REVIEW OF COSTS AND BENEFITS OF ENERGY SAVINGS

Task 1 Report 'Energy Savings 2030'

Prepared by:
Institute for European Environmental Policy (IEEP)
15 Queen Anne's Gate
London
SW1H 9BU
United Kingdom

May 2013

Disclaimer: The arguments expressed in this report are solely those of the authors, and do not reflect the opinion of any other party.

The report should be cited as follows: Sauter, R., Volkery, A. (2013) Review of costs and benefits of energy savings, A report by the Institute for European Environmental Policy (IEEP) for the Coalition of Energy Savings. Task 1 Report. Brussels. 2013

Institute for European Environmental Policy
London Office
15 Queen Anne's Gate
London, SW1H 9BU
Tel: +44 (0) 20 7799 2244
Fax: +44 (0) 20 7799 2600

Brussels Office
Quai au Foin, 55
Hooikaai 55
B- 1000 Brussels
Tel: +32 (0) 2738 7482
Fax: +32 (0) 2732 4004

The **Institute for European Environmental Policy (IEEP)** is an independent not-for-profit institute. IEEP undertakes work for external sponsors in a range of policy areas. We also have our own research programmes and produce the Manual of European Environmental Policy (http://www.europeanenvironmentalpolicy.eu). For further information about IEEP, see our website at http://www.ieep.eu or contact any staff member.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

Europe sits on a huge untapped economic potential for energy savings. Despite recent progress on EU energy efficiency policy, markets are still lacking a concrete, comprehensive and coherent policy framework to guide long-term action. While the EU 2020 climate and energy package successfully set binding targets for renewable energy sources and greenhouse gas emissions it failed to set a binding target for energy savings. Instead only an energy savings objective of 20% (as compared to baseline projections) was agreed.

End of March 2013 the European Commission launched a public consultation on a 2030 framework for climate and energy policies. The consultation constitutes a critical moment to ensure that energy efficiency receives the necessary central anchoring in the future EU climate and energy policy framework.

Given the current weak economic performance, large fiscal debts and growing unemployment rates in many Member States, a post 2020 climate and energy policy framework will be assessed against its impact on economic performance and employment. There is a lot of empirical evidence that energy savings measures often provide an effective, cost-efficient approach to reducing greenhouse gas emissions, while generating co-benefits on employment and competiveness. Long-term market prospects for energy-efficient products, processes and services are stable in the context of a growing global population and increasing resource demand. EU companies perform well in terms of global market share and competitiveness. Energy savings hence need to be the central backbone of the 2030 policy framework.

This report is the first report of the 'Energy Savings 2030'-project which seeks to help the Coalition for Energy Savings to produce a robust and timely input to the 2030 policy discussion. It brings together and summarises recent empirical evidence on costs and benefits of energy efficiency measures.

The evidence gap in terms of reliable ex-post data is well known. In the majority of cases results from ex-ante modelling studies inform the debate. The research carried out for this report confirms the persistent gap in publicly available ex-post evaluations of energy efficiency programmes. In the household/buildings sector robust evaluations are available for the KfW energy efficiency programmes in Germany and to a certain extent for the 'EnergieSchweiz' programme in Switzerland and the Home Energy Scheme in Ireland. For the industrial sector evaluations have been carried out for energy efficiency programmes in the Scandinavian countries and Ireland.

Given the time and resources available for this report, it was outside the scope to review the studies in detail with respect to their assumptions and methodologies used. The results reported here reflect the results and conclusions drawn by the authors.

The report is structured as follows. After a short discussion of key terms and concepts, section 3 presents the empirical evidence reported in ex-post evaluations for the residential/buildings sector, the industrial sector, transport sector and energy infrastructure as well as cross-sectoral results. Section 4 points to the opportunities of export markets for European energy efficiency technologies. The report concludes by comparing costs and benefits.

2 UNDERSTANDING THE CONTEXT

2.1 Key terms and concepts

The key terms related to energy efficiency and energy savings, which are used in this report, are defined as follows in Article 2 of the Energy Efficiency Directive 2012/27/EC[1]:

- (4) 'energy efficiency' means the ratio of output of performance, service, goods or energy, to input of energy;
- (5) 'energy savings' means 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;
- (6) 'energy efficiency improvement' means an increase in energy efficiency as a result of technological, behavioural and/or economic changes;
- (7) 'energy service' means the physical benefit, utility or good derived from a combination of energy with energy-efficient technology or with action, which may include the operations, maintenance and control necessary to deliver the service, which is delivered on the basis of a contract and in normal circumstances has proven to result in verifiable and measurable or estimable energy efficiency improvement or primary energy savings;

Energy efficiency measures reduce the energy needed to produce the same quantity of goods and services or increase the output whilst keeping energy consumption constant. In addition to this direct contribution to improved competitiveness, energy efficiency measures provide indirect or 'non-energy benefits' that can increase the level of productivity. These include lower maintenance costs, higher levels of motivation, safer working conditions (IEA, 2012). The focus of this report is on **end-use energy efficiency**, ie measures that contribute to a reduction in energy demand, as opposed to measures that improve the efficiency of the energy supply chain.

Both direct and indirect energy efficiency benefits therefore affect **competitiveness**. Following Michael Porter from Harvard University, real competitiveness should be defined by productivity which in turn is a function of the value of goods and services (measured in price) and the degree of efficiency of their production (Porter 1990, see ECEEE 2013). In other words, productivity is defined by the relationship between the quantity of goods and services produced by a business or an economy and the quantity of labour, capital, energy, and other resources that are needed to produce those goods and services.

A commonly used measure in this context is the **energy intensity** of an economy which measures the energy consumption of an economy and its energy efficiency; it is the ratio between gross inland consumption of energy and gross domestic product[2]. Energy intensity can therefore improve as a result of structural changes in an economy such as a lower share

[1] Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC, OJ L 315, 14.11.2012, pp1-56

[2] Eurostat Glossary: Energy intensity, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Energy_intensity

of energy-intensive manufacturing. Energy intensity can also be applied to individual sectors of an economy.

Innovation and the capacity of an economy to innovate is a key factor in this context. It was again Michael Porter who formulated in the beginning of the 1990s the hypothesis that environmental regulation does not automatically need to hinder competitiveness. Rather it can often enhance it. The reasoning behind the hypothesis is that pollution, or inefficiency of resource use, actually represents a waste of company resources, and that reducing inefficiency would benefit overall productivity (value of goods and efficiency of production). Other than assumed market failures or imperfect competition may hinder companies from utilising related saving potentials by themselves. Well-designed regulation that is strict in ambition, but flexible in implementation would point companies to the problem of inefficiencies, trigger information gathering, reduce uncertainty and create a market push within an overall level-playing field. Compliance to regulation will lead to greater innovation (cleaner technologies, processes) as a key means to reduce inefficiency, which will lead already to environmental benefits, hence lower overall costs. Moreover, cost savings can (but do not always do) lead to partial or full offsets of regulatory compliance and innovation cost and hence increase overall competitiveness. This is particularly important in terms of first-mover-advantages, where the innovating company might obtain a dominating competitive position in a market vis-à-vis companies that operate under less stringent regulatory conditions and innovate later (Porter and van der Linde 1995).

The first, so called “weak” part of the hypothesis, namely that strict regulation spurs innovation, is met by a lot of supportive empirical evidence. The second, so called “strong” part of the hypothesis is met by more mixed, but still qualified evidence, with a need to distinguish sectors and types of innovation. The temporal dimension is important in this context. In many cases costs are incurred which are not off-set by innovation benefits in the short term, but in the longer term. A key factor in this regard is also the willingness of consumers to pay (Ambec et al 2011, Clementz 2012, Rexhäuser and Rammer 2013).

Understanding the link between competitiveness and productivity and the related role and relevance of innovation and regulation is crucial in the overall policy debate about the future energy and climate policy. The debate is heavily influenced by the widely perceived gap in energy price levels in the EU and some of its main competitors, particularly the USA. The efficiency of production of goods and services, hence energy efficiency, is a key response to price developments. In an increasingly interconnected and interdependent global economy innovation rather than price determines the ability of developed economies to stay ahead (EC 2012, also in the context of environment and innovation policy SRU 2012).

