expenditures decreases with the amount of energy savings targeted. So, beyond a certain threshold it is possible that the present value of energy efficiency cash flow implies higher costs than keeping energy consumption unchanged. In principle, this situation is most likely in analytical studies that assume the majority (if not all) of cost-effective energy efficiency expenditures have taken place already in the reference scenario. This is not the case in the Reference PRIMES scenario. Therefore, the energy efficiency policy included in the energy efficiency policy scenarios aims at imposing an obligation to implement higher energy efficiency expenditures at a level above the one in the reference scenario. This, by assumption, implies that unit costs increase relative to the reference scenario. In other words, the energy efficiency expenditures within the context of the energy efficiency scenario imply that, compared to the reference scenario, disposable income of households would be lower and the gross operating surplus of firms would be reduced. Direct cost gains are obtained since the scenarios are constructed under the assumption that non-market barriers (like information deficits) prevail in the reference scenario, which prevent economic agents (households and firms) from making optimal use of the cost-effective energy efficiency potential. So, an increase in unit costs in the energy efficiency scenarios would have a detrimental effect on consumption and investment in the domestic market, as they tend to offset the effects from the Keynesian multiplier. The income effect increases in line with the degree of ambition of energy efficiency.

d) Foreign competitiveness effects: currently, EU economies are exposed to foreign competition and the relative competitiveness of the domestic economy is affected by pressures in primary production factor markets. This might lead to higher interest or wage rates, and eventual increases in the unit costs of energy services relative to the reference scenario (depending on the scale of the ambition of energy efficiency policy). Under such circumstances, exports will decrease and imports will increase. Thus, domestic activity might be lower due to the multiplier effect, offsetting any upward trend. The response of wages and/or capital rates to changes in demand depends on the degree of flexibility assumed in the respective market. In the policy scenarios the current account balance as a percentage of GDP is kept at reference scenario levels. Thus the policies pursued are not associated with increases in deficits of the external balances. This is achieved via changes in interest rates. Energy efficiency expenditures put pressure on capital markets and interest rates. In the policy scenarios the competitiveness of EU industries increases as a result of improved energy costs but it is also reduced by the higher cost of capital associated with increases in interest rates.

e) Positive externalities in technology: ambitious energy efficiency improvements imply the use of more advanced technologies that may benefit from the increased market potential in order to become commercially mature, with higher performance and lower unit cost. This is a kind of positive externality through learning by doing. Its occurrence depends on the nature of technology, the size of the market, spillover conditions and other factors. Positive externalities alleviate both the negative effects on income and the loss of competitiveness.

Net outcomes of the scenarios

In the energy efficiency policy scenarios simulated with the GEM-E3 model the economic outcome is the result of the joint effects discussed above. The net result depends on several effects associated with energy efficiency expenditures. This section summarizes the effects of the policy scenarios on GDP. The following parts detail the sectoral, trade, competitiveness and employment effects of the energy efficiency policies.

Table 4.5 summarises the simulation results on the effects of the implementation of the energy efficiency policies on GDP. The impact is found to be small and negative, especially in 2030 when energy efficiency expenditures peak (as discussed above energy efficiency expenditures are spread across time and increase up to 2030. Financing of the energy efficiency expenditures from savings in the economy is leveraged allowing smooth closure until 2050, putting less pressure on financial markets up to 2030 and a smaller crowding out effect).

The impact on GDP intensifies from the least ambitious to the most ambitious policy scenario. The impact on GDP is further found to be smooth over time. The contraction in GDP is higher in the early years of the implementation of the energy efficiency policies and lower towards the end of the simulation period (Table 4.5). The effects of crowding out lead to a higher cost of capital, while the effects of a loss of competitiveness outweigh those of improved energy efficiency and the multiplier effect of increased economic activity in the sectors that supply energy-efficient goods and services. The net economic effect is found to be negative with capital costs outweighing the benefits of lower energy costs in all policy scenarios.

The crowding out effect is significant as capital is already fully employed in the reference scenario (a core assumption in CGE models), hence the additional funding for energy saving projects cannot be financed by idle capital resources. The contraction of GDP in the scenarios implies that the negative effects from increasing capital costs are higher than the positive effects of energy saving projects. If capital markets were much more flexible without constraining capital availability (leading to higher capital costs), the negative effect of capital costs on GDP would be lower or could be completely offset. Toward this end a sensitivity run has been performed with the GEM-E3 model and it is presented at the end of this chapter.

Higher capital costs and crowding out is associated with the assumptions on market closure and capital availability. The EU current account balance, as a percentage of GDP, remains the same as in the reference scenario. This happens via the changes in interest rates. Interest rates increase (see Table 4.12) so as to limit pressure on current account. The magnitude of the effects increases with the amount of expenditure on energy efficiency improvements (as seen by the impact on GDP, see Table 4.5). In the long term, the negative effects vanish as the sectors benefit from the cost reductions due to the achieved levels of energy efficiency. However, because of the long-term effects of financing energy efficiency expenditures, and depending on marginal cost and/or effectiveness of efforts towards energy efficiency, the negative effects of financing counteract the positive effects of the reduction in variable costs. Very high ambition in energy efficiency implies high marginal costs of incremental savings and the negative effects are larger than positive ones; therefore, a negative impact on GDP is maintained also in the long term. By contrast, in energy efficiency scenarios of moderate intensity, which involve energy efficiency effort characterised by lower marginal costs, the negative effects are outweighed and the overall negative effects vanish in the long term and can become positive, driven by the reduced variable costs dedicated to energy. The results shown in the table below assume capital market closure strictly at the level of the EU. This implies higher crowding out effects than in the case of fully flexible and mobile capital markets at global level. The mitigation of crowding out effects in this case of extreme flexibility of capital markets is found to lead to eventually positive GDP impacts, as shown in Section 4.5.

Table 4.5: GDP in EU28 in the energy efficiency policy scenarios

(% change from Reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	16,766	19,277	22,129	615,622
EE25	-0.07	-0.03	0.00	-0.02
EE28	-0.13	-0.04	-0.02	-0.05
EE30	-0.22	-0.04	-0.02	-0.08
EE32	-0.24	-0.06	-0.01	-0.10
EE35	-0.52	-0.15	-0.03	-0.20
EE40	-1.20	-0.19	-0.04	-0.35

Sources: GEM-E3 model.

Sectoral impacts

The benefits from the implementation of energy efficiency policies are considerable for the sectors that provide inputs to the energy efficiency projects (Table 4.6). This is the direct effect of increased energy efficiency expenditures; the increased demand for the goods of sectors that produce energy efficient equipment (e.g. efficient electrical appliances for households, retrofits, etc.) and provide inputs to energy efficiency projects (e.g. insulation to improve thermal integrity, etc.). As demand for energy reduces due to energy efficiency improvements, energy-producing sectors experience a fall in demand and thus their production levels are reduced. Similarly imports of energy products fall in the policy scenarios. The effects are intensified in the more ambitious scenarios.

Table 4.6: Impacts on production by sector in the energy efficiency policy scenarios (EU28 totals)

Cumulative % change from reference (2015-2050)	Reference scenario (cum. 2015-2050, €2010bn)	EE25	EE28	EE30	EE32	EE35	EE40
Agriculture	18,721.57	-0.17	-0.15	-0.61	-0.63	-1.43	-1.03
Ferrous metals	8,616.23	1.07	2.15	2.45	2.70	6.26	9.06
Non-ferrous metals	25,688.08	0.64	1.39	1.63	1.80	3.04	3.88
Chemicals	47,771.42	-0.13	-0.58	0.47	0.65	1.72	3.95
Paper and pulp	22,128.31	-0.01	0.12	0.29	0.31	0.46	0.47
Non-metallic mineral	15,487.26	1.41	2.99	3.53	3.98	6.41	8.82
Electric goods	17,799.12	0.24	0.52	0.63	0.70	0.84	0.71
Equipment goods	119,341.64	0.66	1.07	1.34	1.46	1.71	1.64
Consumer goods inds.	73,482.77	0.18	0.38	0.39	0.43	0.42	0.36
Construction	93,628.59	0.72	1.72	2.37	2.67	4.20	5.93
Transport	80,012.42	0.67	0.96	1.05	1.10	1.13	0.95
Services	586,819.22	0.06	0.18	0.34	0.37	0.38	0.37
Energy extraction/supply	23,256.56	-1.95	-5.20	-8.39	-9.22	-11.14	-13.31

Sources: GEM-E3 model.

Table 4.7: EU28 sectoral imports in the energy efficiency policy scenarios

Cumulative % change from reference (2015-2050)	Reference scenario (cum. 2015-2030, €2010bn)	EE25	EE28	EE30	EE32	EE35	EE40
Agriculture	5,887.45	1.14	0.91	1.21	1.25	2.87	1.87
Ferrous metals	2,369.93	0.99	2.38	3.96	4.48	2.02	0.70
Non-ferrous metals	4,938.27	0.49	0.79	1.70	1.92	1.58	1.94
Chemicals	9,339.53	1.41	4.02	2.92	3.00	2.38	-0.29
Paper and pulp	3,477.26	0.67	0.92	1.14	1.23	0.98	0.98
Non-metallic mineral	3,144.63	-0.11	0.98	2.41	2.66	4.23	6.25
Electric goods	9,968.27	0.23	0.41	0.65	0.71	0.96	1.55
Equipment goods	22,351.54	0.67	0.80	1.38	1.50	1.27	1.66
Consumer goods inds.	12,773.88	0.17	0.09	0.57	0.58	0.78	0.98
Construction	528.32	0.87	2.23	3.17	3.58	5.66	8.21
Transport	5,739.88	-0.91	-0.72	-0.62	-0.62	-0.31	0.38
Services	6,844.82	0.49	0.79	0.93	1.00	1.49	2.00
Energy extraction/supply	11,883.94	-2.25	-4.41	-5.92	-6.44	-7.29	-7.99

Sources: GEM-E3 model.

Employment and unemployment

The GEM-E3 model assumes that involuntary unemployment exists under equilibrium conditions. This allows for a more realistic representation of the labour market. This assumption implies that unused labour resources exist that can accommodate higher labour demand occurring in the energy efficiency scenarios, moderating thus the impact of the energy efficiency policies on wages.

In the GEM-E3 model employment is disaggregated by sectors of production and skill level (grouped into skilled and unskilled labour). The effects of energy efficiency policies on employment are quantified at the level of the sectors of production. The model does not provide details on employment effects associated with specific jobs related to energy efficiency policies (technical, administrative, etc.). The employment effects quantified with the GEM-E3 model capture the total impact of the energy efficiency policies. The employment changes simulated quantify the net effect on labour markets of the direct activities to save and produce energy, the indirect supply chain effects and the induced effects resulting from the spending of energy savings in the economy (see previous chapter for a review of the literature on the direct, indirect and induced employment effects of energy efficiency policies).

Table 4.8: EU28 employment in the energy efficiency policy scenarios

% change from reference	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario, million people	218.76	211.24	204.08	7,514.34
EE25	0.50	0.48	0.57	0.30
EE28	1.47	0.67	0.71	0.61
EE30	1.90	0.81	1.07	0.77
EE32	2.02	0.89	1.22	0.84
EE35	2.53	0.97	1.24	1.03
EE40	2.96	1.21	1.59	1.30

Sources: GEM-E3 model.

Based on projections of an equilibrium unemployment rate as implemented in GEM-E3, energy efficiency expenditures increase employment rates in all scenarios (Table 4.8), without strong effects on wage rates. The positive impact on labour combined with the negative impact on GDP implies a more labour-intensive EU economy in the cases where energy efficiency is higher. The employment multiplier effect depends on the labour intensity of those sectors that provide inputs to energy efficiency projects (relatively high for sectors like market services) and of energy sectors (relatively low labour intensity), but it also depends on the proportion of domestically produced inputs to energy efficiency projects. Total labour demand and the rate of employment are affected by changes in the activity of the more labour-intensive sectors. The decreased labour demand in energy sectors is outweighed by increased employment rates in sectors that provide input to energy efficiency projects.

The EU labour market is assumed to have a limited degree of flexibility, clearing by adjustments in employment rather than in real wage rates. Employment increases across all scenarios by 0.3 - 1.3% cumulatively over 2015-2050. The time profile of employment changes show strong positive effects at the times of implementation of energy efficiency expenditures and smaller effects in the following years.

Sectoral changes in the employment rate reflect changes in sectoral demand and production as a result of energy efficiency expenditures (see Table 4.9), particularly the increase in production of relatively labour-intensive sectors (e.g. services sectors that provide input to energy efficiency projects) or sectors with substantial forward and backward linkages with other sectors of the economy (e.g. the construction sector).

Table 4.9: EU28 sectoral employment in the energy efficiency policy scenarios, 2030

(% change from reference)	Reference scenario, millions	EE25	EE28	EE30	EE32	EE35	EE40
Agriculture	7.75	1.09	2.92	1.07	0.90	-0.83	-1.17
Coal	0.11	1.89	2.16	-8.05	-10.30	-14.69	-20.42
Crude Oil	0.01	4.65	9.31	9.52	8.77	2.74	2.76
Oil	0.16	0.43	1.65	-0.78	-1.41	-4.18	-6.57
Gas Extraction	0.01	4.09	7.09	3.38	2.43	-2.51	-4.99
Gas	0.31	2.13	1.86	-10.95	-13.05	-23.15	-29.62
Electricity supply	3.64	1.52	-0.89	-11.01	-13.00	-21.39	-29.56
Ferrous metals	1.07	4.62	13.14	16.72	17.48	27.43	31.73
Non-ferrous metals	4.63	1.46	4.08	5.41	5.75	9.16	10.78
Chemical Products	5.32	0.16	4.74	6.83	7.58	10.49	14.40
Paper Products	4.28	0.16	0.85	1.22	1.27	1.37	1.02
Non-metallic minerals	2.9	2.60	7.76	11.41	12.52	18.88	25.79
Electric Goods	1.66	0.45	1.26	2.00	2.11	2.74	2.32
Transport equipment	5.83	0.89	1.93	2.30	2.44	2.61	3.15
Other Equipment Goods	11.82	0.77	2.28	2.89	2.96	4.26	2.08
Consumer Goods Industries	11.42	0.75	2.03	1.83	1.87	1.56	1.32
Construction	18.07	1.42	4.88	7.97	8.87	13.64	19.12

Sources: GEM-E3 model.

Competitiveness

The impact on the competitiveness of EU industries depends on the net outcome of two contradictive forces. Energy efficiency improvements lower the energy costs and thus the unit costs of production that EU industries are faced with. At the same time energy efficiency expenditures induce crowding out effects and increase the unit cost of capital. At low levels of energy efficiency improvements, the increase in capital costs surpasses the benefits that firms enjoy from lower energy bills. Thus competitiveness falls compared to the reference scenario (cumulative exports are lower in the scenarios where relatively lower energy efficiency expenditures are undertaken than in the reference scenario). In a similar manner, high levels of energy efficiency expenditure, energy efficiency improvements and the induced lower energy costs fail to counterbalance the higher capital costs induced from the crowding out effect. In this case the net effect on the competitiveness of EU products is also negative (cumulative exports fall compared to the reference scenario in the scenarios with relatively higher energy efficiency expenditures). In between these two end cases EU industries enjoy improved competitiveness due to lower energy costs, which have a higher impact on exports as compared to the negative impact induced by higher capital costs. In scenarios of moderate expenditures in energy efficiency improvements, the EU records higher exports as compared to the reference case, cumulatively over 2015-

2050, benefitting from lower energy bills which surpass the contracting effects of higher capital costs.

In the early stages of implementation of energy efficiency projects, the competitiveness of EU sectors is hampered by the impact that higher capital costs have on their production costs. In the latter years energy efficiency expenditures smooth out, putting less pressure on capital markets and hence the capital costs that EU sectors face are lower. EU competitiveness improves in the long run as energy efficiency projects mature and energy costs are reduced (thus EU sectors benefit from lower production costs). Energy costs are reduced due to lower energy intensity and higher energy efficiency in production. As a result of changes in the competitiveness of the EU sectors, exports are lower than in the reference scenario in the initial periods of the implementation of the energy efficiency policies (see Table 4.10). As the competitiveness of EU sectors rebounds, exports increase compared to the reference scenario. Imports in the energy efficiency policy scenarios also increase compared to the reference scenario (see Table 4.11). This is the result of changes in the competitiveness of EU products. Higher capital costs impact on the competitiveness of EU products, thus part of the higher demand in the energy efficiency scenarios is satisfied with relatively cheaper imports.

Table 4.10: EU28 exports in the energy efficiency policy scenarios

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	2,731.62	3,506.87	4,468.77	106,132.14
EE25	-0.21	-0.20	-0.04	-0.11
EE28	-0.33	-0.04	0.28	-0.04
EE30	-0.17	0.10	0.14	0.03
EE32	-0.18	0.11	0.15	0.04
EE35	-0.22	-0.03	0.27	0.00
EE40	-0.22	-0.09	0.12	-0.09

Sources: GEM-E3 model.

Table 4.11: EU28 imports in the energy efficiency policy scenarios

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	2,520.02	3,302.33	4,255.16	99,247.71
EE25	0.19	0.19	0.17	0.18
EE28	0.06	0.44	0.61	0.32
EE30	0.24	0.62	0.55	0.43
EE32	0.23	0.65	0.57	0.45
EE35	0.17	0.51	0.67	0.41
EE40	0.15	0.46	0.53	0.33

Sources: GEM-E3 model.

The expenditures on energy efficiency improvements are implemented without inducing persistent EU current account deficits. In the simulation of the policy scenarios the current account (as a percentage of GDP) is kept balanced through adjustments in interest rates. Interest rates are higher early on in the simulation period where the largest part of the expenditures is undertaken and pressure on capital markets is higher (Table 4.12). Interest rates are lower later on as the energy efficiency expenditures smooth out. Interest rates are also higher in the policy scenarios with higher energy efficiency targets.

Table 4.12: Real interest rate, in %

	2030	2040	2050
Reference scenario	3.73	3.59	3.34
EE25	3.74	3.60	3.35
EE28	3.80	3.61	3.35
EE30	3.80	3.61	3.36
EE32	3.81	3.61	3.36
EE35	3.89	3.62	3.35
EE40	3.95	3.62	3.40

Sources: GEM-E3 model.

Investment in the energy efficiency policy scenarios increases compared to the reference scenario (see Table 4.13). This is the result of higher expenditures on energy efficiency projects and the increased return on capital. The net effects on private consumption are summarized in Table 4.14. Cumulatively over 2015-2050 private consumption declines in the policy scenarios compared to the reference scenario.

Table 4.13: EU28 investment in the energy efficiency policy scenarios

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	3,369.52	3,937.83	4,576.48	124,818.96
EE25	0.07	0.19	0.30	0.14
EE28	0.16	0.19	0.32	0.16
EE30	0.40	0.20	0.29	0.19
EE32	0.44	0.21	0.33	0.20
EE35	0.53	0.34	0.53	0.28
EE40	0.51	0.32	0.65	0.30

Sources: GEM-E3 model.

Table 4.14: EU28 household consumption in the energy efficiency policy scenarios[53]

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	10,112.48	11,850.19	13,809.56	375,097.95
EE25	-0.03	0.00	-0.04	0.00
EE28	-0.17	0.01	-0.03	-0.04
EE30	-0.39	0.01	-0.01	-0.09
EE32	-0.44	-0.02	0.00	-0.12
EE35	-0.94	-0.20	-0.11	-0.31
EE40	-2.06	-0.27	-0.15	-0.56

Sources: GEM-E3 model.

Regarding the rest of the model's countries/regions (i.e. non-EU countries), the effects are found to be positive and small in magnitude by 2050 although negative in 2030 (see Table 4.15). The effects are associated with changes in EU trade, which is translated to varying demand for goods and services.

Table 4.15: World GDP (excluding EU28) in the energy efficiency policy scenarios

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	71,682	94,337	115,214	2,764,638
EE25	-0.01	-0.01	0.00	0.00
EE28	-0.03	0.00	0.03	0.00
EE30	-0.04	0.01	0.02	0.00
EE32	-0.05	0.01	0.02	0.00
EE35	-0.08	-0.02	0.00	-0.02
EE40	-0.11	-0.04	-0.06	-0.05

Sources: GEM-E3 model.

4.5 Sensitivity run

In order to test the robustness of the results of the energy efficiency scenarios simulated with the GEM-E3 model a sensitivity scenario has been performed. The sensitivity scenario examines an alternative financing scheme of the energy efficiency expenditures based on maximum capital market flexibility at global level, in contrast to the previously presented results which assume capital market closure strictly at EU level. In both cases, the agents repay their loans during the period 2035-2050.

Under favourable financing conditions, GDP in the EU increases in the short to medium run but it decreases throughout the repayment period (see Table 4.16). The EU benefits from the better financing conditions for the additional expenditure due to global capital market flexibility, which weakens the pressure on capital markets and reduces the strength of the crowding out

[53] Household consumption is defined as the expenditures undertaken by households for the acquisition of goods and services.

effect. Nevertheless the better financing conditions alone are not enough to net out the capital costs EU countries are faced with and allow for the benefits from energy efficiency improvements to prevail. The cumulative effect of the sensitivity runs on GDP remains negative but smaller in magnitude than the standard policy scenarios results. The effect on employment is positive in all the sensitivity scenarios examined (see Table 4.17).

Table 4.16: EU28 GDP in the energy efficiency policy scenarios (sensitivity)

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario (€2010bn)	16,766	19,277	22,129	615,622
EE25_v2	0.01	-0.17	-0.14	-0.09
EE28_v2	0.10	-0.23	-0.25	-0.12
EE30_v2	0.34	-0.19	-0.14	-0.06
EE32_v2	0.38	-0.21	-0.13	-0.08
EE35_v2	0.32	-0.18	-0.11	-0.09
EE40_v2	0.28	-0.32	0.00	-0.11

Sources: GEM-E3 model.

Table 4.17: EU28 employment in the energy efficiency policy scenarios (sensitivity)

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Ref. scenario, millions	218.76	211.24	204.08	7,514.34
EE25_v2	0.47	0.22	0.35	0.18
EE28_v2	1.13	0.32	0.47	0.39
EE30_v2	1.88	0.61	0.82	0.64
EE32_v2	1.99	0.68	0.94	0.70
EE35_v2	2.56	0.94	1.27	0.96
EE40_v2	2.85	1.10	1.62	1.09

Sources: GEM-E3 model.

From an economic perspective, foreign financing of the EU energy efficiency expenditures is plausible as long as the overall effect on the GDP of other economies is positive. It is found that foreign financing may not be available for the most ambitious energy saving scenario (EE40_v2) but it could be quite plausible for the rest of the scenarios examined (see Table 4.18).

Table 4.18: GDP in the rest of the world (excluding EU28) in the energy efficiency policy scenarios (sensitivity)

(% change from reference)	2030	2040	2050	Cumulative (2015-2050)
Reference (in bn 2010€)	71,682	94,337	115,214	2,764,638
EE25_v2	-0.01	0.01	0.02	0.01
EE28_v2	-0.04	0.03	0.09	0.02
EE30_v2	-0.07	0.03	0.07	0.02
EE32_v2	-0.08	0.03	0.08	0.02
EE35_v2	-0.14	0.00	0.06	0.00
EE40_v2	-0.17	-0.01	0.02	-0.02

Sources: GEM-E3 model.

4.6 Conclusions from the GEM-E3 modelling

The GEM-E3 model has been used to simulate scenarios of energy efficiency policies to 2050. In a stepwise manner the scenarios simulate polices which achieve a 25% (least ambitious scenario) to 40% (most ambitious scenario) reduction in primary energy consumption by 2030. Energy efficiency is achieved with additional expenditures financed by economic agents (firms, households) and aggregate savings with borrowing that extends to 2050.

The results obtained are the outcome of a set of complex interactions: positive effects from higher demand for sectors that provide inputs to energy efficiency projects; and negative effects from crowding out that curbs other productive investment and consumption; and various effects on competitiveness and foreign trade depending on whether the sector faces lower (through energy efficiency) or higher (through capital expenditure) costs.

During the time period 2020-2030, energy efficiency expenditures are particularly high in some scenarios, producing strong negative crowding out effects. In response to energy efficiency expenditures, several sectors (equipment goods, electrical goods etc.) benefit from a decrease in variable costs (energy, commodities, purchasing costs) due to higher energy efficiency. This has beneficial effects on the economy, which then gradually recovers to the growth rates seen in the reference scenario.

The effects of energy efficiency policies depend on how ambitious the scenarios are. In the more modest energy efficiency policy scenarios, the competitiveness effects smooth out and the benefits of lower energy costs outweigh the higher capital costs induced by expenditures in energy efficiency. This is not the case for the scenarios characterised by very ambitious targets for energy efficiency.

A key result is that the degree of ambition of the energy efficiency effort is a critical factor affecting the degree of recovery in the long term, because of the assumption that greater energy efficiency comes at higher marginal cost. So, whereas the negative effects on GDP are temporary in the modest energy efficiency scenarios, they persist in the most ambitious energy efficiency scenarios. Overall, energy efficiency expenditures are found to impact positively on employment and have a small negative effect on EU GDP compared to the reference scenario. Activity and employment effects reflect the changes in demand that energy efficiency expenditures induce in those sectors that provide inputs to energy-saving projects, particularly in more labour-intensive sectors with substantial linkages to other sectors of the economy and sectors less exposed to foreign competition. Energy saving induces a fall in demand for energy sectors, but the consequences for employment are limited due to the relatively capital-intensive nature of these sectors.

The results show quite consistent impacts across scenarios. Specific sectors, such as construction and market services experience the largest benefits from the energy efficiency programs. The effects are more pronounced during the implementation phase of the programmes and diminish in the long term.

The overall changes in investment and funding patterns can be manageable at the EU level under perfect capital mobility within the EU, as they imply mild pressures on capital and labour markets and assume sufficient flexibility in these markets across the EU and over time. The sensitivity run with the GEM-E3 model where EU financial constraints were eased showed that increasing financing availability can reduce the negative impacts of the crowding out effect and improve the overall adjustment of the economic system. This highlights the importance of versatile financing mechanisms (for example, to address the problem that low income households may not be able to secure financing for the high upfront costs that energy saving projects entail) in the successful implementation of large scale energy saving projects.

In a CGE setting the effects of EE policies need not to be negative as long as the policies themselves are accompanied by measures that improve the financing of the energy saving projects. The CGE modelling would be improved by the explicit inclusion of the financial sector in a CGE model and the modelling of capital market imperfections (in the current model version, full use of capital is assumed). These two features would moderate the negative impact on the economy brought about by the crowding out effect in the current model's scenarios.

5 Results of modelling the economic impact of investment in energy efficiency with the E3ME model

5.1 Introduction

In this chapter, we discuss the modelling exercise that was carried out using the macro-econometric E3ME model. Section 5.2 gives a brief introduction to the model. Section 5.3 then describes the reference scenario projections that were used for the analysis and explains how the E3ME model was calibrated to be consistent with the reference scenario projections[54]; it also outlines the inputs and assumptions of the energy efficiency policy scenarios. Section 5.4 presents the model results and Section 5.5 discusses the main conclusions from the modelling exercise.

As with the scenarios run using GEM-E3, only the impact of the energy efficiency policies was estimated and not the impact of decarbonisation.

5.2 The E3ME model

Overview

E3ME is a computer-based model of the world'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 and beyond for policy assessment, for forecasting and for research purposes. Key features of E3ME include:

- 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
- its global coverage, while still allowing for analysis at the national level for large economies
- the econometric approach, which provides a strong empirical basis for the model and means it is not reliant on some of the restrictive assumptions common to CGE models (see below)
- the econometric specification of the model, making it suitable for short and medium-term assessment, as well as longer-term trends

Basic model structure

The structure of E3ME is based on the system of national accounts, with further linkages to energy demand and environmental emissions. The labour market is also covered in detail, including both voluntary and involuntary unemployment. 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.

[54] The REF+ scenario from PRIMES was used.

E3ME's historical database covers the period 1970-2012 and the model projects forward annually to 2050. The main data sources for European countries are Eurostat and the IEA, supplemented by the OECD's STAN database and other sources where appropriate. For regions outside Europe, additional sources for data include the UN, OECD, World Bank, IMF, ILO and national statistics. Gaps in the data are estimated using customised software algorithms.

Comparison with GEM-E3

E3ME is often compared to CGE models like GEM-E3. In many ways the modelling approaches are similar; they are used to answer similar questions and use similar inputs and outputs. However, underlying this there are important theoretical differences between the modelling approaches.

In a typical CGE framework, optimal behaviour is assumed, output is determined by supply-side constraints and prices adjust fully so that all the available capacity is used. In E3ME the determination of output comes from a post-Keynesian framework and it is possible to have spare capacity. The model is more demand-driven and it is not assumed that prices always adjust to market clearing levels.

The differences have important practical implications, as they mean that in E3ME regulation and other policy may lead to increases in output if they are able to draw upon spare economic capacity. This is described in more detail in the model manual. A comparison of the results from the E3ME and GEM-E3 models is drawn in Chapter 6.

Further information about the E3ME model can be found in Appendix A. The full model manual is available at the website www.e3me.com.

5.3 Definition of the reference and policy scenarios

The reference scenario

The E3ME reference scenario was calibrated to match the PRIMES Reference Plus scenario (REF+); this is consistent with the GEM-E3 modelling described in the previous chapter. E3ME takes the following indicators from the projections directly:

- GDP and sectoral economic output
- energy and ETS prices
- projections of energy demand by sector and by fuel
- CO_2 emissions by sector
- population

These indicators combined allow us to construct an economic scenario based on the energy system results from PRIMES. In addition, changes in investment (i.e. relative to the reference scenario) are added in the policy scenarios (see below).

The procedure to calibrate E3ME is described in detail in Appendix A.

The policy scenarios

This section describes the policy scenarios that were modelled, focusing on the way that the PRIMES results were integrated as inputs to E3ME. These scenarios are the same ones that were modelled in GEM-E3 and described in the previous chapter. Table 5.1 outlines the six policy scenarios. For a more detailed description of the policy scenarios please see Section 4.2[55].

Table 5.1: The policy scenarios

PRIMES scenario name	Short description
EE25	PRIMES output 27th May 2014, primary energy savings of 25.0%, compared to PRIMES 2007 projection
EE28	PRIMES output 27th May 2014, primary energy savings of 28.0%, compared to PRIMES 2007 projection
EE30	PRIMES output 27th May 2014, primary energy savings of 30.0%, compared to PRIMES 2007 projection
EE32	PRIMES output 27th May 2014, primary energy savings of 32.0%, compared to PRIMES 2007 projection
EE35	PRIMES output 27th May 2014, primary energy savings of 35.0%, compared to PRIMES 2007 projection
EE40	PRIMES output 27th May 2014, primary energy savings of 40.0%, compared to PRIMES 2007 projection

Sources: PRIMES model outputs.

CO_2 prices

Table 5.2 shows the EU ETS prices in each scenario. In each case the prices are consistent with the prices used in the energy sector assessment with the PRIMES model. Non-ETS sectors do not face carbon prices in any of the scenarios.

Table 5.2 Policy scenarios, EU-ETS prices, 2010 prices, euro/tCO_2

	2020	2030
EE25	10.0	42.0
EE28	10.0	32.5
EE30	10.0	25.0
EE32	10.0	23.0
EE35	9.0	12.5
EE40	8.0	6.0

Sources: PRIMES model outputs.

Power generation and electricity prices

For the purpose of this modelling exercise the power generation sector is treated as exogenous in E3ME. In both the E3ME reference scenario and the policy scenarios, the power generation results are set to match those from the PRIMES model in each case, reflecting the more detailed representation of the sector in PRIMES.

An important input to the scenarios is the amount of investment required to bring about the changes in the power generation mix. The PRIMES policy

[55] It should be noted that, due to time constraints, not all the PRIMES scenarios were modelled. The EE27 and EE29 scenarios were not modelled. The PRIMES runs based on the Reference scenario (rather than Reference Plus scenario) were not modelled.

scenarios contain a different energy generation mix compared to the baseline and the model estimates the amount of investment required to achieve this mix. By looking at the differences between the policy scenarios and the reference scenario of the investment expenditure in power plants forecast by PRIMES we can estimate the additional investment required to achieve the new mix. The additional investment in power plants made by the electricity supply sector that was used to bring about the change in power generation was added exogenously into E3ME. It is assumed to be financed by higher electricity prices, which are also taken from PRIMES. Bringing E3ME electricity prices in line with the PRIMES Reference Plus and policy scenarios ensures consistency across the power generation outcomes (i.e. consistent power generation mix, power plant investment required and resulting electricity prices).

Energy efficiency and investment

In E3ME, the energy efficiency savings were entered exogenously in the model and were set to match the PRIMES results as closely as possible. The changes in primary and final energy demand by sector (including the power sector, industries, transport, services) from PRIMES was used as a guide for the level of energy efficiency savings. These savings were then further distributed among E3ME sectors and energy carriers, using as a guide the shares between energy carriers in proportion to energy consumption.

It is assumed in the scenarios that the energy efficiency investment undertaken by each sector is funded directly by government subsidy. Consequently, the amount of investment affects the public budget and must be financed by changes in taxation (see below).

Revenue recycling

All the scenarios are ‘revenue neutral’ meaning that there are no direct changes in government balance from our scenario assumptions. This approach is applied to avoid bias in the outcomes, for example if we assumed that the government spent more than it received then a stimulus effect could be expected to lead to better economic outcomes.

The main changes to government balances in the scenarios result from public investment in energy efficiency and changes to ETS auction revenues (which will depend on power sector emissions and the EU ETS price, see Table 5.3). We apply changes in income tax rates to compensate the differences (see Table 5.4).

In this study income tax rates are adjusted as this is the largest source of income for European governments and it seems likely that, ultimately, consumers will end up paying the cost of the investment one way or another. This was also the approach used for the assessment of the 2030 energy and climate package, so by adopting it again we ensure consistency with previous E3ME model results. It should be noted that the approach means that there is a shift from spending on current consumption to spending on investment, which is demonstrated in the results in the next section.

One alternative approach would have been to increase VAT rates, which would have had fairly similar results overall. Another approach would have been to make energy companies pay for the investment and pass on the costs through higher energy bills. However, while this policy has merits it did not make sense to apply in our modelling framework as it would have led to changes in energy demand, bringing in an inconsistency with the PRIMES model results.

Another alternative would be to assume that households are forced to make the investments in energy efficiency as a result of direct regulation. In this case households will need to reduce expenditure on other items, effectively reducing their disposable income. The macroeconomic effects are thus similar to adjusting income tax rates.

In reality it will be up to the Member States (and individual households) to choose how to balance their budgets and no single method will be applied. The key factor for the modelling is to ensure that the inputs balance for the public sector overall.

Table 5.3: Revenues from auctioned ETS allowances, EU28, bn euros (current prices)

	2020	2025	2030
Reference scenario	11	15	32
EE25	17	26	55
EE28	17	24	45
EE30	17	22	35
EE32	17	22	33
EE35	15	19	21
EE40	15	10	16

Sources: E3ME, Cambridge Econometrics.

Table 5.4: Additional income tax revenue required to finance EE investment, EU28, bn euros (current prices)

	2020	2025	2030
Reference scenario	-11	-15	-32
EE25	-16	-8	-25
EE28	-16	13	64
EE30	-16	73	161
EE32	-16	91	243
EE35	-15	175	456
EE40	-15	193	1,082

Notes: Negative values mean that revenues from the auctioning of the ETS allowance are more than enough to cover the EE investment, and income tax rates are reduced. Positive numbers show the additional tax revenue required to finance EE investment.

Sources: E3ME, Cambridge Econometrics.

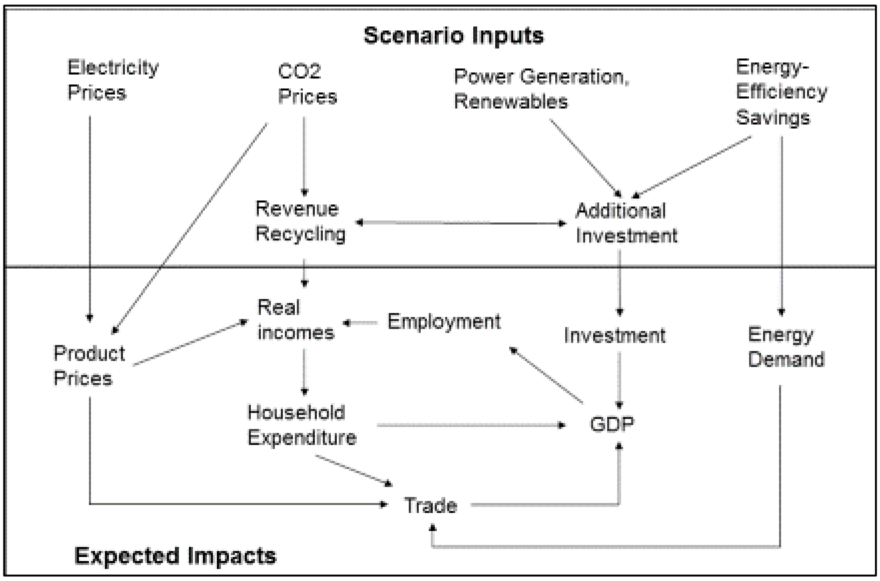
Summary

Figure 5.1 summarises how the scenarios are represented in E3ME. The main macroeconomic components that are expected to change are:

- Investment. In E3ME investment is modelled based on an econometric equation. Changes in product demand, prices and production cost all affect industries' decision to invest. However, the model is not able to predict shifts in policies, such us a higher uptake of energy efficiency measure. As such, the additional energy efficiency investment required to achieve the energy savings is added exogenously into the model, under the form of additional investment (see Figure 5.1).

- Consumer expenditure. This is partly due to changes in product prices (because of changes in CO_2 prices and electricity prices that industries are able to pass through to consumers), but mainly due to changes in income taxes (because of the revenue balancing method).
- Trade (due to changes in fossil fuel imports and the increase in activity, and hence imports in the investment goods sectors).

Figure 5.1: PRIMES scenario inputs and E3ME expected impacts



5.4 Results from the E3ME model

Overview

This section starts by showing the impacts on economic indicators, first at the macroeconomic level and then by sector, and then examines the implications for employment.

The time horizon for this analysis is 2030.

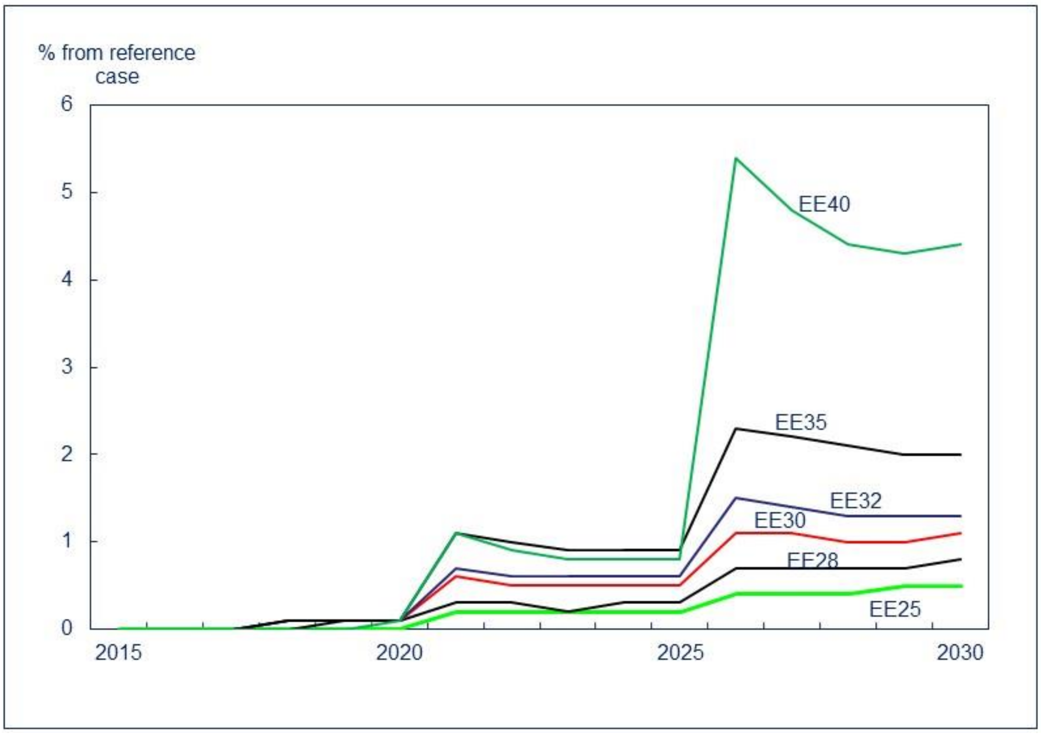
Impacts on macroeconomic indicators

In E3ME, employment is determined primarily by the level/growth of economic output and relative labour costs. To understand and interpret the *employment* impacts of the scenarios it is, therefore, necessary to consider first the context given by the *macroeconomics* of the policy scenarios compared to the reference scenario.

The macroeconomic outcomes are driven by changes in investment after 2025. For example, looking at PRIMES results for 2030, EU28 energy efficiency investment in the EE30 scenario is around 1.4% of baseline GDP in 2030. In the EE40 scenario, EU28 energy efficiency investment is around 7.2% of baseline GDP, also in 2030.