The European Council for Energy Efficient Economy has argued convincingly in a recent study that both price and volume determine overall energy cost to Europe’s companies. Difference in price can be found for many products and materials. It is not automatically the case that the competitor exposed to lower energy or other resource prices is necessarily the more competitive party, which can be explained by the strong relevance of the efficiency of production in this equation (ECEEE 2013). The 2012 Competitiveness Report of the European Commission, which has a special chapter on energy efficiency, does not provide hard evidence on an overly detrimental impact of energy prices on competitiveness of EU companies (EC 2012). A recent PriceWaterhouseCoopers study on economic impacts of decarbonisation in Denmark, Sweden and Germany confirmed that these countries maintained and increased competitive industries in spite of high energy prices through both intelligent policy design and an enhanced role of energy efficiency measures (PWC 2013).

2.2 Challenges to quantify energy savings and related benefits and costs

Measuring and quantifying **energy savings** as a result of specific policy measures or programmes is challenging since it requires a comparison with the counter-factual, *ie* the energy that would have been consumed if the measure or programmes had not been implemented. Similar challenges apply to the quantification of benefits and costs and need to be taken into account when assessing those.

While energy efficiency programmes produce a significant number of 'non-energy benefits', **benefits** are often evaluated only on the basis of the energy savings they deliver. This is due to the fact that 'non-energy benefits' are in general not quantified also due to the methodological challenges involved. As a result cost-effective energy savings potential tend to be underestimated (IEA, 2012). In addition, one needs to note that ex-ante estimates of costs to business of environmental legislation often (though not always) exceed the ex-post estimates by a substantial margin (Oosterhuis et al, 2006).

Costs of energy efficiency measures are in general measured in terms of additional costs as compared to costs for a conventional technology.

Energy savings, benefits and costs can be analysed at **different levels**. In this report it is mainly distinguished between sectoral level (ie residential/buildings, industry, transport), cross-sectoral/national level and the international level. This is illustrated in Figure 1. Note that Figure 1 captures only those benefits and costs covered in the reviewed studies. For instance, it does not include energy security as an important benefit of energy efficiency measures. Table 2 summarises the benefits and costs that have been identified in the evidence reviewed (see chapter 5).

Figure 1: Benefits and costs from energy savings – different levels of analysis

Level	Benefits	Costs
Sectoral level: Residential Industry Transport	Reduced energy costs Indirect benefits	Additional investments
National level	GDP Jobs GHG savings	Expenditure on policies and programmes
International level	Export markets Reduced energy prices	n/a

Source: Own elaboration

3 EMPIRICAL EVIDENCE ON BENEFITS AND COSTS

For households, firms and public authorities a decrease in energy demand as a result of energy efficiency improvements reduces their energy expenditure. In addition to energy savings, improved production and capacity utilisation, and less operation and maintenance are likely to decrease the company's costs as well.

Investment in energy efficiency and the resulting increased disposable income can lead to a net improvement in employment rates in the energy and other sectors through direct job creation and indirectly through consumer surplus spending on top of other benefits for national budgets such as reduced unemployment benefits. One has to account, however, for the possibility that increased investment into energy efficiency is crowding out other investments and their positive socio-economic benefits, and hence need to apply an integrated perspective. However, the IEA has also convincingly shown that measures for improving energy efficiency provide for multiple direct and indirect benefits that are not always easy to capture, including also quality of life aspects

In this chapter empirical evidence on benefits and costs is reported for the residential/buildings, industry, transport, and energy sectors. An overview of the utilised sources of information can be found in section 6.

3.1 Residential

In the residential sector both the energy consumption of buildings and the rising electricity consumption constitute an important challenge for exploiting energy savings potentials.

Buildings are responsible for around 40 per cent of energy consumption and greenhouse gas emissions in the EU. Residential and tertiary buildings have particularly high energy requirements for heating, hot water, and cooling needs. In order to reduce energy consumption in the buildings sector, public policies have been developed across the EU to encourage building owners to implement energy efficiency measures (ADEME, 2012). Compared to other sectors the buildings sector is less exposed to global competition, local and oftentimes very labour-intensive. Support programmes for energy efficiency programmes in the buildings sector have the advantage that implementing these measures are relatively labour intensive and that the related jobs cannot be easily exported. The indirect benefits in terms of additional jobs, social security contributions and other tax income remain therefore in the relevant country. Here the focus is on the residential buildings sector because the industry sector is covered in section 3.2 and most of the assessed energy efficiency programmes in the buildings sector focus on the residential sector.

Ürge-Vorsatz *et al.* (2010) reviewed several empirical studies on the employment effects of energy efficiency measures as a result of buildings retrofit activities inside and outside the EU. Their study concludes that on average around 17 jobs are created per million euro invested. Applying these results to the Hungarian context the study concludes that 'deep renovations are one of the most employment intensive interventions for climate change mitigation or other economic recovery attempts' (Ürge-Vorsatz *et al.* 2010, p23). Another recent review of employment impacts also indicates that the average number of new jobs created per EUR 1 million investment is 12-17 (Meijer et al 2012). In Finland, an Energy Audit Programme that was carried until 2007 and covered almost 40 per cent of the building stock cumulative savings of around EUR 360 million and over 11 TWh (of which 70% in the industry sector) were achieved between 1992 and 2007 (Maio et al, 2012).

A diverse set of fiscal measures and (concessional) loans are used in support of energy efficiency measure in Member States. The programmes implemented by the German public bank KfW ('Kreditanstalt für Wiederaufbau') are by far the most significant programmes among Member States with an annual budget of EUR 1.4 billion in 2010 which equals 0.055% of GDP or an expenditure of 16.70 per inhabitant (ADEME, 2012).

Evaluations of the KfW programmes highlight their overall benefits in terms of energy savings, greenhouse gas savings and other indirect benefits (Diefenbach et al., 2012; Kuckshinrichs et al. 2012). Between 2006 and 2010 on average 280,000 flats were renovated leading to annual energy savings of 2.1 TWh and total investments of EUR 14 billion based on an average public budget contribution of EUR 1.4 billion (see Table 1). It is worth noting that in 2009 and in 2010 the programme budget was increased as economic stimulus.

Table 1: KfW energy efficiency programmes in the buildings sector 2006-2010

	2006	2007	2008	2009	2010	Average
Flats/houses covered	210737	137022	183478	427272	427021	280000
Energy savings (TWh/a	1.782	1.157	1.767	3.017	2.739	2.1
CO2 savings (t/a)	750755	382731	613565	1057271	940838	750000
Total investment costs (EUR billion)	10.999	9.573	11.212	16.85	21.206	14
Federal budget contribution (EUR billion	1.489	0.838	1.293	2.033	1.35	1.4
Multiplier effect	7	11	9	8	16	10

Source: Prognos (2013)

In 2011 the total costs of the KfW programmes for the federal budget in Germany were EUR 952 million (Kuckhinrichs et al. 2012, p4). Due to the multiplier effect the total investment costs were considerable higher and amounted to EUR 18 billion. Direct benefits are energy savings of 1.25 TWh per year and indirect benefits include 251 000 person years of additional employment. Using a conservative estimate (on jobs and investments) public budgets have a net benefit of EUR 3 billion, under an optimistic estimate net benefits are as high as EUR 10 billion in 2011. The social security system benefits most, followed by the "Länder", the federal level and to rather limited extent the local authorities (Kuckhinrichs et el. 2012). Benefits are summarised in Erreur ! Source du renvoi introuvable.: **KfW energy efficiency programmes in the buildings sector 2011**

Scope of programme	Energy savings	Greenhouse gas savings	Costs	Benefits	Employment

Subsidised loans and grants covering 181,000 flats, mostly insulation, but also replacement of heating system	Final energy: 1.25 TWh/a Primary energy: 1.68 TWh/a	457,000 t CO2eq/a (incl. indirect savings) 312,000 t CO2eq/a (direct savings) Taking account of all supported measures since 2005 savings are 4.2 m CO2eq/a	total investment costs of EUR 3.9 billion	Saved heating costs: EUR 125 m/a, over the lifetime of the measures this would amount to EUR 3.3 billion. Of the EUR 3.9 billion investment costs EUR 0.6 billion go back to the public budget in terms of VAT Total net turnover amounts to EUR 5.5 billion with a multiplier effect of 1.68	52,000 person-years
81.000 new flats (41% of all new flats), mostly insulation	Final energy: 300 GWh/a Primary energy reduction: 370 GWh/a	85,000 CO2eq/a (incl. indiret savings), 18,000 direct savings	total investment costs of EUR 14.5 billion	Saved heating costs: EUR 36 m/a, over the lifetime of the measures this would amount to EUR 865 million. Of the EUR 14.5 billion investment costs EUR 2.3 billion go back to the public budget in terms of VAT Total net turnover amounts to EUR 21.5 billion with a multiplier effect of 1.76	199,000 person-years

Source: Diefenbach, et al. (2012)

In an ex ante assessment of a possible continuation of the KfW programme until 2050 Prognos estimates that the programme could contribute to CO2 emission reduction of between 15.6 and 81.4 million t CO2/a by 2050. An increase of the programme budget could contribute to 0.25% of GDP, compared to a baseline growth of 1.1%, and could therefore make a significant contribution. While the public budget has so far generated a surplus with the KfW support programmes, they would become revenue neutral due to higher public expenditure (Prognos, 2013).

A recent study by PriceWaterhouseCoopers on decarbonisation policies in Denmark, Germany and Sweden concluded that all countries achieved notable improvements in increasing the efficiency of end-use in households, including through increasing the stringency of building codes, labelling and financial incentives. Denmark, for example, uses 40 per cent of its environmental tax revenues to fund energy efficiency measures, by co-funding investment cost of companies. Though there is no specific information available on the economic impact of efficiency policies within the broader context of decarbonisation policies in Denmark these policies have led to creating an energy technology industry that by now contributes to 10 per cent of Gross Added Value generated by the total industrial sector in the country (PWC 2013). The study also confirms more generally for all three countries that an ambitious approach to energy-savings leads to higher immediate costs which however create greater long-term opportunities, and that competitiveness impacts can be softened through intelligent policy design and consumer willingness to pay higher energy prices in exchange for better products and services and overall cost-savings.

An evaluation of the Swiss energy efficiency programme 'EnergieSchweiz' concluded that in the year 2006 a net employment benefit of 2,600 person years was achieved as a result of the implementation of energy efficiency measures with a total investment volume of CHF 315 million of which around CHF 32 million were public subsidies (INFRAS, 2007). Most of the supported measures were in the public sector and in buildings. The employment benefits were highest in the buildings sector (1,900 person years) followed by consultancy, planning and IT (820 person years).

In Ireland a Home Energy Saving scheme was implemented between 2009 and 2011 providing financial support in the form of grants to energy efficiency measures such as improved insulation, high efficiency boilers and heating controls. The total value of the grants allocated was EUR 62.8 million which led to total expenditure of EUR 171.5 million due to private sector contributions. The programme delivered a net benefit of five euro for each euro spent in terms of reduced energy consumptions, lower greenhouse gas emissions and less other pollution (Scheer and Motherway, 2011). Households that were supported by the programme are expected to save EUR 450 per year on their energy bills. The scheme supported more than 3,000 full time jobs in the construction and related sector.

Another recent study by Copenhagen Economics estimates the monetised benefits from exploiting the potential for energy savings from the renovation of buildings at EUR 61-87 billion annually in 2020 depending on the level of investments made from 2012 to 2020. Of these benefits, EUR 52-75 billion are modelled to result from lower energy bills and at least EUR 9-12 billion from the co-benefits of reduced expenditure on subsidies and reduced air pollution from energy production. These annual benefits could be doubled in value by 2030 if investments are continued after 2020 (Copenhagen Economics 2012). The European Commission's impact assessment on the Energy Efficiency Directive as proposed in 2011 assumed an annual average reduction in overall spending of about EUR 20 billion.[3]

Moreover such support programmes combined with an ambitious regulatory framework can help to stimulate the development of highly energy efficient technologies such as insulation material, windows and heating systems. These technologies may help to develop new export markets (see section 4). However, evidence from Germany shows that between 2002 and 2012 these technologies did not have an above-average success in export markets (Prognos, 2013). This may be explained by the fact that these rather expensive cutting edge technologies may not meet local market conditions abroad (ibid.).

Besides the need to make buildings more efficient, the residential sector is faced with rising electricity consumption. Between 2005 and 2010 the growth rate was around 1.7 per cent due to an increased number of appliances and more extended usage rates (Bertoldi, et al. 2012). Between 1990 and 2010 final residential electricity consumption increased by

[3] The actual cost savings as a result of energy savings depend of course *inter alia* from the future development of energy prices.

around 32 per cent in the EU27. National programmes such as a tax deduction scheme in Italy, scraping bonus for cold appliances in Austria or price rebate schemes in Spain have been successful in increasing the share of highly efficient household appliances in the residential (Bertoldi, et al., 2012).

Due attention needs to be paid, however, to realising cost-effective projects and activities which exploit energy savings potentials in a targeted manner. The European Court of Auditors questioned in a recent assessment the cost-effectiveness of investments into energy efficiency in public buildings under Cohesion Policy (on the basis of 24 investment projects) and claimed that payback times were extra-ordinarily long (ECA 2013). The validity of the approach to the assessment and the validity of some of the assumptions have been critically debated, ie whether it is adequate to not account for broader co-benefits in terms of tax return from investment, improved health and decrease in spending for health care or how the ration of cost-to-benefit should be weighted over what period of time.[4] Independent of that it remains important to consider which kind of investment provide for the greatest relevance and effectiveness from a long-term perspective.

3.2 Industry

On the economy-wide level, energy efficiency measures enhance competitiveness by allowing companies to consume less energy while maintaining or even increasing economic output. According to analysis carried out in the Odyssee project industry has increased its energy efficiency on average by 2.1 per cent since 1990, while remaining competitive in many markets (ADEME 2009). For industrial processes a productivity increase following the introduction of energy efficient process technologies has been demonstrated (Walz 1999). This effect is, however, generally much smaller for auxiliary energy efficient technologies (i.e. technologies which do not concern the central production process such as, for example, compressed air, pumps, ventilation, etc.).

Energy efficiency measures and related support programmes are widely pursued in Member States. The European Commission's Global Competitive Report 2012 notes that energy use in the EU's manufacturing industry remained fairly constant while moderately increasing its output between 1995 and 2009 in the absence of significant structural changes (EC 2012).

Denmark, Sweden and Ireland have introduced industrial energy efficiency programmes in the 1990s in the context of the introduction of energy and/or CO2 taxes. On the basis of voluntary agreements between the government and industry, industry could benefit from tax rebates if they implemented energy management systems which were to identify energy efficiency opportunities at company level (Goldberg and Reinaud, no date). In Sweden a Programme for improving energy efficiency in energy-intensive industries was introduced for energy-intensive companies[5] (Stenqvist and Nilsson, 2013). The programme started on January 2005 and companies' participation lasts over five years. They need to introduce an

---

[4] See related comments from Randall Bowie at http://www.euractiv.com/energy-efficiency/90-eu-energy-efficiency-funds-mi-news-517041

[5] Companies whose purchases of energy products and electricity amounted to at least 3 per cent of the production value and/or whose energy-, carbon dioxide-and sulphur tax on energy products and electricity amount to at least 0.5 per cent of the added value, i.e. companies from pulp and paper, mining, iron and steel, non-metal minerals and industrial chemicals sectors.

energy management system and carry out an energy audit. Identified measures with a payback period of less than three years need to be implemented. Between 2005 and 2009 companies invested EUR 70.8 million in electricity savings measures. Based on net annual energy savings of between 689 and 1015 GWh it is estimated that each MWh of saved electricity cost between EUR 9.3 and 13.6. This compares to an average annual wholesale price of EUR 29 and 51 in the same period (Stenqvist and Nilsson, 2013). The average payback period of the implemented electricity savings measures was less than 1.5 years.