Figure 5.2 presents GDP levels up to 2030 in each scenario as percentage difference from the reference scenario. There is an increase in GDP in all scenarios compared to the reference scenario. The model results indicate that the changes in GDP are as high as 5.4% in the EE40 case; however, these gains are unlikely to occur in reality because of constraints not included in the modelling framework (see discussion in Chapter 6). It should also be noted, as discussed below, that these GDP increases measure the changes in economic activity associated with energy efficiency: they do not necessarily represent increases in welfare. The reason for this is that the policy scenarios with more ambitious energy efficiency targets are funded by an increase in income taxes and thus lower household incomes. The savings households make through lower energy consumption may not be enough to make up for the loss of household consumption spending due to lower incomes.

Figure 5.2: EU28 GDP, % difference from reference scenario



Sources: E3ME, Cambridge Econometrics.

The profile of the changes in GDP is an important feature of the scenarios. In the period 2020-2025 there is only a small increase in investment and this is reflected in a small GDP increase. After 2025, however, the results from the PRIMES model suggest that a much more ambitious energy efficiency programme is put in place; investment increases very quickly and this results in higher levels of economic activity. The results from PRIMES which are available for every fifth year have been interpolated to give annual figures, and so the annual results from E3ME show a stepping up of investment and output form 2026 onwards.

The increases in the level of GDP in 2030 in the more moderate scenarios that are of the order of 0.5-2% suggest that energy efficiency adds up to 0.18 percentage points to annual GDP growth in the EU over the period 2020-2030. Table 5.5 shows the levels of EU GDP in each scenario over the projection period.

Table 5.5: EU28 GDP, bn euros 2010 prices

	2015	2020	2025	2030
Ref. scenario	13,414	14,479	15,699	16,960
EE25	13,416	14,485	15,730	17,044
EE28	13,416	14,488	15,740	17,088
EE30	13,416	14,489	15,782	17,139
EE32	13,416	14,490	15,791	17,185
EE35	13,416	14,489	15,840	17,304
EE40	13,415	14,486	15,828	17,716

Sources: E3ME, Cambridge Econometrics.

Results by economic indicator

Table 5.6 shows the results by main economic indicator for 2030. This confirms that the main driving force behind the increase in GDP is the additional investment in energy efficiency. The table also outlines the large scale of the energy efficiency investment required to achieve the reductions in final energy demand. Despite higher GDP, household expenditure in all scenarios is *lower* than in the reference scenario. The reason for this is that the public expenditure on energy efficiency requires an increase in taxes (following the assumption in this study, income taxes). In the case of households, the savings achieved through improved energy efficiency are not enough to counteract the impact of higher taxation. The amount households save by implementing energy-efficiency measures in 2030 varies between €9bn (2005 prices) in the EE25 scenario and €31bn in EE40.

Although there is no measure of welfare in E3ME, in macroeconomic models a reduction in household expenditure is often interpreted as being consistent with a loss of welfare. However, there are cases where the two do not necessarily move together: in this case, the investment in energy efficiency allows households to achieve the same level of comfort while spending less on energy (in effect, substituting capital spending for current spending). Consequently, the current spending measure is not necessarily a good proxy for welfare.

Table 5.6: EU28 Summary of results, % from reference scenario, 2030

	Reference (€2010bn)	EE25	EE28	EE30	EE32	EE35	EE40
GDP	16,960	0.5	0.8	1.1	1.3	2.0	4.4
Consumer expenditure	9,535	0.2	-0.2	-0.6	-1.0	-2.0	-4.8
Investment	3,945	1.5	3.6	5.9	8.1	13.8	32.2
Extra-EU exports	3,353	0.1	0.2	0.3	0.4	0.4	0.4
Extra-EU imports	3,019	0.2	0.4	0.5	0.8	1.3	2.9

Sources: E3ME, Cambridge Econometrics.

In terms of competitiveness effects, there is a very small increase in exports of industrial goods to the rest of the world under all six scenarios, because industries are able to reduce prices as a result of their improved energy efficiency. Imports of fossil fuels are reduced in the scenarios, because the energy efficiency measures lead to a decrease in fuel consumption, but imports of some other goods increase due to higher GDP levels and demand for goods.

Sectoral results

Table 5.7 shows the main impacts at broad sectoral level. As might be expected, the sectors that benefit the most in all the scenarios are the ones that produce investment goods, such as engineering. The construction sector that installs the goods also benefits. The non-energy extraction sector is also expected to benefit, as it supplies the construction sector with raw materials.

The effects on other sectors are the result of broad a combination of factors, such as their supply chains (energy products, energy-intensive products), the position they hold in other sectors' supply chain (e.g. if they are part of the supply chain of the sectors that benefit the most from the energy efficiency investment), ability to pass changes in cost to process and so forth. For example, sectors producing consumer goods are the ones most affected by the tax increases needed to finance the energy efficiency investment. However, these sectors are also expected to benefit from the increased distribution activity resulting from the increased activity in the sectors benefitting from the energy efficiency investment (construction, engineering, etc.). Consequently, output of sectors producing or related to consumer goods are expected to be higher than in the reference scenario, but by a smaller margin than in other sectors not so closely linked to consumer expenditure patterns.

Most service sectors are in the supply chain of the sectors benefitting from the energy efficiency investment and are generally expected to benefit. However, these sectors will also be affected by the decrease in consumer expenditure. The effect on the extraction industries is mixed. On one hand, extraction of energy products is expected to decrease because of lower demand (caused by increased energy efficiency). On the other hand, output in non-energy mining sectors is expected to increase, as this sector produces raw materials required by the supply chains of the sectors benefiting from the energy efficiency investment (e.g. processing metals and non-metallic minerals into products later used by the engineering and construction sectors).

Basic manufacturing sectors are also expected to benefit, as some are in the supply chain of the engineering and construction sectors, which benefit the most from the implementation of the energy efficiency measures. However, the sectors that work on the processing of raw energy materials (such as manufactured fuels) are expected to be affected negatively.

The energy efficiency savings are expected to lead to reduced use of electricity and gas, resulting in a fall in output in the sectors supplying them; therefore, output in the utilities sector is substantially lower than in the reference scenario.

To conclude, the sectors that are expected to benefit the most from the energy efficiency measures are those directly benefiting from the investment (e.g. engineering and construction), as well as those that makeup the supply chain of these sectors (e.g. service sectors, basic metals and non-metallic minerals, other mining). The impact on the sectors that manufacture consumer goods is more uncertain, as they are negatively affected by the increase in income taxes, but may also benefit from the increase in distribution activity. Energy and energy-related sectors are expected to lose out, because of decreased demand for their products.

Table 5.7: EU28 output[56] by broad sector, % from reference scenario, 2030

	Ref. (€ 2010bn)	EE25	EE28	EE30	EE32	EE35	EE40
Agriculture	483	0.3	0.3	0.3	0.3	0.1	-0.1
Extraction inds.	116	-0.3	-0.2	0.3	1.0	2.5	7.2
Basic manufacturing	3,762	0.6	1.0	1.4	1.8	3.1	7.5
Engineering and transport equip.	3,752	1.1	1.8	2.8	3.8	6.2	14.6
Utilities	910	-3.0	-6.1	-7.9	-8.5	-12.1	-17.8
Construction	2,175	1.6	4.4	7.6	10.6	18.1	41.7
Distribution and retail	3,401	0.5	0.6	0.6	0.6	0.7	1.4
Transport	1,609	0.3	0.5	0.8	1.0	1.5	3.0
Communications, publishing and television	2,971	0.6	0.9	1.2	1.5	2.2	4.8
Business services	7,331	0.5	0.7	1.0	1.2	1.7	3.8
Public services	4,958	0.1	0.1	0.1	0.1	0.0	-0.2

Sources: E3ME, Cambridge Econometrics.

[56] P1 in the National Accounts, a measure of gross production levels. The sectors are defined as follows:
Agriculture – NACE Rev 2 A01-A03 – agriculture, fishing and forestry
Extraction industries – NACE Rev 2 B – mining and quarrying
Basic Manufacturing – NACE Rev 2 C10-24 – including, but not limited to manufacture of food, textiles, chemicals & manufactured fuels, non-metallic minerals and basic metals
Engineering and transport equipment – NACE Rev 2 C25-33 – including, but not limited to metals products, electronic, electrical equipment, engineering, transport equipment and installation and repair
Utilities – NACE Rev 2 D, E36-39 – electricity, gas, steam and air con, water supply, waste disposal
Construction – NACE Rev 2 F – construction
Distribution and retail – NACE Rev 2 G45-47 – wholesale and retail trade, including motor vehicles
Transport – NACE Rev 2 H49-52 – land, water and air transport, warehousing and. support services
Communications, publishing and television – NACE Rev 2 H53-J63 – including, but not limited to, postal services, telecommunications, publishing activities, broadcasting
Business services – NACE Rev 2 K64-N82 – including, but not limited to, financial and insurance services, legal, accounting and advertising, architecture and engineering, R&D and other professional services
Public services – NACE Rev2 O-U – public administration and defence, education and health care, etc.

Output by Member State

Table 5.8 shows total output by Member State in 2030 for each policy scenario, as well as the reference scenario. An increase in output is driven by the investment in energy efficiency and, while some sectors are negatively affected by the reduction in consumer expenditure (see above), this is not enough to lead to a decrease in total production in any of the Member States.

Table 5.8: Output by Member State, % from reference scenario, 2030

	Ref. (€ 2010bn)	EE25	EE28	EE30	EE32	EE35	EE40
Belgium	908	0.6	1.4	2.2	2.9	4.7	11.4
Denmark	516	0.6	1.1	2.0	2.6	4.4	8.5
Germany	5,529	0.4	0.7	1.1	1.3	2.2	5.2
Greece	376	0.4	0.8	1.5	1.9	3.1	7.1
Spain	2,771	0.4	0.4	0.4	0.6	0.9	3.0
France	4,762	0.1	0.5	1.0	1.5	2.8	7.3
Ireland	614	0.2	0.6	0.9	1.3	2.1	5.1
Italy	3,691	1.0	1.5	2.2	2.8	4.5	10.1
Luxembourg	152	0.4	0.5	0.7	0.8	1.1	2.1
Netherlands	1,432	1.8	1.6	2.0	2.5	3.0	7.4
Austria	736	0.2	0.6	0.9	1.2	2.3	5.3
Portugal	402	0.3	0.6	1.0	1.3	2.0	4.6
Finland	475	0.0	0.5	1.1	2.2	4.2	12.7
Sweden	1,020	0.4	0.8	1.1	1.5	2.4	4.4
UK	5,015	0.3	0.5	0.7	1.0	1.6	3.6
Czech Rep.	481	1.0	1.9	2.8	3.7	5.7	12.7
Estonia	58	1.0	1.6	2.4	2.9	4.4	11.6
Cyprus	35	0.4	0.2	0.3	0.5	0.7	2.8
Latvia	64	1.0	1.8	2.5	2.9	3.9	7.3
Lithuania	68	0.9	1.2	0.5	0.5	2.9	8.0
Hungary	320	0.4	0.9	1.5	2.1	3.3	8.6
Malta	14	0.1	0.2	0.2	0.3	0.4	1.2
Poland	1,181	0.7	1.3	2.0	2.7	4.8	10.7
Slovenia	96	0.6	1.1	1.6	2.1	3.4	8.4
Slovak Rep.	264	0.4	0.8	1.0	1.1	2.4	8.0
Bulgaria	95	1.1	1.8	3.0	4.0	6.5	15.0
Romania	338	1.4	1.1	2.2	3.3	5.8	15.4
Croatia	52	1.6	3.0	4.6	6.0	9.5	20.4

Sources: E3ME, Cambridge Econometrics.

Employment results

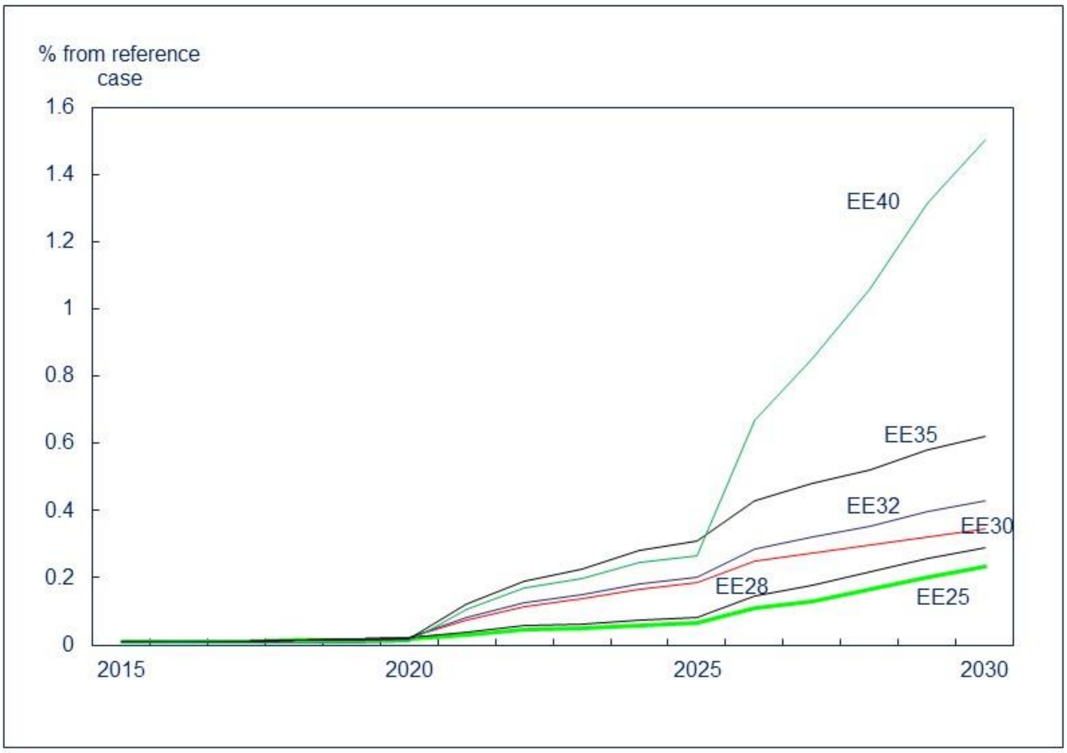
Figure 5.3 shows the employment impacts of the scenarios compared to the reference scenario. Until 2020 there is very little change in overall EU28 employment levels in the scenarios and even up to 2025 the changes are quite small. However, once the energy efficiency investment starts to grow quickly after 2025, employment is expected to increase substantially[57]. In the

[57] This pattern follows through from the PRIMES results for investment used as inputs in the E3ME modelling, see the discussion of the GDP results above.

medium and ambitious (EE35 and EE40) scenarios, the increase in employment levels could be up to 1.4% by 2030. The model results suggest higher increases are possible in the more ambitious cases, but these results are subject to more uncertainty and possible labour market constraints (see Section 6.2).

The impacts on employment are roughly one-third the size (in percentage terms) of the impacts on GDP.

Figure 5.3: EU28 Employment, % difference from reference scenario



Sources: E3ME, Cambridge Econometrics.

Sectoral employment

The outcomes for sectoral employment broadly follow those for sectoral output described above, with construction, engineering and their supply chains benefiting the most (see Table 5.9). The largest increase in employment is expected in the construction sector, on the assumption that a large share of the investment will require construction or installation activities. Relatively more modest increases are also projected in the engineering and transport equipment sector, as well as in basic manufacturing. The reason for this is that, while these sectors benefit directly from the energy efficiency investment, they are also indirectly affected by the decrease in consumer expenditure. For example, lower consumer expenditure may mean less new cars are bought by households, which in in turn affects the transport equipment sectors. It may also mean that households buy less equipment, tools or certain household appliances, which directly affect the above mentioned sectors.

Employment in distribution and retail (and business services in EE35 and EE40) is expected to fall, despite the increase in output in these sectors. The reason for this is that higher employment levels overall (mainly due to the relatively labour-intensive construction sector) and a lower rate of unemployment lead to increases in wage demands[58], a form of labour market crowding out. Employment in utilities is also predicted to fall, in line with the projected fall in output of this sector.

Table 5.9: EU28 Employment, thousand jobs (difference from ref), 2030

	Reference	EE25	EE28	EE30	EE32	EE35	EE40
Agriculture	9,726	0.2	0.0	-0.1	-0.4	-0.9	-3.1
Extraction industries	479	-1.3	-1.8	-1.5	-1.1	-0.9	-2.6
Basic manufacturing	14,869	0.3	0.3	0.5	0.6	0.9	2.1
Engineering and transport equipment	15,268	0.6	0.7	0.9	1.2	1.7	3.8
Utilities	2,274	0.1	-1.4	-3.5	-4.3	-6.3	-8.0
Construction	16,524	0.7	2.1	3.6	5.1	8.6	19.8
Distribution and retail	35,266	0.1	0.0	-0.2	-0.4	-0.7	-1.7
Transport	9,388	0.2	0.1	0.2	0.2	0.2	0.1
Communications, publishing and television	20,278	0.2	0.3	0.4	0.4	0.6	1.5
Business services	40,985	0.3	0.2	0.1	0.1	-0.1	-0.3
Public services	66,671	0.1	0.1	0.0	0.0	0.0	0.4

Sources: E3ME, Cambridge Econometrics.

Employment in the power sector

Table 5.10 presents employment changes in the power sector in greater detail. In EE25, a switch from conventional electricity generation methods to renewables can be seen. As the size of the energy efficiency savings increases, a reduction in employment across most power generation technologies is observed, as the energy efficiency gains and higher electricity prices lead to lower electricity consumption.

[58] While this may not be the case under the 'current' unemployment situation, it is important to note that the results presented are for 2030, when the 'current' situation is not expected to persist. Indeed, in the case of the EU28 the supply of available labour is of particular interest for the medium term time horizon. One obvious example is Germany, where working-age population is expected to shrink more than twice as fast as the population as a whole until 2050. In general, net migration and increased participation rates (due to the rise of the statutory retirement age) are not expected to be sufficient to make up the difference and, as such, employment growth in Germany is projected to be negative. The Baltic states and certain other European countries are expected to face labour supply constraints, if current population and migration trends persist. Impacts on wages are discussed later in this section.

Table 5.10: EU28 Employment in power generation, % difference from reference, 2030

	Ref. (000s)	EE25	EE28	EE30	EE32	EE35	EE40
Conventional	150	-42.8	-35.8	-41.1	-41.3	-45.6	-60.5
Hydro	27	0.1	0.1	0.0	0.0	-0.2	-0.4
Nuclear	109	-6.9	-8.6	-14.4	-18.7	-26.9	-37.6
Solar	157	24.6	14.2	7.7	4.5	-0.5	-10.5
Wind	240	36.5	22.7	13.7	10.1	-6.6	-18.2
Geothermal	3	0.9	0.9	0.2	0.2	0.1	-0.1
Biomass	17	5.0	4.3	3.7	3.4	2.5	0.8
Tidal	28	2.9	0.6	-3.8	-4.5	-4.5	-4.5

Sources: E3ME, Cambridge Econometrics.

Employment by Member State

Table 5.11 shows the change in total employment compared to the reference scenario by Member State. Generally, Member States with a large share of energy efficiency investment in GDP (generally new Member States such as the Baltics, Poland, Hungary and the Czech Republic, but also Finland and the Netherlands) and/or with large investment goods sectors (e.g. construction in Italy and Greece) are expected to see the largest increases in employment, particularly if the level of productivity in those sectors is relatively low. However, countries with economies focused more towards consumer goods and services (such as France, Austria and Portugal) are likely to see smaller increases in employment and, in some cases, even a small decrease in employment levels compared to the reference scenario.

Table 5.11: Employment by Member State, % difference from reference scenario, 2030

	Ref. (000s)	EE25	EE28	EE30	EE32	EE35	EE40
Belgium	4,879	0.2	0.3	0.5	0.6	0.9	2.3
Denmark	2,983	0.3	0.4	0.7	0.9	1.4	2.6
Germany	37,778	0.1	0.1	0.1	0.2	0.2	0.6
Greece	4,320	0.3	0.5	0.9	1.2	1.9	4.4
Spain	19,984	0.3	0.2	0.3	0.3	0.4	1.0
France	29,062	0.1	0.2	0.2	0.3	0.5	1.5
Ireland	2,188	0.2	0.3	0.4	0.6	0.9	2.1
Italy	25,416	0.6	0.8	1.1	1.5	2.3	5.4
Luxembourg	431	0.2	0.3	0.4	0.6	1.0	2.8
Netherlands	8,718	0.4	0.4	0.4	0.4	0.4	1.0
Austria	4,272	0.2	0.1	0.0	0.0	-0.2	-0.2
Portugal	4,972	0.2	0.3	0.3	0.2	0.1	-0.7
Finland	2,559	0.0	-0.1	-0.2	0.1	0.3	4.0
Sweden	4,931	0.1	0.1	0.1	0.1	0.2	0.6
UK	33,855	0.2	0.1	0.0	0.0	0.0	0.1
Czech Rep.	5,228	0.3	0.5	0.6	0.8	1.3	2.7
Estonia	575	0.2	0.3	0.5	0.5	0.9	2.9
Cyprus	438	0.2	0.3	0.4	0.6	0.8	2.7
Latvia	996	0.1	0.3	0.4	0.5	0.7	1.7
Lithuania	1,395	0.1	0.0	-0.5	-0.6	-0.5	-0.7

Hungary	4,242	0.2	0.2	0.3	0.4	0.5	1.2
Malta	172	0.0	0.1	0.1	0.2	0.3	1.0
Poland	15,836	0.3	0.3	0.3	0.3	0.3	0.2
Slovenia	910	0.3	0.3	0.4	0.4	0.5	1.4
Slovak Rep.	2,259	0.2	0.2	0.2	0.2	0.2	0.8
Bulgaria	2,995	0.3	0.3	0.4	0.5	0.7	1.8
Romania	8,910	0.3	0.4	0.6	0.7	1.0	2.1
Croatia	1,427	0.4	0.7	0.9	1.1	1.7	3.3

Sources: E3ME, Cambridge Econometrics.

Implications for wage rates and unit labour costs

As well as affecting employment levels, the measures in the scenarios will affect average wage rates. Wage rates could increase due to:

- higher output per worker, i.e. productivity
- a reduction in unemployment strengthening workers' bargaining positions

In addition there could be changes in the average wage rate due to movements between sectors – e.g. if most new jobs are created in a sector with low wage rates this could pull down the average.

The results from E3ME suggest that average wage rates do increase across Europe, by around 0.3% in 2030 in the EE30 scenario compared to the reference scenario. It should be noted, however, that in most cases unit labour costs do not increase, as the average increase in wage rates, plus the increase in employment, is still less than the increase in total production levels.

Implications for occupations

Previous analysis on the impact of transitioning to a low-carbon and energy efficient economy that drew out the implications of E3ME employment results for the structure of occupations and qualifications has shown that the impacts are very small ('Green Jobs', DG Employment 2011[59]). Indeed, the study found almost no discernible impact of these policies on occupation structure. The reason for this is that changes due to environmental legislation, e.g. emissions targets for vehicles that encourage energy efficiency, are already taking place and therefore are already captured in the baseline. It is also possible that the effects are too small to see at this level of aggregation.

Because the scale of impacts on employment by sector in the energy efficiency scenarios reported here is quite modest (Table 5.9), the same conclusions will apply for occupation impacts at the level of disaggregation that the modelling supports.

Implications for qualifications

Although the modest scale of change in employment by occupation prevents the drawing of striking conclusions with regard to the implications for different skill levels, to the extent that the energy efficiency investment is directed

[59] 'Studies on Sustainability Issues – Green Jobs; Trade and Labour', Final Report for the European Commission, DG Employment, 2011. Available at: http://www.camecon.com/EnergyEnvironment/EnergyEnvironmentEurope/ModellingCapability/E3ME/publications.aspx

towards new technologies, this is expected to lead to increased demand in higher skilled jobs (especially professional and associate professional ones).

The linkages between technology and skills requirements are described in depth in the same report for DG Employment. The broad trend that was found is that the development of new technologies (across the whole economy, not just energy efficiency or environmental products) can, at least initially, lead to higher demands for the more advanced skills groups and lower demands for lower-skilled workers. This is because the development of the new technologies typically requires high-skilled researchers, while the implementation of the new technologies may replace jobs in lower skills groups. In the long run labour markets will be able to respond to the changes in business environment but the short-run impacts during the adjustment period are likely to favour higher-skilled workers.

Implications for employment status

Most of the increase in employment will be accounted for by employees but there will be some increase in self-employment as well, especially as the construction sector has relatively high rates of self-employment. The modelling is not able to distinguish between employees and self-employed but, as noted in Chapter 7, the self-employed could provide a bottleneck in terms of skills, which would need to be addressed by policy.

5.5 Conclusions from the E3ME modelling

In this chapter we have presented the results from the modelling exercise carried out with E3ME. We have assessed the same set of scenarios as considered with the GEM-E3 model in Chapter 4, in which energy efficiency policies are implemented to achieve a reduction in primary energy consumption by 2030 of between 25% and 40%, compared to the reference scenario. In each case the energy system inputs were taken from the results of the PRIMES model, and E3ME was used to assess the economic and labour market impacts of the energy efficiency policies.

The more ambitious scenarios (EE35 and, in particular, EE40 – in which the energy savings are 35% and 40% respectively) were found to require very large shifts in economic resources to fund the investment measures. When modelling such large, systemic changes, it should be noted that there is a greater degree of uncertainty around the results, in particular whether there is adequate capacity available to produce the equipment. However, the results for the other scenarios may be considered more robust.

Economic impacts

The results suggest that the GDP impacts of implementing the energy-efficiency measures are positive in all the scenarios, when compared to the reference scenario. The largest increases in GDP occur after 2025, which is when the bulk of the additional investment is made. In most cases the impact on GDP is in the region of 1%, but the impacts could be larger in the more ambitious scenarios and around 5% in the EE40 case.

Employment impacts

The model results also suggest that total EU employment will increase in all the scenarios, especially after 2025. In the EE30 scenario, there are around 800,000 more jobs in the EU by 2030 compared to the reference scenario, an increase of 0.3%. This result is net, meaning that it takes into account changes across the whole economy, including supply chain effects and incorporating the reductions in employment in the energy sectors.

Most of these jobs will be created in the sectors that produce and install energy efficient equipment, consisting mainly of the construction and engineering sectors. Construction in particular is likely to benefit, as the installation of the many energy efficient goods and appliances is a labour-intensive process. The model results suggest almost 600,000 additional jobs in the EU's construction sector in the EE30 scenario by 2030.

There may also be higher employment in other parts of the economy. Supply chain effects suggest that employment in some of the basic manufacturing sectors (e.g. metals production) will increase, while the increased demand associated with a higher level of GDP could lead to jobs being created in the services sectors. Some sectors may see modest reductions in employment, however. If resources are diverted from household consumption towards investing in energy efficiency, output and employment may fall in other sectors (e.g. retailing). Employment in the energy extraction and distribution sectors is likely to fall, although these sectors are not typically large employers.

Impacts across Europe

The positive impacts are not spread evenly across Europe. Two clear patterns could be seen from the results at Member State level. First, the countries in which the most investment occurs receive the biggest stimulus to their domestic economies and have the largest efficiency gains. Second, countries that produce energy efficient equipment are in a stronger position to benefit.

Overall impacts on energy and labour intensity

Overall, the modelling results show that in the scenarios there is a higher level of economic production that is stimulated by reducing energy consumption. As energy efficiency increases the energy intensity of production falls, both at the sectoral and macroeconomic levels. Higher levels of economic production lead to higher employment levels as well, although by proportionately less. The scenarios therefore also include an increase in labour productivity.

Combining these findings suggests that the scenarios show an increase in overall productivity in Europe's economies, rather than just a shift from energy inputs to labour inputs.

6 Comparison of model results

6.1 Comparison of GEM-E3 results with E3ME results

Overview

The GEM-E3 and E3ME models were used to assess the same scenarios. As described in the report of a previous modelling exercise[60], there are important theoretical differences between these two models. E3ME is a macro-econometric model while GEM-E3 is a Computable General Equilibrium (CGE) model. The differences between the modelling approaches can be summarised by focusing on the assumption about optimisation:

- In the GEM-E3 model, following the standard assumptions of neoclassical economics, it is assumed that individuals and firms behave in an optimal manner. Markets are assumed to operate efficiently so that they achieve equilibrium (with the exception of the labour market in this model version). Total production levels are determined by supply constraints.
- In contrast, E3ME does not assume optimising behaviour, but bases its relationships instead on historical patterns. This means that there are unused resources available and that any policies that mobilise these resources by boosting economic demand could result in higher levels of production and employment.

The reference scenario and the EE policy scenario assumptions in the two models were set to be matched as closely as possible although, due to differences in model structure and classifications, it was not possibly to align the assumptions precisely[61].

This section compares the results from the two models and explains some of the key differences.

GDP

Table 6.1 presents the GDP results. There is one important difference and one important similarity in the two sets of model results.

The most obvious difference is that the GDP impacts are positive in the E3ME results, while they are negative in the GEM-E3 results. However, with the exception of the EE40 scenario (see Section 6.2 for a discussion of this), the impacts are quite small in both cases, so both models predict only a modest economic impact (up to +/- 0.1 percentage point on annual growth rates).

[60] See http://ec.europa.eu/energy/en/content/employment-effects-selected-scenarios-energy-roadmap-2050-0

[61] The assumptions cover population and GDP growth, structure of Member States' economies, ETS prices, power generation mix and corresponding impact on electricity prices, energy efficiency by sector and corresponding investment. Please refer to Section 5.3 for more information on how the assumptions were matched in E3ME.

Table 6.1: EU28 GDP, % difference from reference scenario, 2030

	E3ME	GEM-E3
Ref. scenario (€2010bn)	16,960	16,766
EE25	0.5	-0.07
EE28	0.8	-0.13
EE30	1.1	-0.22
EE32	1.3	-0.24
EE35	2.0	-0.52
EE40	4.4	-1.20

Sources: E3ME, GEM-E3 model results.

Components of GDP

To better understand these differences, we must consider the component parts of GDP. Table 6.2 and Table 6.3: present the results for investment and consumer expenditure.

In the E3ME scenarios there is a large increase in total investment, which is not matched in the GEM-E3 modelling. This partly reflects the scenario assumptions, but also the economic principles underlying the assumptions. In E3ME, the investment in energy efficiency is funded through public expenditure. Generally we see an increase in income taxes across most scenarios, both to pay for the investment and to compensate for the loss of ETS auction revenues that are the result of a lower ETS price. The income that would have been spent by households is instead diverted to investment in energy efficient equipment and, as a result, we see a fall in total household consumption and an increase in total investment. In the GEM-E3 modelling, investment by households replaces current consumption, but industrial investment in energy efficiency crowds out other economic investments due to the restrictions on available finance (see next section). Hence there is a much smaller increase in total investment and a smaller reduction in consumption.

Table 6.2: EU28 investment, % difference from reference scenario, 2030

	E3ME	GEM-E3
Ref. scenario (€2010bn)	3,945	3,370
EE25	1.5	0.07
EE28	3.6	0.16
EE30	5.9	0.40
EE32	8.1	0.44
EE35	13.8	0.53
EE40	32.2	0.51

Sources: E3ME, GEM-E3 model results.

Table 6.3: EU28 household expenditure, % difference from reference, 2030

	E3ME	GEM-E3
Ref. scenario (€2010bn)	9,535	10,112
EE25	0.2	-0.03
EE28	-0.2	-0.17
EE30	-0.6	-0.39
EE32	-1.0	-0.44
EE35	-2.0	-0.94
EE40	-4.8	-2.06

Sources: E3ME, GEM-E3 model results.

Employment

Table 6.4 compares the employment results. Both models show positive results, although with quite a big difference in the scale of the impacts.

In the E3ME results, the net (percentage) change in employment is roughly one-third that of the change in GDP. The GEM-E3 results show a strong increase in labour intensity in the EU economy (higher employment and lower GDP). The differences can be explained partly by the treatment of labour markets; in the version of GEM-E3 that was used, wages are inflexible and so higher demands for labour are met by increases in employment. In E3ME, wages are determined endogenously and so they increase to some extent. This lessens the increases in employment.

A further difference relates to substitution effects between inputs to production (capital, labour, energy, materials, etc.). In GEM-E3, there are higher interest rates in the policy scenarios so that there is no difference from reference scenario in the EU external current account balance (see Table 4.12). Higher interest rates increase the cost of capital relative to the other inputs and can therefore bring about substitution from capital to labour (and other inputs). This effect could lead to slightly higher employment levels in the GEM-E3 results at macro level. As the E3ME model does not force interest rates to rise in response to higher investment in energy efficiency its results do not include this effect.

Table 6.4: EU28 employment, % difference from reference scenario, 2030

	E3ME	GEM-E3
Ref. scenario (€2010bn)	231,728	218,760
EE25	0.2	0.50
EE28	0.3	1.47
EE30	0.3	1.90
EE32	0.4	2.02
EE35	0.6	2.53
EE40	1.5	2.96

Sources: E3ME, GEM-E3 model results.

Sectoral impacts

Table 6.5 summarises the impacts on sectoral output (production) in the EE25 scenario (the pattern is similar in the other scenarios). Although we do not have exactly comparable figures here in terms of the period over which results are reported, there is a very high degree of comparability between the results. The models both give a very strong message that the sectors that benefit are those that produce investment goods or are in their supply chains. The degree of consistency here is perhaps not surprising as the supply chains are represented by the input-output tables that are used in the same way in the two modelling approaches. The finding is therefore independent of the modelling approach applied and can certainly be considered robust.

As we can see from Table 6.5, agriculture is the only sector where the direction of impacts differs between the two models. This sector is linked to wider economic production levels rather than featuring as part of the supply chain for energy efficiency. E3ME shows positive impacts for agriculture because GDP increases while the GEM-E3 results are in line with lower GDP.

The sectoral pattern of employment impacts is also similar in both models. This is important when considering the likely skills requirements of the new jobs that are being created. If the available workforce does not possess the appropriate skills, then this could lead to smaller increases in employment. This is a particular example of the capacity issues that are described in the Section 6.2.

Table 6.5: Sectoral production, % difference from reference scenario, EE30 scenario – GEM-E3 for average 2015-2050, E3ME for 2030

	E3ME	GEM-E3
Agriculture	0.3	-0.61
Ferrous metals	1.9 (all metals)	2.45
Non-ferrous metals		1.63
Chemicals	1.2	0.47
Paper and pulp	0.7	0.29
Non-metallic minerals	5.5	3.53
Electric goods	3.4	0.63
Equipment goods	2.8	1.34
Consumer goods industries	0.9	0.39
Construction	7.6	2.37
Transport	0.8	1.05
Services	0.7	0.34
Energy extraction and supply	-6.2	-8.39

Sources: E3ME, GEM-E3 model results.

6.2 Capacity constraints and the 'optimal' level of energy efficiency

When interpreting the results from the models it is important to keep in mind potential capacity constraints. The constraints apply to the results from both models, but in different ways.

As it is a special case, we describe the labour market separately below and, due to the attention they currently receive in the academic literature, capital markets are also discussed separately. First, though, we set out the general position for the two models.

General position

As described in Section 6.1, the models differ in their assumptions about economic behaviour and this difference is reflected in the level of spare productive capacity in the economy. In GEM-E3 it is assumed that resources are used optimally[62] and so there is no spare capacity, while in E3ME there is the potential for spare capacity (although, as market conditions become tighter, there may be an increase in inflationary pressure).

Although economists often discuss the 'output gap' between actual and potential economic production, it is very difficult to estimate the size of the potential capacity available in the real world at any given time, and the capacity is, moreover, likely to vary between sectors. For the modest scenarios with small changes to output levels (see Table 6.5), it is reasonable to assume that spare capacity is available, but this assumption becomes more contentious in the more ambitious scenarios with larger changes in output levels, because of increased production in the sectors directly benefitting from the energy efficiency investment as well as the increased demand for the intermediate goods they use. In the results for the EE40 scenario, the changes in GDP should be viewed only as possible outcomes, which in reality could be impeded by many different economic bottlenecks.

Labour markets

One area where spare capacity can be measured explicitly is the labour market. Both models include involuntary unemployment and both show workers moving from the unemployed pool into paid employment in the scenarios.

Nevertheless, the treatment of labour market capacity in the two models is not the same. In GEM-E3, wage rates have been fixed (i.e. are inflexible) so that all of the increase in demand for labour is met by higher employment. In E3ME, wage rates may increase due to a tighter labour market, and this chokes off some of the labour demand so that the net increase in employment is smaller.

[62] Except for labour, see below. Also, because PRIMES results for the costs and energy savings of efficiency measures are used as inputs, any assumptions in PRIMES about the sub-optimal take-up of measures in the reference case, and hence the availability of low-cost opportunities to improve efficiency in the scenarios, are carried through into the modelling in both GEM-E3 and E3ME.

Skills constraints

Both models have a very limited disaggregation of the workforce. E3ME does not distinguish between different types of worker[63] while GEM-E3 has just two categories (high and low-skilled). Consequently, neither model is able to address adequately the possible issue of skills shortages in key sectors.

This too is likely to become an issue in the scenarios with larger changes in output and employment. Potential skills constraints are discussed in Chapter 7.

Capital markets

There has been much academic discussion recently about crowding out of capital markets; and the different treatment of crowding out remains a key distinction between CGE models and macro-econometric models such as E3ME[64]. In CGE models real investment may only increase if there is an equivalent reduction in consumption and increase in savings; otherwise other investment is ‘crowded out’.

The treatment in E3ME does not apply this restriction: it allows, for example, for increases in debt and the creation of money by the banking sector to finance fixed investment in new assets. Investment in new assets stimulates real economic activity and therefore produces growth of GDP and employment; it may be financed by debt and does not require a corresponding increase in savings outside the financial sector.

It should be noted that, although it is modelled differently in the two models, the treatment of the direct investment in energy efficiency is, in macroeconomic terms, quite similar in that it leads to either a displacement of other investment or an increase of financial savings in both models (i.e. no change in ‘net’ savings):

- In GEM-E3 much of the investment in energy efficiency displaces other investment; in households it leads to an increase in savings.
- In E3ME, by design the investment is mainly financed through an enforced increase in savings (because of increases in taxes on income that would otherwise be used for consumption).

The differences arise in secondary impacts. In E3ME there is some additional real-economy investment that does not provoke crowding out. Higher rates of output growth (GDP growth) in the scenarios can lead to additional investment that is not necessarily matched by a reduction in consumption. Whether or not this assumption is reasonable is likely to depend on the scale of the increase in investment compared with the reference scenario – if it is a small increase then it can draw upon unused financial resources in the economy but if it is substantial then the resources may not be available.

This difference shows up as a difference in the current account of the balance of payments. As described in Chapter 3, the GEM-E3 scenarios impose the requirement that the EU current account of the balance of payments is the

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[63] Additional modules created by IER that can be linked to E3ME can produce estimates of the skills and qualification mix based on E3ME’s results. However, this analysis is separate to the main modelling exercise and there is no feedback from skills requirements to the economy.

[64] Other macro-econometric models may enforce crowding out of capital.

same (as a percentage of GDP) as in the reference scenario, and it achieves this by varying interest rates until a match is achieved. There is no such restriction imposed in E3ME. But subsequent impacts on investment in E3ME lead, in part, to higher imports, whereas in GEM-E3 it leads to higher interest rates to choke off the higher investment.

The 'optimal' amount of investment for the economy

These factors combined make it difficult to answer the question of how much investment in energy efficiency to aim for as a policy goal. Current economic thinking suggests that the benefits of higher levels of investment will persist until capacity constraints are reached; beyond this point the effects of additional investment could be harmful to the economy as they divert resources from more productive use.

Neither modelling approach can provide a definitive answer to this question; in the CGE model the capacity constraints are already met in the baseline (with the exception of the labour market, see discussion in Chapter 4) while the constraints are implicit in E3ME and require some judgment from the model operator to assess whether the levels of annual investment implied by the most ambitious scenarios for energy efficiency would in practice be feasible without rapidly rising costs due to equipment or labour shortages.

Conclusions

In summary, we see both important similarities and differences in the modelling results. At aggregate level the models show conflicting (but small) GDP impacts, although the sectoral pattern of results is quite similar in the two models. Both models suggest that employment will increase as a result of shifts from production in energy-intensive sectors to labour-intensive sectors.

When we dig a bit deeper into the mechanisms in the models that drive these patterns in results, it becomes clear that it is important to consider possible capacity constraints when assessing the results from the scenarios with large changes in output and employment. This applies in particular to the economic results from E3ME, but also to the labour market results from both models, as they do not adequately cover potential skills bottlenecks.

In this light, the results from the EE40 scenario should be viewed with caution as there are also several other uncertainties in this scenario that are not addressed well by the models[65]. However, the outcomes for the more conservative scenarios may be considered much more robust.

[65] For example possible non-linearities or threshold effects.

7 Social and skills impacts

7.1 Introduction

This chapter examines the social impact of energy efficiency policies. It does this both by reviewing relevant literature and by using a number of case studies to consider in more depth the range of possible effects on:

- labour markets, with a focus on occupations and skills
- household income
- public health

and to identify possible good practice in managing and responding to these challenges. Following a section describing how the case studies were selected and developed, the chapter is organised in sections covering each of these three effects.

7.2 The purpose and selection of the case studies

Basic approach

Case studies serve to identify and showcase good practice examples of effective policy design that maximise the positive social impacts of investment in energy efficiency. The results complement and illustrate the modelling results and the data provided by the literature.

The case studies highlight good practice in promoting job creation and the social benefits of energy efficiency – with particular attention on identifying what worked (or not), and the transferable lessons for other types of activity, EU regions and sectors. In addition to concrete descriptions of actual initiatives, a succinct description of key challenges facing the country/sector has been provided to add a context to the policy developments and the associated findings.