The Sustainable Energy Authority of Ireland has implemented an energy efficiency programme targeted at SMEs since 2007 providing assessment, advice and training. An evaluation of the programme shows that the more than 1,470 companies employing the equivalent of 130,000 full-time which participated in the programme reduced their annual energy consumption by around 10%. The cost of saving one kWh was estimated to be between 1.8c (to 2020) and 0.7c (to 2030) compared to average electricity cost of 8.2c per kWh assuming an average lifetime of 12 years for the energy savings measures implemented (Scheer and Motherway, 2011). The total programme budget in 2010 was EUR 1.2 million.

Other benefits for firms investing in energy efficiency improvements include reductions in resource use and pollution, improved production and capacity utilisation, and less operation and maintenance, which lead to improved productivity and competitiveness (IEA 2012).

In addition to better performance in terms of productivity and competitiveness, firms can gain market shares by offering products that consume less energy. The 2012 Competitiveness Report of the EU notes on the basis of a sample of over 40000 enterprises that those companies which have introduced energy-efficient products onto the market perform on average better on innovation and gain greater sales generated by products innovation than competitors with more conventional product innovation. It also underpins the relevance of energy efficiency for reducing energy import bills, and confirms the overall good performance of EU manufacturing sectors and their leading position in many markets (EC, 2012).

Worrell (2001) reviewed the relationship between energy efficiency improvement measures and productivity in industry on the basis of 70 industrial case studies. The case-study review suggests that energy efficiency investments can provide "a significant boost to overall productivity within industry". Energy efficiency in industry is strongly linked in various ways with competitiveness These different links exist on a micro, company-based level, but also on a more aggregated level for industries and economies: energy efficiency contributes toward reducing overall company expenses, increases productivity, has effects on competitiveness and the trade balance on an economy- wide level, and, by creating a home market for energy efficient technologies, supports the development of successful technology supply industry in that field (Eichhammer and Walz, 2011). The economic potential in the industrial sector may however be limited in practice due to payback times of not more than 2 years that are usually required by businesses to make the investments (Pehnt et al. 2011).

While energy efficiency has contributed positively to industrial competitiveness, it is important to note that many of the completed measures can be considered as ‘low hanging fruits’ with short payback times. Moreover sectors are very diverse in terms of their scope, size, structure and exposure to global competition. They also have different financial capacity to stem the required upfront investment in times of strong market competition and varying energy prices.

3.3 Transport

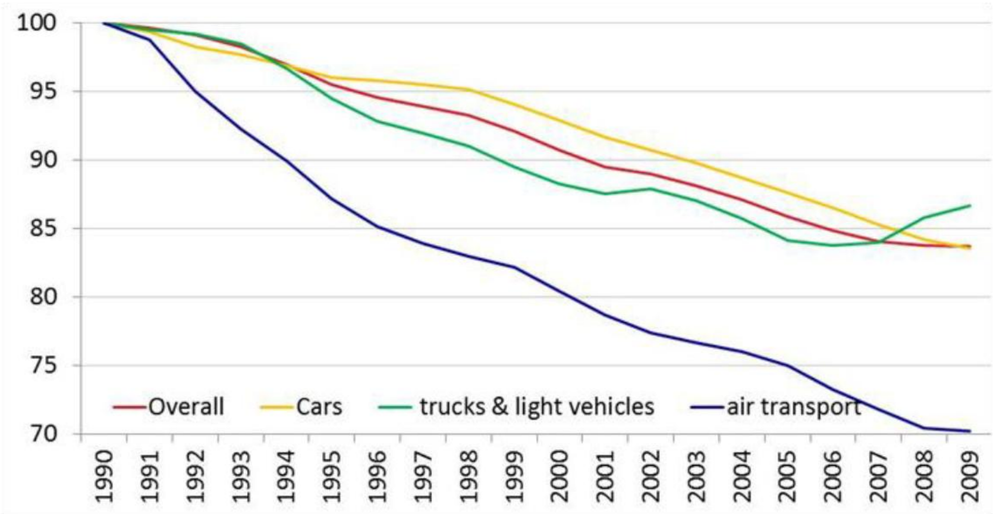
According to the IEA (2010), the transport sector will account for 97 per cent of the increase in world oil use between 2007 and 2030. The IEA estimates that there is a potential for cost-effective technical improvement in new vehicle fuel economy of 50 per cent by 2030. This would result in a reduction of close to 500 000 tonnes of oil equivalent (toe) fuel use and almost 1 Gt of annual reduction in CO_2 emissions. Achieving this target will require strong policies that maximise technology uptake and minimise fuel economy losses due to increases in vehicle size, weight and power (IEA, 2009). The IEA’s World Energy Outlook (2012) estimates that the fuel economy improvement potential of the passenger light-duty vehicle market ranges from 40% to 67% by 2035 (including hybridisation) which can be achieved with current technologies. For trucks, the potential to reduce fuel consumption by 2035 is estimated to be in the range of 30-50%, compared with today’s vehicles.

Efficiency, modal shift and demand-side management are key interlinked pillars of a sustainable transport system. The EU has geared most of its past policy efforts on improving vehicle efficiency, with less emphasis on modal shift and demand side management.6 Steady improvements in the average fuel efficiency of the transport fleet have helped to moderate the increase in transport energy consumption which has been largely driven by the increase in passenger mobility. In 2011, average CO2 vehicle emissions for most carmakers were below target levels estimated for 2012 (EEA 2012). Greater energy efficiency in the transport sector is happening (see

[6] This includes regulations setting CO2 limits for new passenger cars and vans (as of 2012), regulations requiring gear shift indicators in new passenger cars (as of 2012), regulations requiring tyre pressure monitoring in new passenger cars (as of 2012), low rolling resistance tyres (as of 2014) and related labelling schemes (as of 2012) as well as the inclusion of the aviation sector in the EU ETS.

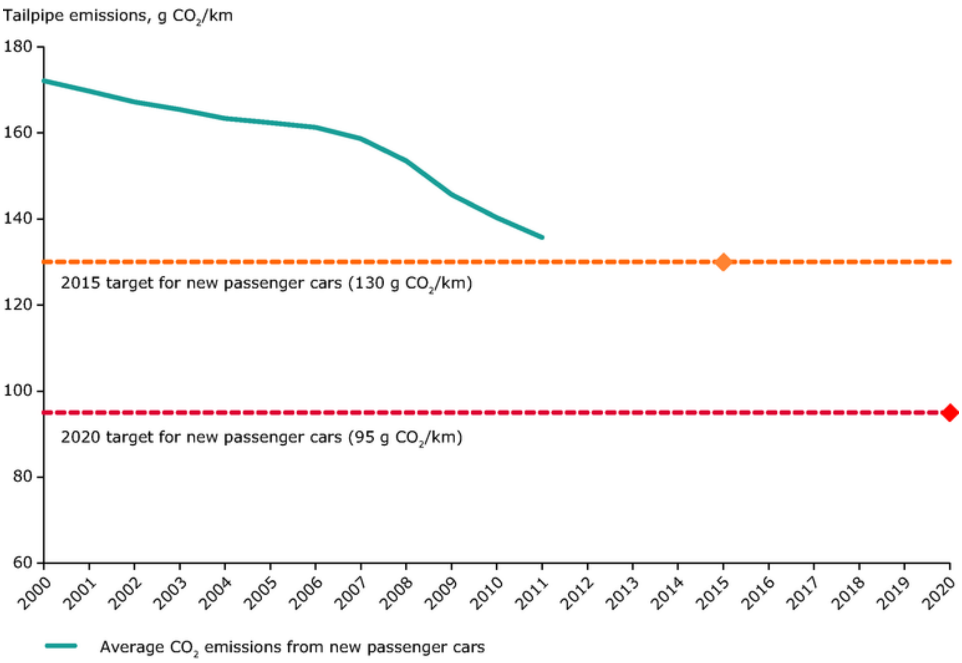
Figure 2). But it is developing not fast enough: the sector still accounts for the largest and rapid growth in overall energy consumption across sectors in the EU. Its carbon-dioxide emissions rose by 21 per cent between 1990 and 2011, and it is responsible for more than 30 per cent of final energy consumption in the EU.