The selection of the relevant case studies sought to identify examples where some qualitative research and assessment of energy efficiency policies, measures and programmes had been undertaken and from which lessons might be drawn. Besides the energy saving impact, special consideration was also given to the need for and supply of training to build on existing capacity or develop new skills, and to improve distributional outcomes, for example by targeting the energy poor.

Identification and selection of case studies

The initial identification of possible cases was based on consultation with a number of experts in the field, who provided recommendations and possible contacts with whom to further explore the possibility of case studies. This was followed by a preliminary screening of potential case studies based on an initial scoping of relevant national, local or sectoral policy initiatives and programmes. The objective was to identify energy efficiency policies and programmes that have as their underlying rationale and intended effects the promotion of positive social outcomes.

For this preliminary screening, case studies were selected considering the balance of several factors and criteria, such as:

- the geographical spread, so that all European regions would be represented
- the coverage of the identified key sectors
- the EE measures whose training that builds on existing capacity or develops new skills
- the countries with strategies or projects aimed at creating EE-related jobs and/or improving distributional or health outcomes
- the availability of existing information and evaluations

A long list of some 15 case studies was identified.

Multicriteria analysis for case study selection

A total of six case studies were shortlisted, based on a multi-criteria analysis. First, all projects identified were evaluated for the following criteria based on a scale from 0 (not applicable / not available) to 2 (highly relevant):

- information availability
- feasibility of the study
- relevance for jobs /skills & training[66]
- relevance for incomes / poverty[67]
- relevance for health / environment[68]
- relevance for energy savings
- stage, scale and identified contact points

Then both an average and a weighted average (where additional weight was granted to social impact variables) were calculated.

Case study methods

The case study research was based largely on desk research using available documentation, particularly existing evaluation material. In some cases this work was supported by consultations with relevant policy makers and industry stakeholders, as well as researchers where relevant.

7.3 Impacts of energy efficiency on the occupations and skills of the EU workforce

The analysis in Chapter 3 identified, using US data, the approximate demand for employment in the EU from the demand for energy efficiency goods and services of between approximately 0.9m (using a core definition) and 2.4m jobs (using a broad definition), in 2010. Most of these jobs are in manufacturing and construction (with the exception of public transport in the broad category).

Results of the modelling in this study (Chapter 6) indicate that, at the level of the EU, positive net changes in employment compared to baseline arise, increasing with more ambitious plans for the implementation of energy

[66] EE measures include training to build on existing capacity or to develop new skills.

[67] EE measures include actions to improve distributional outcomes / target the energy poor.

[68] EE measures include actions to improve health and local environmental outcomes.

efficiency measures. Since the method of projecting changes by occupation and hence skill needs are driven by sectoral changes, the modelling results do not imply large changes in employment by occupation and qualifications. However, the literature reporting on the effects on the demand for skills, indicates that there can be more substantial, particular effects at the local level, to meet particular demands or (in the case of job losses) because of a concentration of energy supply or energy-related employers.

As a context for the likely changes in the demand for skills we summarised here the current assessment of the energy saving potential across end-use sectors and Member States, adjusted to the nominal GDP of each country, to indicate where the potential is greatest, recognising the need of government action at national and local levels to respond to the identified opportunities.

7.3.1 Estimates of current energy savings potential

The need for skills as a result of investments in energy efficiency will be shaped by the type of energy savings opportunities and their distribution across the EU.

Analysis of the available database[69] on energy saving potential used to consider employment effects (in Chapter 3) can also be used to consider where the relative demands for related skills might arise, and which Member States might be expected to see a particular increase in demand.

Economically viable opportunities exist in a range of sectors. Current (2012) energy savings potentials in the EU are distributed by end-use sector as follows (with estimates of the growth in potential expected to 2020):

- Industry – 15% (112% growth)
- Buildings – 27% (120% growth)
- Appliances – 5% (263% growth)
- Transport – 53% (divided roughly equally between passenger and freight) (39% growth)

As previously noted, most of these opportunities translate into demand for goods and services produced primarily by the manufacturing sector but also construction and the professional services sector.

The need for skills driven by the demand for energy efficiency products can also be expected to vary between Member States, depending on their present levels of activity to address energy efficiency and current levels of inefficiency, and hence the remaining scale of energy savings potential.

For example, it is noted in the literature (see below) that there is a relatively greater opportunity for energy efficiency measures in Eastern Europe because of the age and condition of the building stock. Analysis of current energy

[69] The dataset is publicly available at: http://www.eepotential.eu/esd.php. The database provides estimates of energy saving potentials broken down by Member State and by sector, with projections to 2020 permitting the necessary level of analysis. This source provides a more detailed basis for the assessment of skills needs than is available from for example the Odyssee-Mure database: http://www.indicators.odyssee-mure.eu/energy-saving.html.

saving potential by end use sector by Member State, adjusted for national GDP provides one measure of the relative opportunities. Table 7.1 compares current (2012) energy saving potentials (tonne of oil equivalent, toe) per euro of GDP, between the EU15 and the EU13 (including Croatia). Appendix E provides the same analysis by Member State.

Table 7.1: Energy saving potential in 'old' and 'new' Member States (toe per €m GDP), 2012

	Industry	Buildings	Appliances	Transport	Total
EU28	1.2	2.1	0.4	4.1	7.8
EU15	1.1	1.9	0.4	4.0	7.4
EU13	2.3	4.3	0.6	5.8	12.8
Multiple	2.2	2.1	1.5	1.4	1.7

Notes: Multiple is the ratio of EU13 to EU15.

Sources: http://www.eepotential.eu/esd.php (accessed 22nd January 2015). Eurostat data are used for GDP.

The analysis indicates that the ranking of end-use sectors according to the potential for energy savings is similar in the EU15 and the EU13, but the potential savings are higher in the EU13: in the case of industry and buildings there are over twice the scale of opportunities in the EU13 compared to the EU15. This multiple is broadly the same across each of the EU13 countries, but generally higher in Bulgaria, Romania and the Baltic states, depending on the end-use. These multiples reflect to some degree the lack of current policy response and the related lack of investment resource.

Consequently, the change in the demand for the skills required to identify, undertake and, where relevant, operate energy saving technologies is expected to be greatest in the newer Member States, where the gap to be closed between current and potential energy efficiency levels is largest.

7.3.2 Results from the literature review – impacts at the aggregate labour market level

Previous studies carried out for the European Commission (Cambridge Econometrics et al, 2011, 2013) have shown that, at the aggregate level, the transition towards a low-carbon economy only has a modest impact on the demand for skills. From a skills perspective, transition does not constitute a separate policy challenge compared to other factors, like technological change and globalisation, in managing the demand for skills. In other words, whatever the EE investment scenario it is likely that existing trends in the occupational structure, and changing demand for skills, will remain relatively unchanged. Promotion of more rapid take-up of EE technologies can influence broader technological change and stimulate the demand for the required skilled workers but only at the margin of the workforce; however, the faster and more ambitious the change, the greater the likelihood that existing education and training systems will need support to adjust.

Some studies (Martinson et al, 2010; Colijn, B., 2014), using approaches based, respectively, on analyses of current skill levels in green occupations and hiring demands emanating from employers, found evidence that the greening of the economy (especially renewables) will benefit employees in middle-skill occupations.

Martinson et al identify increased demand for middle-skill occupations, which include energy auditors and installers. The 'middle-skill' occupations considered in the study and relating to energy efficiency include: mechanics, technicians, and electricians, i.e. jobs in occupations that require some postsecondary education (but not a university degree).

The study doesn't specifically make an economy wide comparison of the bipolarisation of skill structure, but it does suggest that both the 'Green Construction' and 'Manufacturing' sectors have fatter tails in terms of their skill spectrums, having a higher proportion of both high-skilled and low-skilled workers. Colijn (2014) suggests that a 'green' job focus on technical skills has a positive impact on medium-skilled workers and could counteract trends leading to the hollowing out of the medium-skilled group that the ICT revolution has started in Europe and the U.S.

Other studies based on quantitative modelling, including Cambridge Econometrics et al (2011) and the present study, conclude that EE policies will have limited effects on medium or less skilled groups (for example, clerks, operators and assemblers and labourers), with slightly greater effects on more highly skilled workers (for example, managers, engineers, business and computer professionals and technicians), at least in the short term. Over the longer term, when technologies mature, medium-skilled employees (e.g. maintenance workers) could be more sought after (Cambridge Econometrics et al, 2011). The literature has not sought to identify specific links of jobs resulting from energy efficiency with unemployment, or types of unemployment.

The greening of industries: an amplifying factor for the evolution of the demand for skills

An important message from Cedefop (2010) is that the systemic weaknesses currently observed in the skills base of European countries, notably the lack of availability of science, technology, engineering and mathematics [STEM] related skills, need to be addressed in the wider context of improving EU industrial competitiveness, but also in order to support the transition to a green economy reflecting the demand for skills driven by the introduction of newer green technologies. Manufacturing industries already highlight how the lack of STEM skills undermines their competitiveness[70].

STEM subjects are indeed of particular importance for green jobs because of their high technological content. This point has been made by numerous studies including Colijn (2013) who found that technical skills, resource management skills and complex problem-solving skills are highly relevant for green jobs. Cedefop (2010) concludes that in comparison to the above STEM related problem, shortages of 'new' green skills is an issue of lower policy importance.

[70] Orgalime & CEEMET (2012).

There are a few new occupations that will be created when implementing green policies. These are mainly high-skilled jobs related to: diagnosis, auditing and consulting; new technologies (measurement, metrology); and to organisation and coordination (optimisation of logistic chains, managers of major building projects) (Cedefop, 2010). More generally, however, a shift to a greener economy will tend rather more to contribute to the evolution of existing occupations (Cedefop, 2010; Cambridge Econometrics et al 2011); green skills will mainly be added to the existing skill set without substantially altering the job content.

The greening of the economy will translate into an increasing demand for generic skills, such as leadership, commercial understanding or management, and for generic green skills (e.g. ability to implement new environmental legislation, awareness of energy conservation measures). In certain sectors, it will also require the ability to apply existing technical skills within a green context (e.g. the ability of electricians in the construction sector to install solar energy technologies). Such transitions are feasible, at least in particular sectors, as illustrated by case studies carried out for the Cedefop study (2010). For example, it showed that the wind-turbine industry was recruiting workers with experience in shipbuilding and in the oil and gas sector for their skills in welding, surface treatment and outfitting.

Skills development is positively correlated with job quality (Cambridge Econometrics et al, 2011) and, indirectly, to higher income, better health, better career progression and higher general satisfaction with working life. In this context, Eurofound (2013) presented findings in which stakeholders reported that increased demand for additional qualification requirements and demand for training tend to be greater for employees working with green business practices than for the rest of the employees. Employees working with green business practices were said to receive better organised learning.

Another development, concerning in particular high-skilled non-manual and manual occupations, relates to an increased demand for multi-skilling (i.e. combining new environmental and conventional skill sets), cross-sectoral qualifications and interdisciplinary skills (Cedefop, 2010; Eurofound, 2013).

A recent EU conference[71] discussed the latest findings as identified by EU Member State employment services on the challenges of addressing the skill needs arising from ‘green growth’. A key conclusion was that there were few specific challenges because of the nature of green growth led employment; but rather that generic weaknesses affected education and training responses to all types of employment growth, including green growth. These challenges relate to, for example, the need for finer grained analysis of future skill needs at geographic as well as industry levels, coupled with improved forecasting and anticipation systems. The continuing issue of the lack of scientific, technical, engineering and mathematics skills and the need for more effective responses was also highlighted.

[71] Green Growth, Green Jobs: Integrating Environmental and Employment Policies in the EU, A symposium held in Brussels on Wednesday 17th June 2015.

In summary, the transition to a green economy, and specifically increased demand for goods and services to improve energy efficiency, is unlikely to represent a significant change in demand by occupation or the range of skills required; more importantly, general weaknesses such as the shortage of STEM skills, are more likely to represent a barrier to the take-up of energy efficiency measures.

7.3.3 Results from the literature review – impacts at the sectoral and local levels

Even though the introduction of green policy, including energy efficiency policy, is expected to have only a limited effect on skills when focussing at the aggregate level, there might be more noteworthy changes in demand at the sectoral level, or in particular regions or within specific occupations.

Sectoral skills impacts linked to employment effects

Cambridge Econometrics et al (2011) details how there are sectors which are expected to experience employment decline while others will gain employment. It states that the sectors which will lose from the introduction of environmental policy are energy production sectors which are dependent upon fossil fuels and energy-intensive industries. There are some similarities to the present study in which the energy production sectors are also affected negatively; however in Chapters 4-5 impacts on energy-intensive sectors are positive. For localities in Europe where fossil fuel energy producers are concentrated, specific geographic factors could present a major policy challenge. Employment gains will need to be made in industrial production related to energy conservation / renewable energy production, the renewable energy sector and services related to energy conservation (e.g. construction services, environmental services, etc.).

Cedefop (2013) also illustrated how the skills and employment impacts are likely to vary across Member States as a result of energy efficiency measures and highlighted, for example, the significance of the differences between Member States in the energy characteristics of their existing building stock. For example, as noted above, the central and eastern European countries have the least energy efficient buildings due to access to cheap energy at the time when most buildings were erected. (Eurofound, 2013) noted that the stance of public authorities will have an impact on the extent and speed with which the building stock is made more energy efficient, both through the public investments that they make and the building regulations that they issue, and these can be expected to vary between Member States. This impact will vary depending on the extent to which they call for higher standards or requirements with regards to, for example, retrofitting.

Sectoral skills impacts

Regardless of the employment impacts, all sectors will experience new skills demands. For instance, the aluminium and coal sectors which are vulnerable to restructuring still need to make investments in more energy efficient production systems, which will give rise to skill requirements (in installation and operation) for the existing workforce. Another example is the need for drivers in the road haulage industry to expand their skillset in order to save fuel by using telematics and adopting eco-driving (Cambridge Econometrics et al, 2011).

With the aim of assessing the impacts of the shift to a greener economy on the quality of jobs, including on skills development, Eurofound undertook a large-scale qualitative study in 2011/2012, entitled *Greening of industries in the EU: Anticipating and managing the effects on quantity and quality of jobs*. It covers ten target sectors: automotive, chemicals, construction, distribution and trade, energy, furniture, non-metallic materials, shipbuilding, textiles and transport and is based on results of an online survey, stakeholder interviews and 48 company case studies[72] which bring a qualitative insight into how companies are anticipating and managing greening effects.

The results of the study, summarised in Table 7.2, show that the sectors which will experience the highest skills impacts are the construction and energy sectors. The automotive, chemicals, distribution and trade, furniture and non-metallic materials sectors are also expected to be affected but to a lesser degree, while in the remaining sectors examined, skills effects are expected to be low.

Table 7.2: Summary of the impact on the quality of jobs of a shift to a greener economy

Sector	Type of impact
Construction	■ High impact ■ Move towards more skilled jobs (high demand for, for example, technicians and (associate) professionals) ■ High demand for recognition of green skills, training innovations (for example, on-site training of workers), interdisciplinary (especially in retrofitting) and generic green skills ■ Progress in green skills development is especially needed in SMEs and the relatively large informal construction sector
Energy	■ High impact ■ High demand for hard transferable skills such as STEM ■ Highest need for new skills in renewables ■ Lower impact in waste and gas subsectors
Automotive	■ Moderate impact due to strong sector resilience ■ High demand for highly skilled in EU15, for medium- to low-skilled in EU12 ■ Demand for interdisciplinary skills and multi-skilling ■ Highly skilled, especially in demand in emerging industries such as low carbon vehicle production
Chemicals	■ Moderate to high impact due to rather long period of greening of sector ■ Lower impact on pharmaceuticals sector, which is more driven by climate change adaptation
Distribution and trade	■ Moderate impact ■ Highest demand for transferable skills such as eco-product knowledge and understanding customers' needs ■ Likely loss of employment for low-skilled workers ■ High need for multiskilling
Furniture	■ Moderate impact ■ Most effects are on highly skilled
Non-metallic materials	■ Moderate to high impact ■ High demand for R&D staff

Sources: Eurofound (2013).

[72] The individual company case studies are available at:
http://eurofound.europa.eu/observatories/emcc/case-studies/the-greening-of-industries-in-the-eu

The analysis is based on extensive consultations with stakeholders and is supported by additional research examining similar sectoral skills issues. This research is referenced in the following discussion.

We summarise below the key findings from the literature for those sectors where impacts are expected to be high.

Construction

In the construction sector, which is expected to be a major source of both low-skilled and high-skilled job creation in the context of EE investment, there will be a demand for new skills at both the design and construction stages. Eurofound (2013) underlines how interviews with representatives from the European Construction Industry Confederation (FIEC) and the European Builders Confederation (EBC) confirm that greening of the construction sector leads to a movement towards more skilled jobs.

Eurofound (2013) find that new green skills required will include use of new materials and technologies, sustainable construction processes and energy efficiency adapted technical solutions, planning and management skills, including client counselling and advice to meet new market demands, design evaluation and calculation of carbon footprints (see also DTI, 2009). In addition, there will be an increased need for cross-cutting knowledge as retrofitting projects involve many different occupations and it is important to coordinate the different trades in order to guarantee good EE results (ILO, 2011).

The construction and refurbishment of more energy efficient buildings has been in progress for many years and further investment implies mainly an upgrading of the current skill set. Bird and Lawton (2009) pointed to a possible bottleneck here, simply because of the number of workers concerned requiring an upgrade to their skills, linked to the speed with which new requirements are introduced.

A lack of technicians, managers and operators with the adequate green skill set is reported in Eurofound (2013). A study by the Buildings Performance Institute Europe (2011) confirms that skill shortages exist in both the design and construction stages. It stresses that these shortages are identified as barriers that hinder the uptake of renovation measures and can even lead to unsatisfactory retrofits as reported by, amongst others, experts in Estonia, France and Ireland. Beyond the lack of knowledge and competence per se, the lack of focus on energy efficiency among building professionals was also reported to be an issue, e.g. in Norway.

Energy

In the energy sector, skills needs will relate to the acquisition of legislative and regulatory knowledge as well as technical knowledge and soft skills (social skills, problem-solving skills, self-management skills, entrepreneurship skills, management skills), as reported by Eurofound (2013) based on (TNO et al, 2009). STEM skills will also be highly sought after (Eurofound, 2013).

Automotive sector

In the green vehicle sector the main challenge relates to the combination of electrical and mechanical skills required in the production of electric or hybrid cars, with additional backward (e.g. production of batteries) and forward (maintenance, battery charging, etc.) linkages to take into account (UNEP, 2008). New and emerging green occupations include design, driver aids and emission control engineers, motor vehicle mechatronics technicians, automotive engineering technicians and automotive engineers (Cambridge Econometrics et al, 2011; Eurofound, 2013).

Chemicals Knowledge of environmental legislation and regulation as well as quality management and process-optimising skills are key for the sector. Other green skills such as green marketing and environmental communication, environmental impact assessment, life cycle analysis, ecology of products are also outlined, be it for managers, engineers, sales and marketing workers or supply chain managers. The pharmaceuticals subsector is not expected to experience so many skills changes as the environmental concerns are not yet a prime driver of the business. (Eurofound, 2013; TNO et al, 2009).

Non-metallic materials To meet the EE challenge, the employees in this sector need to increase both hard and soft skills. Important skills include legislative and technical knowledge (especially materials science, process and mining, health and safety, environmental and technical risk management) as well as social, problem-solving, flexibility, understanding and management skills. Providing economic prospects stay optimistic, R&D staff (for example, environmental engineers and agronomists working on technical solutions regarding energy efficiency and on developing sustainable products) will be highly sought after (Eurofound, 2013, TNO et al, 2009).

Actions taken by enterprises to manage the need for green skills

Eurofound (2013) concluded that companies tend to manage changes in the demand for green skills retrospectively, rather than anticipate them. Most enterprises were found to estimate future skills demands only a few years ahead based on their business strategy/plan or on an ad-hoc because of specific developments (e.g. opening of new facilities). There were a few examples of companies cooperating with partners (trade unions, associations, universities) in anticipating greening effects.

As far as the management of change is concerned, most companies favoured internal training activities. These training activities were either provided selectively as a one-off intervention or continuously through on-the-job training, and were often based on educational plans. Findings from case studies undertaken by GHK (2009) also confirmed that most companies engage in internal training activities, be it environmental training programmes to raise general skills and awareness levels or more technical training. Beyond internal training, Eurofound (2013) underlined how companies were also often collaborating with trade unions, business associations and education providers (vocational schools and universities) with regards to green skills development, e.g. to set apprenticeship or internship schemes.

In summary, skill shortages within certain sectors and locations are likely to represent a barrier to the adoption of environmental technologies (including for energy efficiency) and related goods and services. This will occur especially where there is lack of anticipation and planning (a particular problem where the change in demand takes place over a short period of time), where businesses tend not to undertake their own in-house training activity, and where wider stakeholders and social partners are not effectively engaged to promote changes in training planning and practices. Based on the sectoral review by Eurofound, and in the context of the range of end-use opportunities for energy efficiency, this problem is especially acute in the construction sector and to a lesser extent (reflecting substantial in-house training activity) the automotive sector.

7.4 Skills needs for energy efficiency and related policy responses

This section uses case studies to examine a number of specific skills needs for energy efficiency and examples of related national and local policy responses. It also examines the need for policy responses to provide support for skills that help to facilitate the articulation of demands for energy efficiency. Further details from the case studies are provided in Annex F.

7.4.1 Responding to the opportunities of new technologies for energy efficiency – Policy responses to challenges to the development of electric vehicles and related infrastructure

One of the key sectors investing in energy efficiency is transport. A major opportunity for improved energy efficiency is the production and use of electric vehicles. We summarise findings from the case study describing the developmental activity concerned, the need for skills and policy responses to meet these needs. Further details on all the case studies in this report are provided in Annex F.

Case study: Policies and initiatives for electric vehicles in the EU

Introduction

The use of electric vehicles (EVs) features in European policy due to the role that these technologies can play in achieving various targets around sustainability, climate change and CO_2 emissions. In 2010, the European Commission presented a strategy for clean and energy efficient vehicles (‘green vehicles’). Vehicles using alternative fuels, battery EVs and hydrogen fuel cell vehicles are included in this strategy. The strategy emphasises the need for research on electric cars to ensure their manufacture eventually becomes economically feasible and sustainable. Policies and initiatives on EVs, and electromobility more broadly, tend to focus on development and improvement of technologies and development of markets for EVs. Amongst the priority areas are issues regarding: battery life and reliability; building up the charging infrastructure; and, ensuring compatibility across Europe to allow for ease of movement. Activities concerned with the development and use of EVs in Europe are focused on reducing CO_2 emissions and meeting the 2020 and 2050 emission reduction targets. Other benefits associated with EVs which have been noted in various policy and project documents include: reduced traffic congestion; sustainability and reduced reliance on fossil fuels; and, reduced noise and vibration compared with road transport using internal combustion engines.

In developing electric vehicles, the OECD has drawn attention to the wide variety of actors who will be involved if there is to be substantial take-up of

EVs in the future[73]. The actors include, for example, electricity generators, vehicle manufacturers, producers and installers of rapid chargers, etc. To date, the role of public policy has been in large measure to stimulate R&D activities in relation to electric power chains and charging technologies[74]. These tend to bring together R&D institutions (e.g. universities) and business. In France, for example, The Vehicles of the Future programme has a €950m funding package aimed at supporting the development of innovative transport technologies. Clearly this generates a substantial demand for high level skills linked to, amongst other things, R&D specialists.

If the trend is a move away from the internal combustion engine to increasingly electrified power-trains, coupled with the move to the use of lighter materials this also creates a substantial demand for skills used in the production of electric vehicles / hybrid vehicles. An understanding of the specific skills needs resulting from moves to using increasingly electrified power-trains is increasingly becoming apparent. Higher level skills courses are emerging in the tertiary sector aimed specifically at electric vehicle technologies – for example, the Master's degree offered by the Paris Engineering Schools in Electric Vehicle Engineering[75]. The emphasis at the moment, however, is very much on policies aimed at the development of a mass market in electric vehicles and changes that need to take place in order for that to happen. To some extent, the emerging skill needs, especially at the level of the craft and related trades worker is, perhaps, less apparent at the moment. But as the German example below demonstrates, there is perhaps a need to concentrate on emerging skill needs at all levels if skills are not to act as a drag on the potential employment opportunities presented by electric vehicles.

National examples

Two examples have been identified in the case study (one national – Germany and one regional – the North East in the UK) of policy responses to the development needs of the sector:

- In Germany - the policy response has taken the form of the design and implementation of a relatively long-term strategy for development of the EV sector and market, as set out in the example of Germany. The longer term planning horizon allows for skills development to take place so that required skills are available and can be used to take advantage of and to support growth in the market. It also allows for other factors which may or may not already be in place to be put into place or improved, again to ensure that the strategy is being followed.
- In the UK North-East region - the policy response has been the use of demonstration projects to provide information to consumers and to address those concerns they have about the practicalities of using EVs. This project takes the up-front risk away from individuals/companies of purchasing a first EV without being sure of the benefits. The large-scale

[73] Stevens, B. and Schieb, P.A. (2013) *Developing Infrastructure for Alternative Transport Fuels and Power-trains to 2020/2030/2050: A Synthesis Report*. Paris: OECD International Futures Programme.

[74] Ministry of Ecology, Sustainable Development and Energy (2014) *The Energy Transition for Green Growth*. Paris: Ministère de l'Écologie, du Développement durable et de l'Énergie.

[75] http://www.enpc.fr/en/node/8470

data collection which took place alongside the trial (on CO_2 emissions from the EVs) as well as surveys of users are also strong features of the trial as this has allowed for a breadth of analysis about the impacts of EV use and indications of the implications that widespread uptake could have.

The automotive sector has proved to be an important source of output and skilled employment in the EU. It is likely that the consumption of EVs will increase in the future. It is important, therefore, that the technologies are developed in the EU. In this way the potential employment and skill gains that result from technical change are maximised in the EU, and the potential benefits that stem from the EU's knowledge base can be realised. This is important in the context of EU policy initiatives such as New Skills for New Jobs.

There are, however, significant risks attached to development of EVs for private firms, including those that relate to ensuring that the technologies are capable of being brought to market, and if they are brought to market that the skills are available that will allow the products to be produced in the EU. The pilot projects are important in this regard insofar as they simultaneously address the development of the technologies and, at the same time, ensure that the skills necessary for that development and the production of EVs are either in place and / or provide a roadmap to effectively developing those skills:

- In Germany, the strategy brought together various stakeholders not just to develop the technologies but to develop the skills base – or at least provide a roadmap for its development and certification – that will be essential if the production of EVs is to significantly increase. The lack of skills was clearly recognised as a potential constraint on being able to fully capitalise upon the development of EVs and ensure that production takes place without being hampered by a lack of skilled personnel;
- In the North-East of England the emphasis, in part, was on learning how to persuade drivers of the merits of eventually moving over to using EVs, (there is no point in scaling up production if potential consumers are potentially unwilling to move over to EVs). Establishing and then developing and maintaining the infrastructure that drivers are willing and able to use to allow EVs to operate is clearly a vitally important first step in facilitating the development of wider economic activity in the sector.

Conclusions

It is likely the future production of EVs will be geographically concentrated. It is also likely that the production will be concentrated in areas that are already heavily involved in vehicle manufacture. Whilst programmes are important in ensuring that EVs are developed and manufactured in the EU and that the skills base is in place to support that development and production, it is likely that the scope for developing similar pilot projects will be limited. This is not to suggest that such pilots are not important. To the contrary, they are important in ensuring that the production of EVs is not constrained by skill shortages. There is potential merit in looking at how the approach in Germany could be replicated in other areas that are dependent upon vehicle manufacture.

The example from the North East is also important in looking at how an EV infrastructure can be developed and drivers persuaded to move over to EVs.

This will be essential if the various economic and health benefits that potentially accrue from the diffusion of EVs is to be realised. The particular strength of the North East approach is that it could be rolled out almost anywhere in the EU. There is, therefore, considerable potential for policy makers to look at how more of these type of projects could be initiated across the EU. It also emphasises the importance of a wide range of stakeholders working in concert to ensure that EVs are used – car retailers, those providing the charging infrastructure, electricity providers, etc.

7.4.2 Responses to the need for changing occupational profiles and skills

The second key sector identified in the move to improve energy efficiency in buildings is the construction sector. Here there are particular issues with defining the evolving occupational profiles and associated need for training.

Two case studies have examined the responses to the changing demands for skills and the requirements for adjustments in both education and training systems, as well as within industrial sectors. These cases indicate the nature of the changing demand and the scope for policy led responses at the national (Spain) and local (Austria) levels.

Further details from the case studies are provided in Annex F.

Case study: BUILD UP Skills Spain – a national response to the need for new skills in the construction sector

It is estimated that between 25% and 35% of the Spanish construction workforce will need to be trained, or retrained, in Energy Efficiency (EE) and Renewable Energy (RE) matters in order to contribute to the achievement of Europe 2020 energy targets. Vocational training in the country did not fully address all relevant EE and RE requirements. The BUILD UP Skills project aimed to identify skills shortcomings and to plan for the improvement of the skills of construction workers.

In Phase 1, the programme identified nine key roles and developed detailed analysis of the competencies required as the basis of subsequent training programmes and related curriculums and educational materials for EE and RE training. As a result the National Institute for Qualifications is reviewing existing qualifications in terms of EE and RE, and related competencies are now to be included in professional occupational families.

The programme has also established a roadmap for the second phase of the programme, to 2020, setting out a clear plan of action to implement training and qualification reforms to ensure a response to the skills and training needs needed to achieve an energy performance of buildings aligned to the EU2020 targets, identified in Phase 1. The roadmap is detailed and comprehensive. It includes 29 actions and 11 recommendations with training measures and accompanying measures.

Training actions include the development of training courses and training itineraries for the priority professions, as well as e-learning platforms and multimedia educational resources. Accompanying measures and actions include a mechanism for monitoring skills needs and ensuring the quality assessment of training, the revision of professional qualifications profiles, retraining trainers, and campaigns for the general public to foster demand for a high energy performance in buildings.

Initial estimates have been calculated for the energy efficiency savings associated with the delivery of the BUILD UP Skills II training, and a better trained workforce. They suggest savings of 12,000 toe of primary energy per year and 26 thousand tonnes of CO_2 per year.

Case study: The Green Building Cluster of lower Austria – Eco-Plus – supporting a sectoral response to the need for the expansion of new methods and techniques in the buildings sector

The province of Lower Austria started to implement cluster initiatives in 2001, in the key strategic development sectors of the region. The aim of establishing clusters was to increase productivity, competitiveness and innovation in the Lower Austrian companies. This was to be achieved through scale effects such as improved division of labour, shared utilities and distribution channels, joint promotional activities and organised specialised trainings. In addition, spillover effects were expected such as know-how, new technologies and innovation. The Cluster initiative is funded through the Regional Innovation Strategy, part funded by EU regional development funds. The Green Building Cluster was a result of this initiative.

The launch of the clusters was based on an in-depth mapping study which analysed the importance and relevance of the sector for the regional economy and identified the main regional actors, existing collaborations and public support needs for the future. The construction sector has been traditionally one of the economic strengths of Lower Austria, with almost 10% of green jobs in Austria located in the construction sector. It is also estimated that by 2020 up to 10% of the workforce in Austria would work in green industries.

The cluster aims to strengthen the sustainable building sector in Lower Austria. The majority of the cluster members are companies, R&D and educational institutions, organisations, and administrative bodies; 87% of the cluster companies are SMEs.

The programme connects construction and building professionals with researchers to foster their competencies in the areas of sustainable building and living, and is expected to have an impact not only on the innovation capacity of Lower Austrian companies in the sector but also on energy savings in buildings and on the generation of new green jobs in the construction sector and related professions. A key focus of the Green Buildings Cluster has been the development of skills, with more than 500 professionals (representing cluster members as well as non-cluster members) trained in new technologies to reduce energy consumption of buildings including master builders, carpenters, architects, planners, site managers, heating and plumbing professionals and energy and building consultants.

As well as the refurbishment of old buildings the cluster, members are active in the construction of nearly zero energy houses according to standards in the EU Buildings Directive, mainly detached and semi-detached houses. The building standard results in ultra-low energy buildings which require little energy for space heating or cooling. In 2009, passive homes represented only 5% of new buildings built in Lower Austria. Currently the development of passive houses has reached a market share of some 20% to 25% of new built houses.

The cluster initiative provides lessons on how to foster capacity building and development of competencies by providing training within the cluster and enabling an environment for collaboration between companies, R&D institutions and funders.

Summary of lessons from the case studies

The two cases (although different in scale) provide lessons for other policy makers seeking to address the lack of skills limiting the deployment of energy efficient technologies and related goods and services:

1. Ensure agency responsibility for clearly defining the skills needs that are being generated, and ensuring that these are likely to remain unsatisfied with current systems; and that the scale of demand justifies the changes needed in education and training systems and related costs.

2. Research is required to achieve the necessary definition and assessment of skills needs and training requirements (and possibly qualification reforms), based on detailed stakeholder consultation and utilising wherever possible existing networks of businesses and training providers. This research has to give sufficient weight to the technologies and technological development giving rise to the new demands.

3. Ensure that intermediary bodies and agencies with an influence over design and delivery are engaged and collaborate, and that ‘training for the trainers’ is built into the delivery of the programme.

7.4.3 Responses to the need to encourage the demand for energy efficiency measures

- The previous sub-sections have summarised examples of current Member State practice in targeting the development of skills in two key sectors providing goods and services for energy efficiency. The following two case studies (in Germany and the UK, see Annex F for fuller descriptions) indicate current EU practice to stimulate the demand for energy efficiency measures, providing information and advice and financial incentive for energy users to take-up measures, enabling suppliers to invest in skills development. In so doing the measures address a range of market failures, especially information failures preventing rational decisions and limiting investment in energy efficiency.

Case study: Make your home fit! – a national programme but with local delivery designed to support domestic awareness and the demand for energy efficiency measures

Germany is the biggest energy user in Europe. In order to reduce the consumption of energy the Government has implemented an ambitious energy saving program, aiming for a 30% reduction in energy usage by 2020.

In this context, special attention was paid to the building and construction sector, which is its largest energy consumer.

The official government body created to promote energy saving and renewable technologies is the Deutsche Energie Agentur (DENA). It provides advocacy and technical advice to drive energy efficiency at national level. It works with independent regional agencies to deliver specific projects. The DENA sets out standards, and regional agencies implement them and pass on the expertise to regional building organisations and professionals. Hence, the main purpose of the DENA is to link government subsidy programmes to promote energy efficiency and market-oriented activities to spread the take-up of energy efficiency and renewable technologies. One of the most relevant projects implemented was the campaign 'Make your home fit!' which targeted an area with above average unfit houses relative to latest standards to reduce energy consumption of buildings in the district of Hamelin-Pyrmont.

The campaign provided free of charge saving and information advice to local communities in order to reduce the energy consumption of buildings. It started in October 2011 and was offered to all cities and municipalities of the district of Hamelin-Pyrmont. The local energy agency together with cities and municipalities identified one or more neighbourhoods with a high number of one and two-family homes built before 1960, not in line with the current standards on energy efficiency. The total target group accounted for 34,300 one and two family houses, of whom 10,300 households were reached through the information campaign carried out in the local media. Approximately 3,500 households have been directly reached through the information and advice campaign. Of these about 1,400 have been informed individually through door-to-door advice.

During the first year of the campaign, 70% of households reached through the campaign were reported to have carried out energy efficient renovation activities or were in the process of doing so, while 16% of households were planning to carry out the work within the next two years. Only 14% of households did not take any action.

The campaign required an additional ten energy advisers hired by the local energy agency. The subsequent investment, triggered by the campaign has had a positive impact on employment in building refurbishment services in the area. The measures implemented through this campaign are estimated to have reduced the annual demand for heating energy by approximately 2.4m kWh, which corresponds to an annual saving of 570 tonnes of CO_2.

Case Study: The ENWORKS 'Embedding Resource Efficiency in Key Sectors' (EREIKS) project – a regional programme to support industrial sectors to identify and invest in resource efficient measures

This project (with a budget of approximately €10m over the project period 2009 – 2013) provided business support in the form of technical audits and advice to companies in the North West of England between October 2009 and 2013. It was established in order to address a range of market failures which lead to under-investment in resource efficiency. The key objective was to create a regional programme to cover the full spectrum of environmental impacts generated by a business – from the products it makes, through to the processes it uses and the waste it generates.

More specifically the project was designed to improve the competitiveness and productivity of companies in the region (focusing on priority sectors and high growth and high environmental impact companies), by reducing their exposure to environmental risk and improving their resource efficiency.

Selected businesses received up to four days of technical advice paid for by the programme, examining the products and processes of identified businesses. This included audits of various resource uses, and identification of key actions / investment cost that could result in resource savings. Payback periods were indicated where costings had been provided. Businesses that wished to implement identified savings measures were advised on possible suppliers but were required to finance the costs themselves.

Key features of the project were:

- That the initial contact was made with selected advisors operating at local (County) level and therefore have a good understanding of both the business base, and the resource efficiency issues faced by businesses. They are also in a position to propose and assess technical advisors selected and paid for by the programme
- The operation of a resource efficiency toolkit that can provide benchmarks and monitoring of proposed and achieved resource savings.

The purpose of the project was to provide support to firms in the region to assist them to identify resource efficiency measures and to develop implementation plans. Improving the supply side (auditing and advisory services) was not a primary aim of the project (reflecting the long-established industrial base and related technical knowledge) but of the €10m project funding, approximately 80% (€8m) was spent on business advisors supporting the retention and development of this professional service.

The project resulted in savings of 320,000 tonnes of CO_2e[76]. The project assisted firms to implement an average of €22,500 in cost savings, producing an additional economic impact for the region of €20m of GVA.

Business assistance leveraged an additional €20m of capital spend on implementation. This activity realised 23% of identified resource efficiency improvement opportunities. If further identified opportunities were implemented this could result in a further €65m of capital expenditure on implementation of resource opportunities. This would provide opportunities for suppliers in the region.

The programme has operated in the region since 2001, supported by EU regional development funds and related matched funding. The programme has been subject to regular evaluations by different evaluators, and has demonstrated a high level of cost-effectiveness.

[76] No estimate of energy savings is provided, but if would likely be in the range 1,100-1,700 GWh, depending on the fuel mix.

The emphasis has been placed on the information failures that prevent businesses from establishing the range of resource saving potentials, through targeted technical audit and advice. Given high paybacks, it is not considered cost-effective to provide direct grant finance for investment measures; although a high share of resource savings remain unrealised (due in part because of long payback periods). Comparison with other UK regional programmes suggests it has one of the highest levels of value for money. The collection of data over the various programmes has provided the basis of advice to national government on the costs and benefits of resource efficiency programmes.

The project has benefited from the continuity achieved from the well-established regional basis of the programme grounded in the participation of local actors well versed with the industrial base and related resource efficiency issues, and with the necessary technical knowledge, reflecting the long-established industrial base. This means that whilst the programme design is easily replicable, it will take time to achieve similar levels of effectiveness as the necessary industry networks and advisory services are built up.

Summary of lessons from the case studies

The two cases provide lessons for other policy makers seeking to address information failures limiting energy efficiency:

1. Clearly define the target actors (e.g. certain types of household, business) and their information needs.

2. Clearly establish the nature and detail of information failure and the required support necessary to stimulate behavioural change.

3. Provide free information through well trained advisors, using established agencies and networks.

7.5 Impacts of energy efficiency on income and fuel poverty

This section examines the effects of improved energy efficiency on household income and fuel poverty. The evidence of the effects of energy saving on household incomes available from the literature is summarised, followed by an econometric analysis of the distributional effects of increased energy efficiency. The section is completed with a brief case study analysis of a national Member State response to fuel poverty, with further detail provided in Annex F. This case study complements the material available from the EU Fuel Poverty Network Site[77] and the EU ManageEnergy project[78]

7.5.1 Results of the literature review

Effects on income and energy use

When improved energy efficiency leads to a reduction in energy bills, there are monetary savings that translate into increased disposable income. This applies across all income levels and for firms and individuals. How this surplus

[77] http://fuelpoverty.eu/

[78] http://www.managenergy.net/casestudies.html

disposable income is spent will have an impact on the overall effectiveness of energy efficiency programmes in reducing total energy use. Should the surplus disposable income be saved or spent on less energy-intensive activities than the activity of generating the energy saved, then overall energy savings will be positive. However, should the surplus income be spent on more energy-intensive activities either by increasing demand for energy (e.g. increasing the temperature in a building or increasing production capacity) or spending the surplus income on additional goods and services (e.g. by going on holiday or hiring additional employees), total energy use may not fall by much. This is the rebound effect discussed in Section 2.4.

Factors determining how additional disposable income is spent, and hence the size of the rebound effect, for individuals include: original income level; demographics; personal preferences; behavioural factors; education; availability of information; and the substitutive options available. Similarly, a number of drivers determine firms' investment decisions such as: financial situation; knowledge of energy efficiency potential; commitment to the environment; public and market demands; and regulatory obligations (OECD/IEA, 2012).

The transition to a low carbon economy also has the potential to lead to an increase in incomes, due to increased productivity as a result of resource efficiency innovations.

A recent review of fuel poverty in the UK by the Centre for Analysis of Social Exclusion for the Hill Review of Fuel Poverty (CASE, 2012)[79] developed a framework for defining full poverty. This focused directly on the overlap of high costs and low income. The framework contains twin indicators: a Low Income High Costs indicator (which measures the extent of the problem) and the fuel poverty gap (which measures its depth).