Figure 2: Energy efficiency progress in transport in the EU[7]



Source: AEA 2012

Figure 3: Average emissions for new cars (gCo2/km) (EU 27)



Source: EEA 2012

Member States pursue a wide range of regulatory, fiscal, organisational or voluntary policy approaches and measures targeted at energy efficiency in transport, though they are mainly geared again towards passenger transport and efficiency of cars. But emphasis is increasing on efficiency of other modes as well as modal shift. The evaluation of national energy efficiency action plans shows, however, that few Member States pursue a comprehensive

[7] The indicators is calculated as a 3-year moving average and is based on fuel consumption per km for cars, buses, and motorcycles, per km for passenger rail, per passenger for air travel, and per tkm for all freight transport. The overall trend is the average of trends by mode weighted to a share of each mode of the energy consumption in the transport sector (AEA 2012).

approach to transport energy efficiency, covering also planning and infrastructure and technological development.

Data from ex-post evaluations are not widely available and overall not too robust. The potential employment effect of investing €1 billion in sustainable transport in the EU has been estimated in one study to be 21,500 full time jobs (Sustainlabor 2013). A sustainable transport policy is likely to overcompensate job losses in car manufacturing through more jobs in manufacturing of buses, light railways, subways, and railways; planning, managing and maintaining these systems another study shows (European Parliament, 2010). For the EU 25, estimates suggest around 900,000 people are employed in urban public transport. The number of direct jobs in public transport amounts to about 1–2 percent of total employment, underpinning the stronger relevance of public transport investment for job generation (ETUC 2012).

3.4 Energy supply

A reduced demand for energy has also important consequences on the required investments for additional energy generation capacity and the operation and maintenance of the energy infrastructure. The IEA estimates in the World Energy Outlook 2012 that a reduced global energy demand of 28,000 Mtoe, as assumed in the 'Efficient World Scenario' as compared to the 'New Policies Scenario' between 2010 and 2035, would lead to an electricity demand that is 56,000 TWh or 8% lower. As a consequence, the required investments in generation capacity as well as transmission and distribution infrastructure would be USD 5.9 trillion (or 16%) lower between 2012 and 2035. These savings would offset half of the additional investment needs on the demand side (IEA, 2012a).

By comparing the annual cost of energy efficiency investments, which refers to any expenditure that improves energy efficiency throughout the economy, against the new demand for energy-related goods and services, Laitner (2013) concludes that the productivity of the U.S. economy 'may be more directly tied to greater levels of energy efficiency rather than continued mining and drilling for new energy resources' (Laitner 2013, p2). The empirical analysis suggests that historically energy efficiency covered three-fourths of the new demand for energy-related goods and services, whereas energy supply contributed one-fourth only. Moreover, Laitner argues, that investments in energy efficiency were most cost-efficient. In 2010, U.S. expenditure on energy efficiency (USD 90 billion) was one-half the cost of conventional energy supply (USD 170 billion). A recent study by ABB comes to a similar conclusion, stating that "*Energy efficiency is mandatory for the United States to maintain continued economic leadership in a global economy*" (ABB 2013).

In addition policy support for demand-side instead of supply-side technologies in the energy system appears more attractive for their political feasibility and robustness (Finger et al. 2013). Demand-side energy policies come with higher political feasibility because they do not benefit only those regions or countries where major producers of supply technologies are located, but all Member States as jobs are mostly created locally. Moreover demand side policies appear as the more robust policy choice because there is lower risk of picking the wrong supply technology.

3.5 Cross-sectoral evidence

While most studies on energy efficiency consider the cost savings for consumers and businesses resulting from avoided energy use, only some of them outline the fact that energy savings do not only result in direct cost savings, but have a multiplier effect due to their downward effect on energy prices. Ecofys (2013) argues that international energy markets are under pressure because the energy production capacity is relatively constant compared to an increasing energy demand. Energy prices are therefore very sensitive to changes in energy demand. As a result, it is argued, the real cost savings from exploiting the EU's cost-effective energy savings potential are likely to be higher than commonly assumed. Against this background Ecofys (2013) estimates that for every EUR 1 of direct energy cost savings, an additional EUR 1 could be saved due to lower energy prices. Since studies have already shown that energy efficiency measures will generate net direct savings for European businesses and consumers projected to amount EUR 107 billion annually in 2020, net additional annual cost savings on the order of EUR 100 billion can be expected (Ecofys 2013). There is however mixed evidence on whether reduced energy demand in the EU would result in lower energy prices at global level.

By making products more energy-efficient and supporting the up-take of energy efficient products via the Ecodesign Directive and the EU energy label, considerable benefits are can be made. The Ecodesign Directive can deliver net savings of up to EUR 90 billion a year, equivalent to EUR 280 per household in the EU (Ecofys, 2012).

Energy efficiency can have positive macroeconomic impacts, including increases in GDP and improved trade balance (for fuel importing countries). The few studies examining the macroeconomic effects of improved energy efficiency point to positive macroeconomic effects in terms of GDP growth (IEA, 2012). In its World Energy Outlook 2012 the IEA estimates that under the 'Efficient World Scenario' the EU could reduce its energy demand by 13% in 2035 as compared to 2010. Such an efficiency improvement could increase GDP by 1.1% in OECD Europe countries compared to the 'New Policies Scenario'. Additional investments of USD 2.2 trillion between 2012 and 2035 would lead to savings in energy expenditures worth USD 4.9 trillion in the same period (IEA, 2012a).

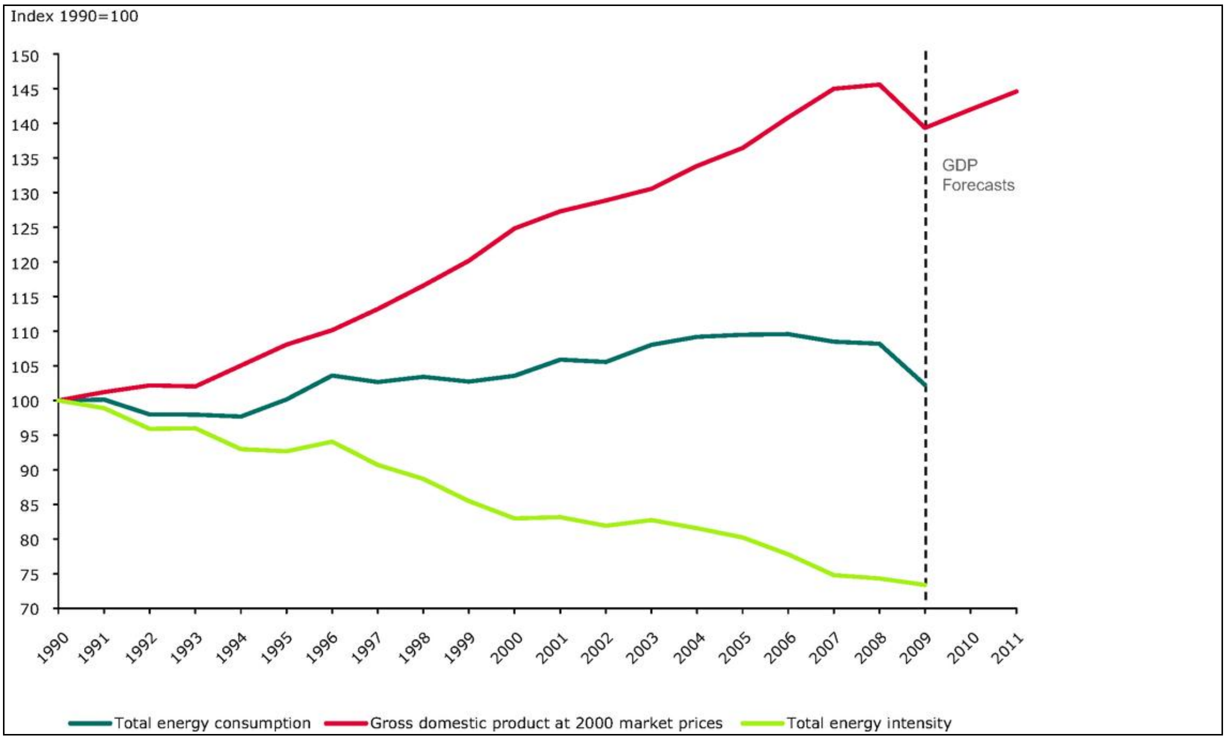
A study based on a review of 48 studies that evaluated the ex-ante macroeconomic impacts of a wide variety of cost-effective energy efficiency and renewable energy policy scenarios in the U.S. estimates that a 20 per cent to 30 per cent energy efficiency gain within an economy might lead to a net gain of 500.000 to 1.500.000 jobs by 2030. The number of jobs per trillion Btus of efficiency gains ranged from a low of 9 to a high of 95. The average among all studies was a net benefit of 49 jobs per trillion Btus of savings (Laitner & McKinney 2008). A recent evaluation of the Energy Savings and Industrial Competitiveness Act of 2011 in the US estimates that the Act is likely to create a net 102.000 additional jobs in 2020, rising to 185.000 net jobs in 2030 (K. Farley and al. 2012).

Modelling by the European Commission showed that sizable economic benefits could have flowed from their original proposal for an Energy Efficiency Directive by 2020, namely an increased in EU GDP of € 34 billion and increased net employment of 400 000 jobs (EC, 2011).

While the above-reviewed evidence mainly quantifies employment benefits in the buildings sector which are mostly low skilled and hence do not require major training efforts for them to materialise, an assessment of the potential effects of the Energy Efficiency Directive by the Danish Energy Association concludes that 'about half of the total market for energy efficiency in Europe of 640bn euro is in high-skilled energy efficiency technology development and advice' (Danish Energy Association, 2012). The study shows that European companies currently have a market share of 70 % of the high-skilled energy efficiency market within Europe. Lower skilled energy efficiency markets such as installation and renovation are nearly exclusively covered by European SMEs.

In the EU GDP has grown by approximately 40 per cent in the last two decades, while actual energy consumption has increased by 3.2 per cent. Meanwhile, the energy intensity of the European economy has fallen by 25 per cent. Total primary energy intensity[8] in the EU-27 decreased by 1.5 per cent per year between 1990 and 2010 (EEA 2013) (see Figure 4).

Figure 4: Trends in total energy intensity, gross domestic product and total energy consumption, EU-27



Source: EEA (2013) http://www.eea.europa.eu/data-and-maps/indicators/total-primary-energy-intensity-1/assessment

Implementing energy efficiency measures in the industry sector can be an important way to improve international competitiveness by hedging against volatile and increasing primary energy prices such as oil (DENEFF, 2013). In addition to reduced exposure to price risks energy efficiency measures can reduce the overall expenditure on energy imports (ibid.).

[8] Units of energy per unit of GDP

4 ENERGY EFFICIENCY TECHNOLOGIES FOR EXPORT MARKETS

Energy efficiency programs also positively impact the trade balance, both in terms of reduced expenditure on energy imports and increased export capacities. By advancing strong European market demand for energy efficient products, processes and services, the dependence on technology imports is reduced, or may open up the potential to become a technology provider for other countries (Eichhammer and Walz 2011).

Markets for energy-efficient products, processes and services have been witnessing strong growth over the past years, but starting from a lower level. According to Bloomberg, about EUR6.5 billion of venture capital and private equity has been invested into energy efficiency markets since 2007 worldwide.[9] Markets for energy management systems are still considered to be nascent in many places, with new entrants, products and technologies entering on a larger scale. EU firms are playing a leading role in global markets for energy efficiency which is described in more detail in the next paragraph. Market forecasts differ quite widely, but there is a strong underlying agreement that global market prospects are positive and average annual growth rates until 2020 and further to 2030 will be above average economic growth.

Roland Berger has recently estimated that the global market for energy efficiency was worth EUR720 billion in 2010, having grown from a volume of EUR538 billion in 2007. It is by far the largest segment of the overall market for clean-teach and resource efficiency and is expected to increase by 3.9 per cent annually to EUR1.240 billion by 2025 (German Federal Ministry for the Environment 2012). [10] Smart grids and building energy efficiency are expected to grow strongly and reduce costs per unit of production (Copenhagen Eco-cluster 2012). It is forecasted that more than 1.4 million homes will be participating demand-response programme by 2018, from up to 600.000 at the moment, with by far the biggest increase in Asia-Pacific region (PIKE research 2013). A recent NAVIGANT study estimates the global market for green building and construction materials to grow from $116 billion in 2013 to $254 billion in annual market value in 2020 (NAVIGANT 2013). More specifically, PIKE Research estimates the global market value for energy-efficient homes[11] to be growing to USD 82 billion by 2020 (PIKE Research 2012). The World Resources Institute also estimates markets for insulation, lighting and building controls to grow at a range of between 3 and 6 per cent average growth rate until 2020 and to 2030 (Mulki and Hinge 2010). Another estimate for the enabled Smart Grid technology markets sees these markets grow to USD220 billion globally by 2020 (Zpryme consultants, 2013). The global market for heat exchangers is projected to reach USD20,8 billion by 2018 - Europe represents the largest market worldwide (Global Industry Analysts 2012).

---

[9] http://about.bnef.com/markets/energy-smart-technologies/energy-efficiency/

[10] One needs to note, however, the difficulty in establishing an accurate assessment: Energy efficiency and environmental technology in general is a cross-sectoral industry that, in many areas, overlaps with other key industries. In this study, the market includes four key sub-segments, namely energy-efficient production processes, cross-application technologies for industry and commerce, energy efficiency buildings and energy-efficient appliances.

[11] Defined as defines as properties that are built to exceed the 2009 International Energy Conservation Code by 15% on a kilowatt-hour per square foot basis

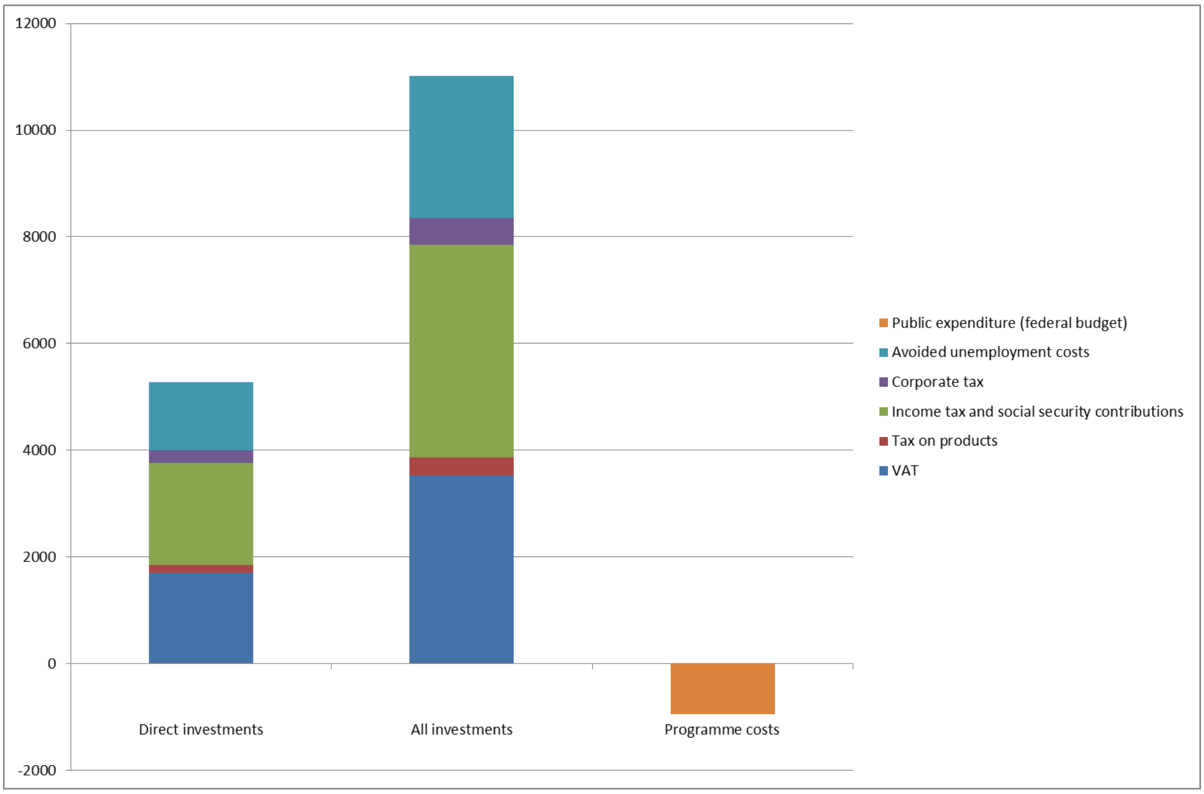
All these estimates underpin the strong growth potential for these markets but also point to their policy dependency. It is estimated that the building appliances market as well as Smart Grid technologies might be the first market segments to become less policy-dependent. It is also worth mentioning that a lot of the recent forecasts are correcting assumptions of earlier forecasts which provided lower expectations. Historically, Europe has been shaping clean technology markets towards maturity, combining strong enterprises with a skilled labour force and incentive schemes. This has characterised global market development for wind energy or photovoltaic, for example, or pump and turbine technologies. Market developments in the future will be increasingly shaped by Asia, where urbanisation and economic growth creates strong demand for clean technology, efficiency services and infrastructure (Copenhagen Eco-Cluster 2012).