Under the first indicator, households are considered fuel poor if:

- they have required fuel costs that are above the median level
- were they to spend that amount they would be left with a residual income below the official poverty line

The number of individuals in this position should be counted as well as the number of households they live in.

The second indicator is of the depth of fuel poverty as represented by the average and aggregate fuel poverty gap, defined as the amounts by which the assessed energy needs of fuel poor households exceed the threshold for reasonable costs.

Effects on fuel poverty

Energy efficiency measures can have redistributive and poverty alleviating effects. The issue of energy affordability is both a cause and a symptom of poverty. Faced with high energy prices and financial limitations, the poor are often unable to afford enough energy to maintain healthy living conditions – a situation known as fuel poverty. Exacerbating this, the poor are more likely to live in inefficient housing than those on higher incomes, further increasing

[79] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48299/4664-exec-summary-fuel-pov-final-rpt.pdf

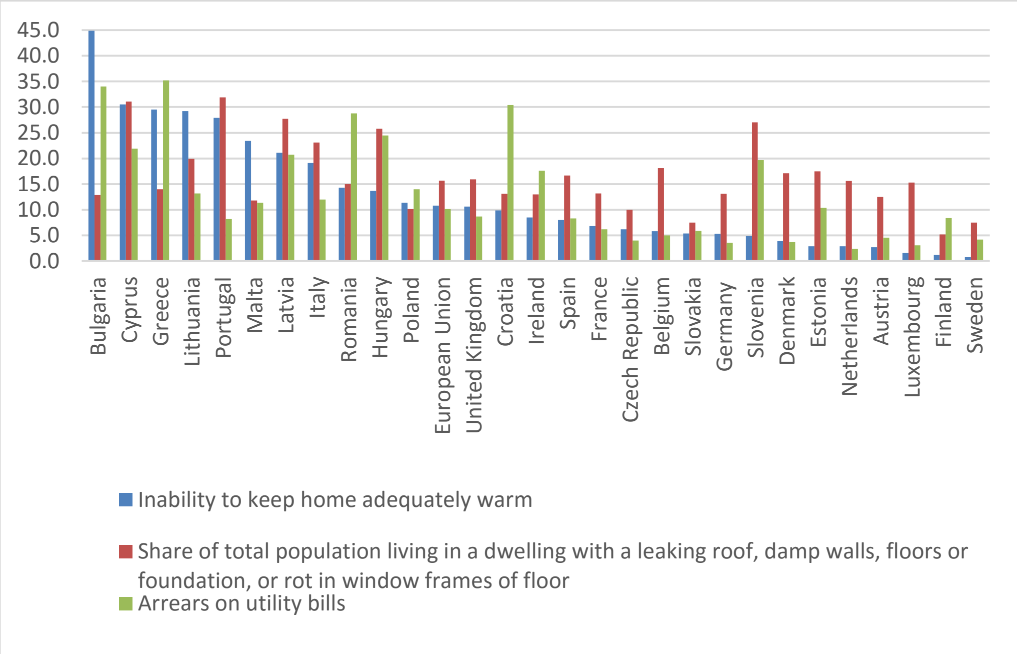
their energy costs. It is estimated that between 50m and 125m Europeans are currently fuel poor (OECD/IEA, 2012).

According to EU Statistics on Income and Living Conditions (EU-SILC) data, the share of the total EU population with the ‘inability to keep home adequately warm’ is 10.8% in 2013. It had declined from 12.3% in 2005 (the first year of available data) to 9.3% in 2009, before increasing again in recent years.

The issue of fuel poverty is not confined to member states with colder climates – in fact, the countries with the highest share of the population that cannot keep their homes adequately warm are Bulgaria (44.9%), Cyprus (30.5%) and Greece (29.5%), while Sweden (0.8%) and Finland (1.2%) have the lowest. Rather, the incidence of fuel poverty is more closely (negatively) correlated with average household incomes, with a correlation coefficient of -0.54.

Figure 7.1 shows the incidence of fuel poverty across Europe, as measured by inability to keep home adequately warm, and two other related indicators.

Figure 7.1: Incidence of fuel poverty across the EU



Sources: EU-SILC.

Related maps are available from the EU Fuel Poverty Network (op cit).

Fuel poverty results from a combination of three factors: low household income; poor heating and insulation standards; and high energy prices. Investment in the energy efficiency of homes reduces fuel poverty by addressing the second of these factors and offsetting to some extent the adverse effect of high energy prices. Work in the UK for the Hill Review of Fuel Poverty (CASE, 2012) examined the cost-effectiveness of various policies to reduce fuel poverty. The benefits of policy options, each with a budget of £500 million (€700m), spanning the three key drivers of prices, income and energy efficiency were assessed.

The analysis indicates that policies to improve the thermal efficiency of the housing stock, targeted on those with low incomes and with energy-inefficient homes would be most effective at reducing the level of fuel poverty. These polices would have very substantial net societal benefits in relation to cost, particularly when their distributional impact is allowed for.

7.5.2 E3ME results on the distributional impacts of energy efficiency measures

The following section summarises the EE household distribution results for the EE30 policy scenario. The first part of the section outlines the E3ME methodology in estimating distributional impacts. The second part of this section looks at the distributional results.

E3ME treatment of distributional income

E3ME's model of household distributional effects is relatively basic, and identifies income quintiles and some specific socio-economic groups, as defined by the Eurostat data.

The E3ME approach is based on two components. The first of these is the income component. For each social group, the shares of their income from wages, benefits and other income (minus their tax deductions) are scaled in line with the aggregate model results for wages and welfare benefit payments, and so forth. This means that a scenario that includes increases in benefit rates would show positive results for low-income groups who rely more on benefits. The second part links household expenditure survey data[80] to the model results for consumer prices by category of consumption. This is mainly used to assess the effects of higher energy prices, as in many countries low-income households use a larger share of their incomes for space heating. A rise in energy costs would therefore reduce their real incomes disproportionately.

It is important to note that the analysis of household distributional effects described above sits outside the main modelling framework, as the time-series data required to estimate econometric equations are not available. This means that there is no feedback from the distributional analysis to aggregate household expenditure.

Limitations of this approach

There are many limitations to this approach, reflecting the available data. These include the following:

- It is not possible to estimate different responses to higher energy costs among the groups. For example, it is often suggested that high-income households have access to finance to pay for energy efficient equipment, which could be reflected by a higher price elasticity.
- It is not possible to consider how changes in wage rates affect particular social groups. For example, there is no linkage between sectoral employment and the social groups, and it is not possible to address differences in wages within sectors.

[80] From the Living Conditions and Welfare section of the Population and Social Conditions branch of the Eurostat database.

- The approach cannot address heterogeneity in the groups. For example, model results suggest that higher costs for motor fuels often affect low-income households less, as they are less likely to own a car. But low-income households that do have cars will still be affected.

In summary, the results should be considered carefully in the context of the scenarios modelled and at times perhaps viewed with caution. Nevertheless, the approach is able to give at least an indication of the type of distributional effects expected, possibly suggesting grounds for further analysis with a dedicated tool.

E3ME distributional results

Figure 7.2 and Figure 7.3 present the impact on household income by quintile[81] and other socio-economic group in the EE30 scenario in 2030. The implementation of EE measures appears to have a negative impact on real incomes across all quintiles and socio-economic groups. The reason for this result is not the EE measures themselves, but the way in which the investment in EE is financed. As discussed in Chapter 5, income taxes are increased to pay for investment in new equipment. The increase in income taxes leads to a decrease in incomes and the savings households make from improved energy efficiency are not enough to compensate for the increase in taxation. Generally the impact of the financing method is small and evenly spread across quintiles and socio-economic groups.

Real incomes in Latvia, Lithuania and Hungary are the worst affected by the EE financing measures, with the impact evenly spread across quintiles and socio-economic groups. In all three countries the ratio of EE investment to GDP is among the highest, so they are expected to see higher increases in income taxes to pay for the investment (reflecting the PRIMES model results, see Chapter 4). The pattern is consistent across all Member States; those that make the most investment are financing it at the expense of household incomes.

The unemployed and retired are the most affected in Sweden in the EE30 scenario because of indirect price effects. Changes in consumer prices can affect socio-economic groups differently, depending on their expenditure patterns (i.e. consumption basket). A relatively small change in the price of consumer goods can have disparate affects across different socio-economic groups, depending on the weight the respective good has in the groups' consumption basket. A similar issue can be seen in fifth quintile in Poland.

When considering different policies, it is important to consider the indirect affects these policies may have on different socio-economic groups. If the structure of the consumption basket varies considerably across groups within a country, it is likely that different policies can have disparate affects across the groups. For example, lower income groups will spend a larger share of their income on necessities (e.g. food) compared to more well-off groups, so any policies that affect the prices of these necessary goods will have a greater impact on the lower income groups compared to those with higher incomes.

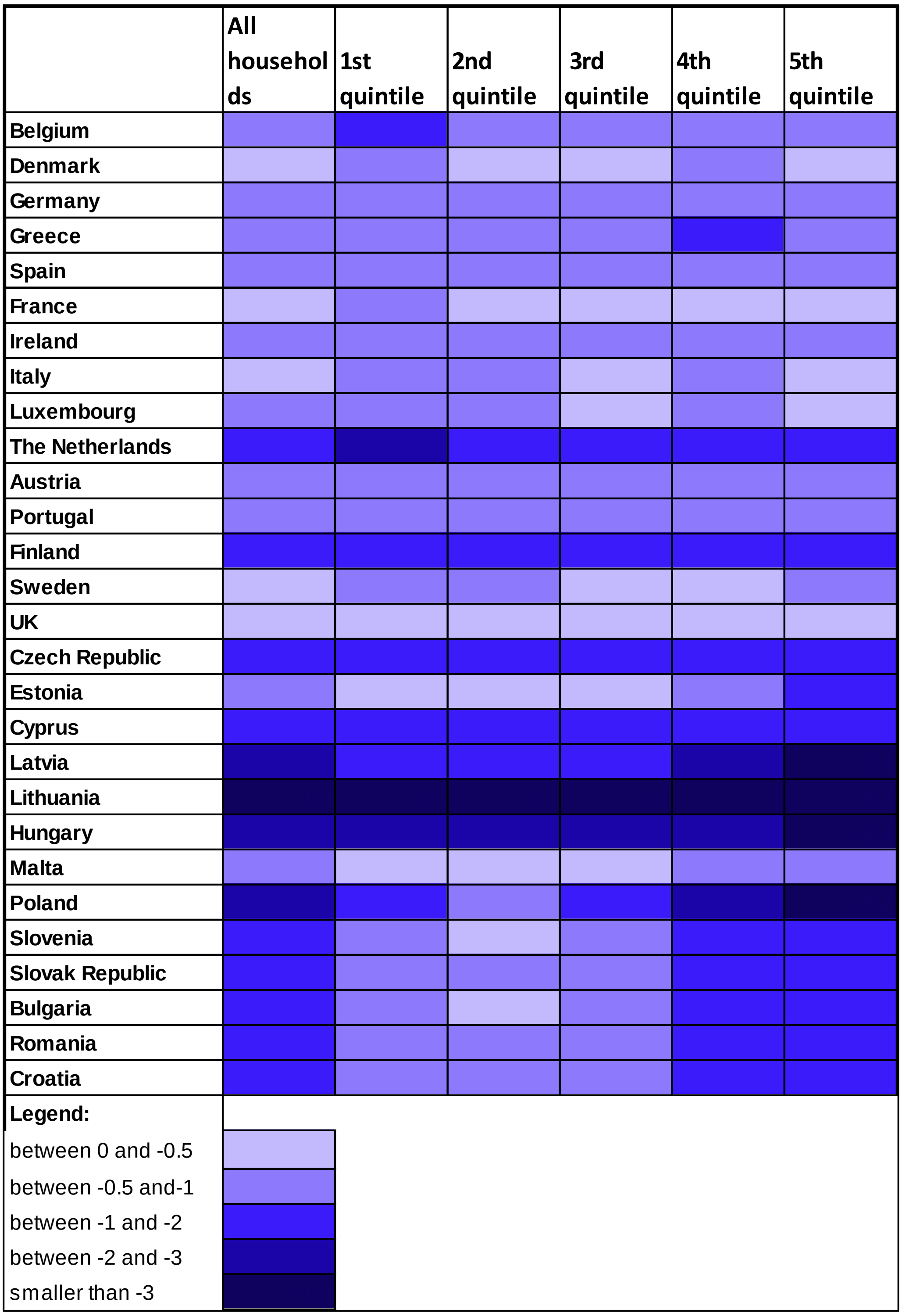
Welfare implications

However, as noted in Chapter 4, real monetary incomes and household consumption cannot be used as adequate proxies of welfare in these

[81] The first quintile is the lowest income groups and the fifth quintile those with highest incomes.

scenarios. Although incomes may be lower, expenditure on heating bills will also fall by households that have implemented energy savings measures (i.e. necessary outgoings as well as income will be reduced) and the welfare benefits of this are not included in the figures below. The distributional effects of lower required spending on energy depend on how the energy efficiency measures are implemented; if they are targeted at low-income households then the outcome could be progressive overall.

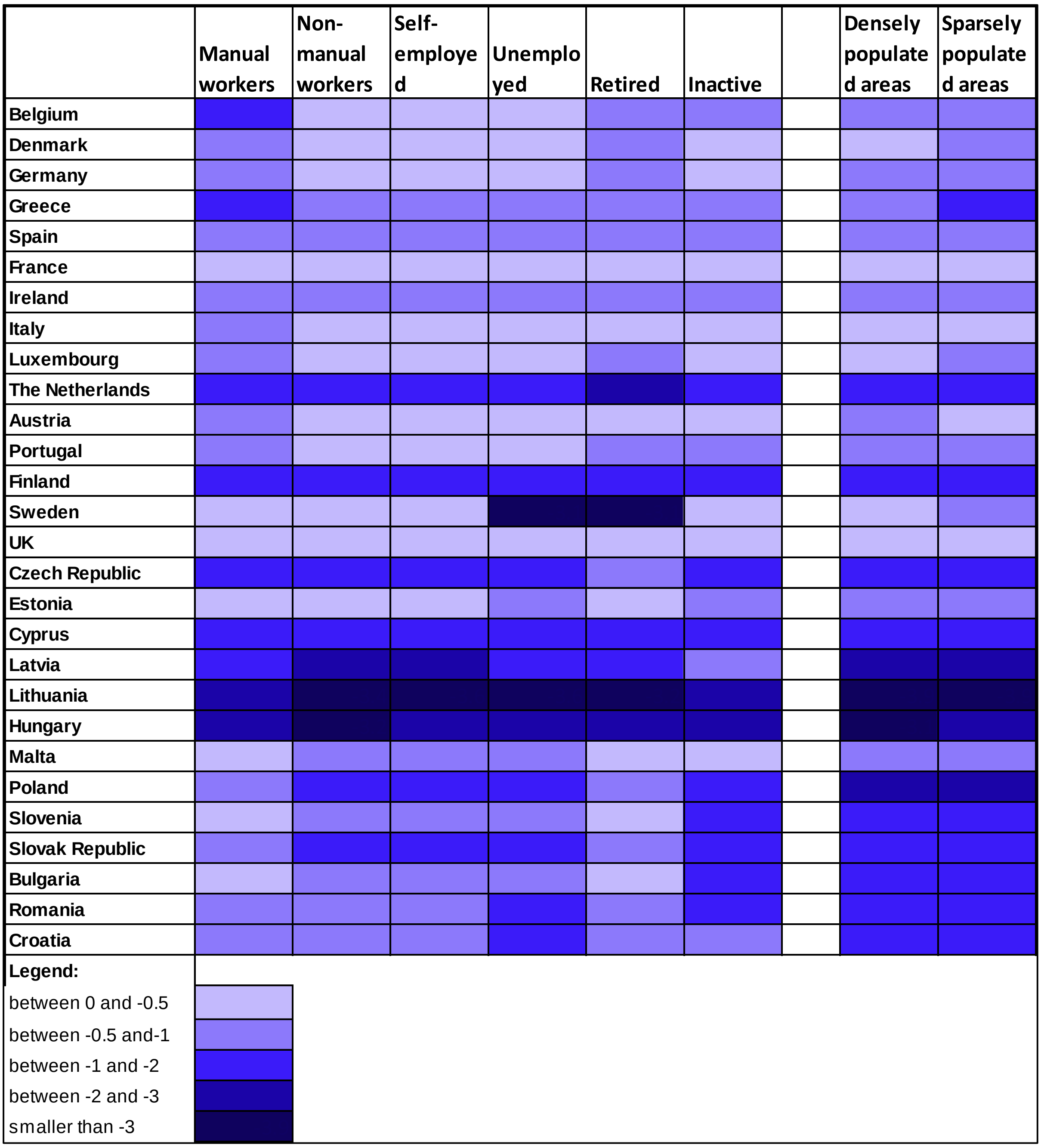
Figure 7.2: Impact on household incomes by income quintile, EE30, % difference from baseline, 2030



Notes: 1st quintile is the lowest income households, 5th quintile the highest income households.

Sources: E3ME, Cambridge Econometrics.

Figure 7.3: Impact on household incomes by socio-economic group, EE30, % difference from baseline, 2030



Notes: Manual and non-manual workers refer to the type of job held by the head of household. Inactive includes households where the head of house does not participate in the labour market. The final two columns separate urban and rural households.

Sources: E3ME, Cambridge Econometrics.

7.5.3 Case Study – Impacts of energy efficiency on income: Improving energy efficiency in low-income households and communities in Romania

To illustrate the nature of the scale of the problem in some Member States and the scope to address fuel poverty and to improve incomes in low-income households, a significant national programme has been identified, from which some lessons might be learnt. We summarise the main features here, and Annex F provides further details.

The building sector in Romania accounts for 36% of final energy consumption and around one-third of CO_2 emissions (2007). The vast majority of residential units are in serious disrepair despite being owner-occupied. This is a problem which is especially severe for low-income households. Further complications arise as new construction, especially in rural areas, tend to use energy inefficient materials and apply 'Do-It-Yourself' (DIY) projects, which are unlikely to be energy efficient.

The existing energy inefficiencies in the District Heating systems, and more generally in the building sector, alongside the slow pace of building turnover result in high energy consumption and wastage and a need for large quantities of expensive fuel (especially natural gas and oil) to be imported. High levels of energy consumption and costs have significant effects on fuel poverty. Many Romanian households are not able to afford to adequately heat their homes in winter. In 2008, nearly 15% of families in Romania struggled to pay their heating bills. This figure is likely to have risen with the planned removal of District Heating subsidies.

In response, the 'Improving Energy Efficiency in Low-Income Households and Communities programme', funded by a UNDP-GEF grant of €2.5m and €100m of other funding, was introduced in 2011 with completion due in 2015. This is a national programme, with local pilot projects, and it seeks to remove barriers to the implementation of improvements in the energy performance of buildings, especially with respect to households which may be classified as being in fuel poverty. Activities to date include the establishment of an Inter-Organisational Working Group to coordinate activities and policies and to facilitate dissemination of information and good practice; grants for the retrofitting of social buildings; installation of more efficient heating systems in pilot areas; and building capacity for implementation of energy efficiency measures in poorer regions over the short and medium terms (e.g. through training of energy auditors and architects).

The programme, as reported in its mid-term evaluation, has resulted in the thermal rehabilitation of seven social buildings in two counties with benefits to 1,000 people, and subsidised the installation of biomass fuelled central boilers in another eleven buildings. Capacity building has also taken place through training programmes.

The wider activity of the programme is reported to have benefited so far some 160,000 people in Romania now living in more energy efficient apartment blocks with lower heating bills, well in excess of the planned target of 110,000 people.

Without further information on outcomes and progress on key indicators to date, which one would expect to have in the project's Mid-Term Evaluation, it is difficult to assess how effective the project is and to conclude anything about value for money.

However, our own research suggests that particular strengths of this project include:

- It is a national level programme, with substantial funding and cross government support.
- Inter-organisational cooperation.
- Capacity building, with an emphasis on increasing local skills and dissemination of information which should enable further energy savings and reductions in emissions in the future as well as employment opportunities with the expansion of the market for EE materials and buildings (GEF has indicated that this project will help to ensure there is capacity in the public sector and communities to take advantage of financing for EE that is generally available).
- Targeting of groups who are at highest risk of being in fuel poverty.

Weaknesses include:

- Overall, the unavailability of documentation regarding measureable outcomes and progress on the project is a shortcoming of the project.
- There appears to be some delay in production of evaluation reports or at least in the publication of these – this may suggest that the overall timetable of the project has incurred delays.
- The overall outcome of fuel poverty is not being directly measured though it is useful that the project has involved an assessment and recommendations of how to best measure fuel poverty – it would be helpful to have the before and after figures for fuel poverty indicated on the basis of the recommendations of the assessment report.