5 BENEFITS COMPARED TO COSTS

The limited number of ex-post evaluations that provide relevant information strongly suggests that the benefits outweigh the costs of energy efficiency measures both from the perspective of the beneficiaries and the public authorities providing financing for the relevant measures and/or programmes.

For the KfW energy efficiency programme in Germany it is estimated that in 2011 alone public authorities at the regional and federal have enjoyed a net benefit of EUR 3 billion based on conservative assumptions covering investments directly supported by the KfW programme. The total net benefits could be as high as EUR 10 billion if all induced investments are taken into account. Figure 5 shows the different elements of these benefits. The highest benefits arise from the VAT income on the goods and services delivered and the additional income tax and social security contributions. Avoided unemployment costs are also an important component in the overall benefits. These benefits by far outweigh the total programme costs of EUR 952 million. While the programme costs are borne by the federal budget, the benefits go mostly to the social security system and the Länder. However, it is important to note that these benefits occur at the time of programme implementation and can only be maintained if the programme is continued. As soon as the loan repayments are higher than new investments the overall picture changes and net impact on GDP becomes negative (Prognos, 2013).

Figure 5: KfW energy efficiency programmes 2011: costs and benefits (in billion EUR)



Source: own elaboration based on data from Kuckshinrichs et al. (2012, p10)

The evaluation of the Swedish Programme for improving energy efficiency in energy-intensive industries estimated that between 2005 and 2009 companies invested EUR 70.8 million in electricity savings measures leading to net annual energy savings of between 689 and 1015 GWh. It is further estimated that each MWh of saved electricity cost between EUR

9.3 and 13.6 compared to an average annual wholesale price of EUR 29 and 51 in the same period (Stenqvist and Nilsson, 2013). Similarly the evaluation of the Irish energy savings programme in SME estimated costs of between 1.8c (to 2020) and 0.7c (to 2030) for energy savings measures compared to average electricity cost of 8.2c per kWh (Scheer and Motherway, 2011).

Table 2 summarises the key findings of ex post evaluations reviewed for this report.

Table 2: Summary of key findings of ex post evaluations reviewed for this report

Study reviewed	Scope	Key findings
Residential/buildings sector		
Prognos (2013)	Evaluation of German KfW energy efficiency programmes in the buildings sector	• Between 2006 and 2010 annual energy savings of 2.1 TWh and total investments of EUR 14 billion were achieved based on an average public budget contribution of EUR 1.4 billion • An increase of the programme budget could contribute to an average increase of GDP by 0.25%, compared to a baseline growth of 1.1%
Kuckhinrichs et al. (2012)	Evaluation of German KfW energy efficiency programmes in the buildings sector	• In 2011, using a conservative estimate on jobs and induced total investments, public budgets have a net benefit of EUR 3 billion, under an optimistic estimate net benefits are as high as EUR 10 billion
INFRAS (2007)	Evaluation of Swiss energy efficiency programme 'EnergieSchweiz'	• Net employment benefit of 2,600 person years as a result of energy efficiency measures with a total investment volume of CHF 315 million of which around CHF 32 million were public subsidies • Employment benefits were highest in the buildings sector (1,900 person years) followed by consultancy, planning and IT (820 person years).
Scheer and Motherway (2011)	Evaluation of Irish Home Energy Saving scheme	• A net benefit of five euro for each euro spent in terms of reduced energy consumptions, lower greenhouse gas emissions and less other pollution • Households that were supported by the programme are expected to save EUR 450 per year
Ürge-Vorsatz *et al.* (2010)	Employment effects of energy efficiency measures in the buildings sector	• On average, around 17 jobs created per million euro • 'deep renovations are one of the most employment intensive interventions for climate change mitigation or other economic recovery attempts' (p23)
Industrial sector		
Stenqvist and Nilsson (2013)	Evaluation of Swedish Programme for improving energy efficiency in energy-intensive industries	• Each MWh of saved electricity cost between EUR 9.3 and 13.6 compared to an average annual wholesale price of EUR 29 and 51 in the same period • The average payback period of the implemented electricity savings measures was less than 1.5 years.
Scheer and Motherway (2011)	Evaluation of Irish energy efficiency programme targeted at SMEs	• The cost of saving one kWh was estimated to be between 1.8c and 0.7c compared to average electricity cost of 8.2c per kWh
2012 Competitiveness Report of the EU	Assessment of EU competitiveness	• Companies which have introduced energy-efficient products onto the market perform on average better on innovation and gain greater sales generated by product innovation than competitors with more conventional product innovation

6 REFERENCES

AEA (2012) Energy efficiency policies in the transport sector in the EU, Odyssee/Mure project phase 12, report for the European Executive Agency for Competitiveness and Innovation, Oxford.

ADEME (2012) : Étude comparative sur l'efficacité des soutiens publics aux investissements de maîtrise de l'énergie dans l'Union européenne. Report by Stefan Scheuer SPRL for ADEME.

Ambec, S. et al. (2013) The Porter Hypothesis at 20. Can environmental regulation enhance innovation and competitiveness? Review of Environmental Economics and Policy Advance, 2013, 1-22.

Bertoldi, P., Hirl, B., Labana, N. (2012) Energy Efficiency Status Report 2012. JRC.

Maio, J., Zinetti, S., Janssen, R. (2012): Energy efficiency policies in buildings – the use of financial instruments at Member State level. BPIE, http://bpie.eu/documents/BPIE/publications/BPIE_Financial_Instruments_08.2012.pdf

Cambridge Econometrics, Ricardo-AEA (2013) An economic assessment of low carbon vehicles, http://europeanclimate.org/documents/Cars-Economic-assessment-vehicles-FINAL.pdf

Clemenz, G. (2012) Intra-industry trade, environmental policy and innovations: the porter hypothesis revisited. Regulatory Policy Program Working Paper RPP-2012-09, Cambridge, MA: : Mossavar-Rahmani Center for Business and Government, Harvard Kennedy School, Harvard University.

Copenhagen Clean Tech Cluster (2012) The global clean tech report. A snapshot of future global markets – showing market growth and clean tech opportunities, Copenhagen.

Copenhagen Economics (2012), Multiple benefits of investing in energy efficient renovation of buildings - Impact on Public Finances, http://www.renovate-europe.eu/uploads/Multiple per cent20Benefits_per cent20Study_Key_per cent20Messages_per cent20Brochure.pdf

Danish Energy Association (2012), New energy efficiency directive creates growth, http://www.danishenergyassociation.com/Theme/Directive.aspx

Deutschen Unternehmensinitiative Energieeffizienz e.V. (DENEFF) (2013) Branchenmonitor Energieeffizienz 2013, Berlin.

Diefenbach, N., Stein, B., Loga, T., Rodenfels, M., Gabriel, J., Fette, M. (2012) Monitoring der KfW-Programme „Energieeffizient Sanieren" und „Energieeffizient Bauen" 2011

EC (2012): Reaping the benefits of globalization, Commission Staff Working Document SWD (2012)299 final

EC (2011): COMMISSION STAFF WORKING DOCUMENT IMPACT ASSESSMENT Accompanying document to the Energy Efficiency Plan 2011 Brussels, 8.3.2011 SEC(2011) 277 final

ECA – European Court of Auditors (2012) Cost effectiveness of Cohesion Policy Investments in energy efficiency, Special report no 21 / 2012, Luxembourg.

ECEEE – European Council for an Energy Efficient Europe (2013): European competitiveness and energy efficiency: focusing on the real issue. A discussion paper. Download at http://www.eceee.org/press/2013/highlighting-real-issue-on-energy-and-competitiveness/ee-and-competitiveness

Ecofys (2012), Economic benefits Ecodesign: Saving energy, improving European economies

Ecofys (2013), Saving energy: bringing down Europe's energy prices for 2020 and beyond

EEA (2013), Total Primary Energy Intensity Assessment, http://www.eea.europa.eu/data-and-maps/indicators/total-primary-energy-intensity-1/assessment

EEA (2012), The contribution of transport to air quality – TERM 2012: Transport indicators tracking progress towards environmental targets in Europe. EEA Report No. 10/2012, Copenhagen.

Eichhammer, W., Walz, R. (2011), Industrial Energy Efficiency and Competitiveness, UNIDO working paper 05/2011

ETUC (2012) Trade Union Vision On Sustainable Transport project. http://www.itfglobal.org/etf/trust.cfm

Farley, K. et al. (2012), Impacts of Energy Efficiency Provisions in Pending Senate Energy Efficiency Bills, ACEEE White Paper May 2012

Finger, M., Ruester, S., Schwenen, S., Lassource, A., Glachant, J. M. (2013), A New EU Energy Technology Policy towards 2050: Which Way to Go? European University Institute.

German Federal Ministry for the Environment (2012), GreenTech made in Germany 3.0, Environmental Technology Atlas for Germany, February 2012.

Global Industry analysts (2013) Heat Exchangers – a strategic business report, executive summary, download at http://www.prweb.com/releases/heat_exchangers/shell_tube_plate_frame/prweb10148825.htm

Goldberg, A., Reinaud, J. (no date): Promoting Energy Management Systems through Energy Efficiency Programmes, Incentives and Support – Lessons Learnt from Evaluations in Denmark, Ireland and Sweden

IEA (2009), Transport, Energy and CO_2: Moving Toward Sustainability, http://www.iea.org/publications/freepublications/publication/transport2009.pdf

IEA (2010), Transport Energy Efficiency Implementation of IEA Recommendations since 2009 and next steps, https://www.iea.org/publications/freepublications/publication/transport_energy_efficiency.pdf

IEA (2012), Spreading the Net: The Multiple Benefits of Energy Efficiency Improvements, http://www.iea.org/publications/insights/ee_improvements.pdf

IEA (2012a), World Energy Outlook. OECD/IEA, Paris.

INFRAS (2007): Auswirkungen von Energieeffizienz-Massnahmen auf Innovation und Beschäftigung. Inputpaper für den Energie Trialog Workshop vom 25. Oktober 2007, Zürich, 17.Oktober 2007.

Kuckshinrichs, W., Kronenberg, T., Hansen, P. (2012): Wirkungen der Förderprogramme „Energieeffizientes Bauen“, „Energieeffizient Sanieren“ und „Energieeffiziente Infrastruktur“ der KfW auf öffentliche Haushalte: Förderjahr 2011.

Laitner, J.A. & V. Mc Kinney (2008), Positive Returns: State Energy Efficiency Analyses Can Inform U.S. Energy Policy Assessments, ACEEE

Laitner, J.A. (2013), Calculating the Nation’s Annual Energy Efficiency Investments, ACEEE Report Number E133

Meijer, F. et al. (2012) Job creation through energy renovation of the housing stock, NEUJOBS Working Paper D14.2, December 2012 http://www.neujobs.eu/sites/default/files/publication/2013/01/Energy%20renovation-D14-2%2019th%20December%202012_.pdf

Navigant (2013) Materials in Green Buildings. Timber, Steel and Metals, Concrete, Glass, Insulation, and Other Materials Utilized for Structural, Building Envelope, and Interior and Finishes Applications in Commercial and Residential Green Buildings, http://www.navigantresearch.com/research/materials-in-green-buildings

Pehnt and al. (2011), Energieeffi zienz: Potenziale, volkswirtschaftliche Effekte und innovative Handlungs- und Förderfelder für die Nationale Klimaschutzinitiative, http://www.ifeu.de/energie/pdf/NKI per cent20Zusammenfassung_Endbericht per cent20NKI_per cent20V37.pdf

PIKE Research (2013) Executive Summary: Demand Response for Commercial Buildings Load Curtailment, Dynamic Pricing, and Ancillary Services for Commercial Buildings: Global Market Analysis and Forecasts, http://www.navigantresearch.com/research/demand-response-for-commercial-buildings

PIKE Research (2012) Executive Summary: Energy Efficient Homes. Building Envelope, Lighting, HVAC and Appliances, Water Heating, Energy Audits, and Soft Costs: Global Market Analysis and Forecasts, download at http://www.navigantresearch.com/research/energy-efficient-homes

Porter, M. and van der LInde, C. (1995) Green and competitive. Ending the stalemate. Harvard Business Review September/October 1995.

PriceWaterhouseCoopers (2013) Decarbonisation and the economy. An empirical analysis of the economic impact of energy and climate change policies in Denmark, Sweden and Germany, Study for the European Climate Foundation, Brussels (forthcoming).

Prognos (2013): Ermittlung der Wachstumswirkungen der KfW-Programme zum Energieeffizienten Bauen und Sanieren.

Rexhäuser, S. and Rammer, C. (2013) Environmental innovations and firm profitability: unmasking the porter hypothesis, Environmental and Resource Economics (May 2013)

Scheer, J., Motherway, B. (2011): Economic Analysis of Residential and Small-Business Energy Efficiency Improvements. Sustainable Energy Authority of Ireland.

Stenqvist, C., Nilsson, L.J. (2013): Energy efficiency in energy-intensive industries – an evaluation of the Swedish voluntary agreement PFE, Energy Efficiency, May 2012, Volume 5, Issue 2, pp225-241.

Sustainlabour (2013) Green jobs and related policy framework – an overview of the European Union, http://www.sustainlabour.org/recurso.php?lang=EN&idrecurso=590

Ürge-Vorsatz, D. et al. (2010): Employment Impacts of a Large-Scale Deep Building Energy Retrofit Programme in Hungary. Prepared by the Center for Climate Change and Sustainable Energy Policy (3CSEP) of Central European University, Budapest, on behalf of the European Climate Foundation.

US EPA (2008), Understanding Cost-Effectiveness of Energy Efficiency Programs: Best Practices, Technical Methods, and Emerging Issues for Policy-Makers, http://www.epa.gov/cleanenergy/documents/suca/cost-effectiveness.pdf

Walz R. (1999), Productivity effects of technology diffusion induced by an energy tax. Energy and Environment, 10(2):169-180

Worrell (2001), Productivity Benefits of Industrial Energy Efficiency Measures, http://escholarship.org/uc/item/0013f49z

Zpryme (2013) Smart Grid Core & Enabled-Tech Market $220B by 2020, sayzs Zpryme report. Press release http://www.prnewswire.com/news-releases/smart-grid-core--enabled-tech-market-220b-by-2020-zpryme-reports-185349102.html