7.6 Impacts of energy efficiency on health

7.6.1 Results of the literature review

The benefits of energy efficient homes go beyond simple carbon emissions and energy security arguments; energy efficiency can improve health and well-being, particularly of vulnerable residents (Verco and CE, 2014). Energy efficiency measures aim to reduce the amount of energy needed to heat a home, making it more affordable. Given the evidence linking cold homes to poor health, it follows that energy efficiency measures should have a positive impact on health.

The direct health impacts of living in a cold home can be divided into higher risk of mortality and increased morbidity rates. There is a longstanding body of evidence describing the relationship between higher mortality rates in winter and cold temperatures as well as higher morbidity rates. Fuel poverty and lack of adequate heating is also detrimental to mental health, through the financial stress that it causes to households (Marmot Review, 2011).

The main health conditions associated with cold housing are circulatory diseases, respiratory problems and mental ill-health. Other conditions influenced or exacerbated by cold housing include the common flu and cold, as well as arthritis and rheumatisms. For a detailed review of the literature linking cold homes to poor health see the Marmot Review (2011) and Maidment et al. (2014).

Higher morbidity rates naturally lead to increased mortality rates. Across Europe there were an estimated 250,000 excess winter deaths annually. Of these, an estimated 30% are directly related to cold housing (WHO, 2011).

Living in a cold home also has adverse mental health effects, increasing anxiety and depression. A study by Shelter (2006) shows that children living in cold homes are more likely to have mental health problems and experience delayed cognitive development, while children living in cold homes were five times more likely to be unhappy in their family than those living in warm homes (Marmot Review, 2011). More than a quarter (28%) of young people living in cold homes exhibited four or more negative mental health symptoms, compared to just 4 percent of young people who had always lived in warm homes (Marmot Review, 2011). Similar mental health effects are observed in adults. Evidence from the evaluation of the Warm Front Programme found that receiving a Warm Front package is associated with significantly better mental health. The study showed that as average bedroom temperature rose, the chances of occupants avoiding depression increased. Residents with bedroom temperatures at 21°C are 50% less likely to suffer depression and anxiety than those with temperatures of 15°C (Green and Gilbertson, 2008).

There may also be negative health impacts associated with energy efficiency measures. The Warm Front Programme showed that a majority of participants suffering from respiratory problems reported improvements in breathing, however a small but significant proportion felt that the new heating systems aggravated their chest conditions (Green and Gilbertson, 2008). Moreover, insufficient ventilation in increasingly airtight houses may lead to increased levels of indoor pollutants such as radon, carbon monoxide, nitrogen dioxide, and formaldehyde, and the higher relative humidity might promote growth of mould and dust mites, which are implicated in the development and worsening of asthma (Bone et al, 2010). Risk of overheating in heatwave conditions, caused by an over-insulation, is a further concern.

Maidment et al (2014) conducted a meta-analysis of the impact of energy efficiency measures on health, synthesising research from 36 primary research studies with a combined sample of over 36,000 participants. A small but significant and positive effect of household energy efficiency measures on health was found. The health impacts were positive for each of the interventions and all of the population subgroups analysed. Moreover, significant health benefits were identified for children in particular, as well as those with existing health conditions and vulnerable groups in general, supporting the continued use of household energy efficiency improvements to tackle fuel poverty and reduce health inequalities, rather than purely as a tool for carbon reduction.

In addition to the health benefits from domestic energy efficiency measures which alleviate the effects of fuel poverty and lack of adequate heating, there are wider benefits from reduced air pollution and emissions. Air pollution from transport and power generation contributes to a range of respiratory and cardiovascular diseases. The WHO estimates that these factors alone are responsible for 2.6m deaths annually (WHO, 2011). Consequently, energy efficiency measures aimed at reducing emissions from vehicles through improved technologies or a shift to more efficient modes of transport will reduce health risks associated with air pollution for the local population. In addition, reducing the demand for energy will also reduce emissions from fossil-fuel burning plants (OECD/IEA, 2012).

7.7 Conclusions from the review of literature and evidence

The review presented above has indicated the scope for future energy savings, by end-use sector and Member State. These potential savings represent the opportunity to deliver improvements in competitiveness because of lower industrial energy costs, social benefits in the form of lower household energy costs and higher effective real incomes, and health benefits from the affordability of warmer homes, and reduced climate related damage.

The expansion of economic activity to exploit this potential and deliver these benefits is likely to be constrained by:

- the lack of practical information on the use and effectiveness of new technologies and techniques, for example because of various information failures in industry or households, or because of the novelty of the technology (electric vehicles)
- the lack of demand for information from energy users (domestic and non-domestic) on ways to reduce energy
- the lack of business managers and production and construction workers with the necessary skills to apply both new and established techniques for energy efficiency, reducing the capacity to deliver, at commercial scale, energy saving measures

These benefits and problems are reasonably well documented (if not always clearly quantified), and apply to the introduction of new technologies, especially low carbon technologies, and to the scale-up of more mature but viable solutions (such as insulating existing buildings).

The policy responses reviewed in the case studies indicate the scope and effectiveness of these measures, which all bear replication in other locations or sectors. Three groups of responses can be identified:

- Sector Development – in the case of new technologies which represent major changes in both behaviour and the use of new goods and services, long-term strategic approaches need to developed, in which measures are taken to raise awareness of the new technology, test behavioural responses and trial the use of new systems.

- Raising awareness of energy saving potential – information failures are difficult to solve. The case studies demonstrate how awareness raising and targeted technical advice can address these failures and stimulate investment in the take-up of new and existing techniques for energy saving. These measures are often highly cost-effective, not requiring any major capital expenditure but leveraging private expenditure.
- Ensuring sufficient skills and productive capacity are in place – to deliver the required goods and services. As previously reported by Cedefop and Eurofound, the lack of skills is on the one hand tied to wider weaknesses in the education and training system (for example the lack of STEM skills) and on the other reflects largely incremental change to existing occupational profiles. Policy responses based on clear needs assessment combined with sufficient planning to facilitate the necessary institutional changes in training and qualification systems are emerging in different sectors and locations. These demonstrate the feasibility of well-structured measures based especially on broad and effective stakeholder engagement.

  These responses have been developed through national programmes, with local delivery, and through more specific regional and local initiatives (aided by EU regional programmes). Especially relating to skills issues, it is important to consider geographical location, as displaced workers from sectors that contract due to energy policy will provide a potential workforce for new or expanding industries.

8 Conclusions and Recommendations

In this study we have assessed the direct and indirect linkages between energy efficiency, labour markets and social welfare at both the micro and the macro levels. We have used a mixture of qualitative and quantitative approaches to carry out the analysis and considered both gross and net impacts. The following sections highlight the key conclusions and recommendations in the report.

8.1 Evaluation of the labour market and social impacts of the implementation of energy efficiency policies at European and national scale

The number of jobs currently associated with energy efficiency activities

It is not straightforward to estimate the number of jobs in Europe in ‘energy efficiency’, because the classifications used for economic and employment statistics do not identify this either as a distinct sector (into which firms can be allocated) or as a distinct set of occupations (to which workers can be allocated). This problem is not unique to energy efficiency: the same difficulty has in the past been encountered in attempts to assess of the number of ‘green’ jobs, ‘high-tech’, ‘creative’, or ‘tourism’ jobs, to name just a few examples of themes that are not readily identifiable in economic statistics.

Defining and measuring jobs in energy efficiency

The EU Energy Efficiency Directive (EED) 2012/27/EC defines energy efficiency as ‘the ratio of output of performance, service, goods or energy, to input of energy’. In principle, the aim is to count jobs in any activity that develops technologies to improve energy efficiency, or promotes or implements take-up of those technologies, or promotes changes in behaviour that improve energy efficiency. In practice it is seldom possible to identify whether, for example, construction workers (or particular occupations within the construction industry) are engaged in (say) making buildings more energy efficient.

Constructing estimates of energy efficiency jobs in the EU

In the absence of data for the EU that identify firms and workers engaged in energy efficiency activities, we have drawn on US sources to make estimates. The method estimates the share of employment in each sector of the US economy that is related to energy efficiency activities and then applies these shares to the size of employment in each sector in the EU.

When the scope is restricted to the provision of products and services that are mainly purchased for the purpose of improving energy efficiency, the estimated number of jobs in the EU in 2010 is some 0.9m. When the scope is expanded to include also products and services that have the potential for energy savings but which are not purchased primarily for that purpose, the estimated number of jobs in the EU in 2010 is 2.4m (approximately 1% of total EU employment). Separately, the number of jobs in the EU in which workers are mainly engaged in achieving greater energy efficiency in their own establishments is estimated at 0.8m in 2010.

The economic benefits of energy efficiency

Our review of the literature has identified that investment in energy efficiency is likely to:

- Lead to net employment generation given that energy efficiency activity is more labour intensive (and less capital intensive) than the production of energy saved. Per million euros of spend, investment in energy efficiency could create up to double the number of jobs as investment in new energy generation.
- Lead to employment benefits as a result of the export potential of energy efficiency activities and/or from the substitution of imported energy.
- Increase building values and rentals as a consequence of improved energy efficiency. US data suggest that values of buildings with certified energy performance are 10-16% higher than similar non-certified buildings.

The number of jobs that could be created by greater take-up of energy efficiency technologies and practices

We have also reviewed and reported estimates of the number of jobs that would be created per unit of energy saved by the adoption of various energy-saving technologies or per unit of spending on such technologies, which can be used as a rule of thumb for estimating employment impacts of greater take-up of technologies. These ratios typically provide ‘net’ impacts: recognising the scale of associated job losses in energy supply implicit in the ratio depends on what is assumed for which fuels are displaced. The ratios also typically exclude ‘indirect’ jobs created in the supply chain and ‘induced’ jobs (sustained by the spending of the incomes earned in direct and indirect jobs).

Application of macroeconomic modelling to estimate economic and employment impacts to 2030

A fuller analysis of these employment effects was carried out using two macroeconomic models to estimate the impacts of various levels of ambition in energy efficiency across the EU in the period up to 2030. One of the models, GEM-E3, is a CGE model based on neoclassical economic theory, while the other, E3ME, is a macro-econometric model with a post-Keynesian theoretical basis.

Both models found that setting a fairly ambitious energy efficiency target for Europe (achieving 30% higher energy efficiency in 2030 than in the reference scenario[82]) would have a modest impact on **GDP**: a difference compared to the reference case of -0.2% (GEM-E3) to 1.1% (E3ME) of GDP in 2030[83]. The modelling results indicated that still more ambitious targets could have an even larger impact, but the greater scale of change that these targets involve is associated with greater uncertainty about the scale of impact.

While the differences in results for GDP impact between the two models were not large (slightly negative or slightly positive), they show that estimates of the qualitative nature of the impact depend on underlying assumptions about how the economy works. E3ME allows for the possibility of spare economic capacity that can be taken up when aggregate demand is boosted (e.g. by replacing spending on fuel imports with spending on domestic production), while GEM-E3 assumes that the starting point is an equilibrium in which resources (except for labour) are already fully employed. Consequently, in

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[82] The reference scenario already includes improvements in energy efficiency compared with today’s levels, driven in part by the implementation of agreed policies to 2020.

[83] This compares to a range of 0.3% to 1.3% found in previous studies, although the time periods and scale of energy efficiency adopted in these studies can be quite different (see Chapter 2).

E3ME spending on energy efficiency programmes can lead to higher demand and GDP, but in GEM-E3 this spending tends to crowd out (rather than add to) other spending.

In the case of **employment**, both models predict an increase in response to more ambitious energy efficiency programmes. In GEM-E3 this comes as the result of a shift from energy-intensive to labour-intensive production methods. In E3ME there is also the effect of the higher levels of overall activity (GDP). Involuntary unemployment falls as a result. The range of impacts on EU employment between the two models in the 30% higher energy efficiency scenario (difference in 2030 compared with the reference scenario) is 0.3% (E3ME) to 1.9% (GEM-E3).

Sectoral impacts

While the precise sectoral impacts vary somewhat between the results of the two macroeconomic models, there is agreement that the sectors that see the largest net increase in output and employment are those that produce investment goods or are in the supply chains for investment goods: construction, equipment and electrical goods, metals and non-metallic mineral products. As expected, the sectors from which output and employment are displaced are in energy extraction and supply (and, by extension, imports of energy products into the EU).

Differences by Member State

Generally, Member States with a large share of energy efficiency investment in GDP (generally new Member States such as the Baltics, Poland, Hungary and the Czech Republic, but also Finland and the Netherlands) and/or with large investment goods sectors (e.g. construction in Italy and Greece) are expected to see the largest increases in employment, particularly if the level of productivity in those sectors is relatively low. However, countries (such as France, Austria and Portugal) with economies focused more towards consumer goods and services are likely to see smaller increases in employment

Social impacts

Effects on fuel poverty

Energy efficiency measures can have redistributive and poverty alleviating effects. The issue of energy affordability is both a cause and a symptom of poverty. The poor are often unable to afford enough energy to maintain healthy living conditions and are more likely to live in energy inefficient housing than those on higher incomes. Concern over the potential impact on poor households has in the past served as a counter-argument to the objective of raising the price of carbon-based fuels.

The issue of fuel poverty is not confined to Member States with colder climates – in fact, the countries with the highest share of the population that cannot keep their homes adequately warm are Bulgaria, Cyprus and Greece, while Sweden and Finland have the lowest. Rather, the incidence of fuel poverty is more closely (negatively) correlated with average household incomes.

Consequently, investment programmes that improve the energy efficiency of homes offer a clear route to tackling fuel poverty, provided that obstacles to implementation (access to finance for poor households; a way to incentivise landlords to implement improvements to privately-rented dwellings) can be overcome.

Effects on health

There is a longstanding body of evidence describing the relationship between higher mortality rates in winter and cold temperatures as well as higher morbidity rates. The main health conditions associated with cold housing are circulatory diseases, respiratory problems and mental ill-health. Other conditions influenced or exacerbated by cold housing include the common flu and cold, as well as arthritis and rheumatisms.

Living in a cold home also has adverse mental health effects, increasing anxiety and depression, exacerbated by the stress associated with financial difficulty in paying bills. Children living in cold homes are more likely to have mental health problems and experience delayed cognitive development.

A meta-analysis[84] of the impact of energy efficiency measures on health, synthesising research from 36 primary research studies, found a small but significant and positive effect of household energy efficiency measures on health, with significant health benefits for children in particular.

In addition to the health benefits from domestic energy efficiency measures which alleviate the effects of fuel poverty and lack of adequate heating, there are wider benefits from reduced air pollution and emissions. Air pollution from transport and power generation contributes to a range of respiratory and cardiovascular diseases. Consequently, energy efficiency measures aimed at reducing emissions from vehicles through improved technologies or a shift to more efficient modes of transport will reduce health risks associated with air pollution for the local population. In addition, reducing the demand for energy will also reduce emissions from fossil-fuel burning plants.

Evaluation tool

The project has delivered a separate Excel 'ready-reckoner' tool to allow employment estimates to be made by Member State and for specific sectors.

8.2 Identification of the skills that are needed to implement large-scale energy efficiency programmes

A reinforcement of existing trends toward higher skills…

Transition to a more energy efficient economy does not constitute a separate skills policy challenge compared to other factors, like technological change and globalisation. Within reasonable limits regarding the scale of ambition for implementing energy efficiency measures, it is likely that existing trends in the occupational structure, and changing demand for skills, will not be shifted much, but there can be impacts at the margin and in particular areas.

The particular skills and occupations for which higher demand is likely are mainly high-skilled jobs related to: diagnosis, auditing and consulting; new technologies (measurement, metrology); and to organisation and coordination (optimisation of logistic chains, managers of major building projects).

… notably STEM skills…

As for 'green jobs' in general, science, technology, engineering and mathematics (STEM) subjects are of particular importance because of the high technological content of at least some of the required occupations. STEM skills are an important foundation for the technical skills, resource

[84] Maidment et al (2014).

management skills and complex problem-solving skills that at least some of the jobs in energy efficiency (and other green jobs) require, and the most important impact of the transition (from the point of view of skills policy) is likely to be in exacerbating skills shortages in STEM subjects, rather than in stimulating demand for ‘new’ skills.

…and generic skills…

More generally, to facilitate adaptation to change, there is expected to be an increasing demand for generic skills, such as leadership, commercial understanding or management, and for generic green skills (e.g. ability to implement new environmental legislation, awareness of energy conservation measures). In certain sectors, it will also require the ability to apply existing technical skills to different technologies.

…with particular impacts in the sectors that supply technology and which install the energy efficiency measures

Analysis of the gaps between current levels of efficiency of energy use and the technical potential suggests that the opportunities are greatest in transport and buildings, and to a lesser extent in industry, which points to greater demand for the occupations involved in the identification and implementation of measures and in the development of equipment in the supply chain.

In the *construction* sector, which is expected to be a major source of both low-skilled and high-skilled job creation in the context of energy efficiency investment, there will be a demand for new skills including use of new materials and technologies, sustainable construction processes and energy efficiency adapted technical solutions, planning and management skills, including client counselling and advice to meet new market demands, design evaluation and calculation of carbon footprint.

In the green *automotive vehicles* sector the main challenge relates to the combination of electrical and mechanical skills required in the production of electric or hybrid cars, with additional backward (e.g. production of batteries) and forward (maintenance, battery charging, etc.) linkages to take into account. New and emerging green occupations include design, driver aids and emission control engineers, motor vehicle mechatronics technicians, automotive engineering technicians and automotive engineers.

The *non-metallic minerals* sector requires skills including legislative and technical knowledge (especially materials science, process and mining, health and safety, environmental and technical risk management) as well as social, problem-solving, flexibility, understanding and management skills.

The skills gap is likely to be greatest in countries where the technical potential for energy savings is greatest

The same kind of gap analysis indicates that the opportunities are generally greater in the newer Member States (notably Bulgaria, Romania and the Baltic states), and considerably greater in buildings and industry. Consequently, if finance for the investment can be mobilised, the change in the demand for the skills required to identify, undertake and, where relevant, operate energy saving technologies is likely to be greatest in these Member States, where the gap to be closed between current and potential energy efficiency levels is largest. Precisely because previous implementation has not been strong, existing skills in implementation are likely to be less well developed.

8.3 Recommendations

- The empirical basis for assessing the employment impacts of energy efficiency investment in the EU is limited, with no available data at the EU level based on agreed definitions. As with previous challenges associated with the measurement of employment in the production of environmental goods and services, an ESTAT led initiative (perhaps with OECD given the work in the USA) to formalise definitions and data collection systems should be considered.
- The macroeconomic benefits of meeting more ambitious energy efficiency targets will be maximised if the new technologies are produced within the EU. A key sector in this respect is automotive vehicles, which should be a priority for policies to promote innovation, strengthen skills and, in the case of technologies that represent a radical change from the internal combustion engine, encourage consumer take-up.
- The goal of promoting energy efficiency on a substantial scale reinforces the priority of actions to improve the supply of workers with STEM skills from school and vocational education.
- Because of the importance of opportunities for energy saving in buildings, the biggest impact on employment is expected to be in construction. The fragmented nature of the industry and its high level of self-employment, particularly in the field of housing renovation, make it particularly difficult to target for engagement in skills improvement programmes. The quality of services available in this sector could therefore represent a significant bottleneck to the take-up of energy efficiency measures, and this should be targeted by the industry’s training bodies. Experience from the best examples of existing programmes (including the development of new competencies and qualifications, and cluster initiatives with sharing of resources and learning) should be diffused more widely.
- The largest potential for energy savings lies in the newer Member States. If policies to close the gap in the level of energy efficiency between these countries and the rest of the EU are to be successful, the STEM and housing renovation skills issues need to be addressed particularly in these countries.
- Take-up of energy saving opportunities tends to be weakest among users with limited resources to acquire the necessary information and for whom energy bills are not so high that they overcome inertia to change. This is most obvious in the case of the household use of energy for space heating and hot water, but also in the information failures amongst industrial users of energy, especially smaller businesses. Case studies demonstrate how awareness-raising and targeted technical advice can address these failures and stimulate investment in the take-up of new and existing techniques for energy saving. These measures are often highly cost-effective, not requiring any major capital expenditure but leveraging private expenditure.
- Achieving higher levels of energy efficiency in the homes occupied by poor households offers an important route to improving welfare and health. It

also helps to overcome an important social and political obstacle to the use of higher prices as an instrument for curbing energy consumption. Since the required work is usually labour-intensive, investment programmes will also create jobs in the localities where the funds are spent. Policies to tackle the financial and institutional obstacles (especially the landlord-tenant problem) to improving the energy properties of these homes should be given priority given their relatively high cost-benefit ratio compared to other measures targeting energy prices or incomes.

- There is a need for continued EU funding of national and sub-national programmes to provide the initial stimulus and to facilitate replication and modification, recognising that although programmes need to reflect local context and circumstance, there is sufficient common interest and core activity to make use of the demonstration of approaches identified in each case study. Given that energy saving opportunities, social needs and the funding resources available are greatest in the newer Member States, European Structural Investment Funds (ESIF) provide a critical dimension to the policy response.