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BURDEN SHARING
Impact of Climate Change mitigation policies on growth and jobs

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STUDY FOR THE EUROPEAN PARLIAMENT'S TEMPORARY COMMITTEE ON CLIMATE CHANGE

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BURDEN SHARING - IMPACT OF CLIMATE CHANGE MITIGATION POLICIES ON GROWTH AND JOBS

CONTENTS

EXECUTIVE SUMMARY

The impact of climate change mitigation measures on growth and jobs has to date been little investigated, and its implications on different economic sectors is still subject to debate. An overall picture of the existing analysis could be helpful to understand the status of knowledge on the subject so far, and key findings. This report therefore aims to provide a useful synthesis and review of existing studies addressing the impact of climate change mitigation polices – aimed at CO_2 reductions – on growth and jobs. It also looks at the implications of different mitigation scenarios for 2020 and beyond. In the review, particular attention is given to the impacts of these policies on different economic sectors.

The study reveals that, according to many literature sources, mitigation policy will lead to job creation in some sectors (e.g. related to RES, energy efficiency, CCS, etc), while some jobs will be lost in others (e.g. related to fossil fuels and production of inefficient products). In general, many studies highlight that the overall net effect is likely to be positive, as jobs in less labour intensive industries could be replaced by jobs in more labour intensive ones, or in sectors with longer value chains – hence having wider effects in the economy. The ETUC foresees a small but positive increase of 1.5% in the number of jobs in the next 10-20 years.

Furthermore, the average cost of mitigation is usually considered relatively small, in the order of no more than 1% of GDP (Stern, 2007) – with changes to assumptions resulting in slightly higher and lower estimates. According to some, aggregated EU GDP could even slightly increase thanks to positive restructuring of the economy, such as the opening of profitable new markets (e.g. RES, CCS technologies and fuel efficient vehicles).

At the sectoral level, it is expected that most job reallocation will happen within rather than across sectors. The sectors that will need major restructuring will be the greenhouse gas (GHG) intensive sectors, especially the energy and energy intensive industries. The production of cement and lime, steel, aluminium, primary container glass and some basic chemicals are for instance expected to be among the activities most affected by climate policies.

The overall effects of mitigation policies on growth and employment in the *energy sector* are expected to be negative, although they may be more a reduction of growth than an absolute decline. Depending on the scenario chosen, a greater or lesser growth of employment is projected for electricity generation from renewable sources, especially from biomass and wind. This should compensate to some extent for job losses in electricity generation from non-renewable sources (e.g. coal and oil).

Europe’s *iron and steel* sector has gone through a massive transformation in the past decade and is still subject to uncertain developments at the global level. As a result, the assessment of the impacts of mitigation policies differs widely between sources. According to the European Commission, the impact of climate policies on the output of the iron and steel sector could be between 5 and 8% in 2020 (in comparison to BAU). The impact on employment would be roughly in the same order of magnitude. In the most pessimistic ETUC scenario, however, the impact of climate policies could be up to 37% of current and baseline production, endangering the employment of 80,000 people.

Many studies reveal that the impacts of climate change policies on future activity and employment in the *cement sector* are likely to be limited, in the order of a few percentage points. In the worst-case scenario, employment could fall by 8,000 (15%) by 2030.

The effect of climate change policies on growth and employment in the European *transport sector*, however, is ambiguous. Fuel efficiency measures to reduce CO_2 emissions per km for passenger cars are assumed to have a relatively marginal impact on growth and direct employment in the automobile sector, while they could stimulate growth and employment in the upstream component supply sectors. The economic and social impacts of bringing aviation under the EU ETS were assessed to be minor, while the environmental benefits could be substantial. With respect to policies that affect the relative prices of transport modes, some modes will lose while others may win. Overall it is possible that employment would be positively stimulated by policies that rebalance transport modes in favour of less-emitting modes (rail), and that stimulate clean technologies in all forms of transport.

At the same time, the *construction sector* is expected to experience significant job creation. Employment is already stimulated by existing policies aimed at energy efficiency in buildings, increasing the overall demand for construction workers by almost 1%. Additional policies and measures have great potential in terms of energy savings, CO_2 reduction, and employment, especially in the new Member States. These policies and measures could increase growth and employment in the construction sector by an additional 3%.

In general terms, in some cases energy savings led by climate policies can actually result in lower costs for industries, leading to competitiveness advantages. In most cases, though, it is expected that mitigation policies will negatively affect the competitiveness of industries exposed to international markets which do not have similar policies. There is the risk that some carbon intensive industries will be relocated abroad, where climate policies are less stringent and hence less expensive. It was highlighted, however, that only a small number of the sectors most affected by GHG reduction measures may actually risk relocation. Some for instance do not have internationally mobile plants and processes. Others are less exposed to competition – for example the cement sector – due to high transportation costs. Also, other factors may come into play in the decision to relocate, like quality of capital and workforce, access to technologies and infrastructures and so on, which may be more relevant than emission reduction costs.

Competitiveness impacts across countries could also be reduced by the use of sectoral agreements across segments for GHG-intensive industries. According to the European Commission, global sectoral agreements could lead to substantially greater GHG reductions at the global level and have a small positive effect on the output performance of energy intensive industries (European Commission, 2008).

The cost of emission abatement for the economy could also be reduced by access to international carbon credits. This may imply lower costs for industries, hence reduced job losses, including for GHG-intensive sectors, which could abate their emissions more cheaply by buying credits abroad. The downside is that the possibility to reduce emissions cheaply elsewhere may reduce the emphasis on developing mitigation solutions domestically, hence leading to lower emission reductions within the EU than if no access to CDM was allowed. As a consequence, investment on research and development (R&D) may be lower than in the case of no CDM, and some opportunities to develop leadership in green technologies may be lost, which may also harm medium and long-term industrial development and employment in Europe. Some limitation to CDM – so that the carbon price remains relatively high – could however stimulate innovation internally.

Furthermore, in order to reduce the burden on the sectors most hit by climate policies, free allocation of ETS allowances to energy intensive industries on the basis of benchmarks has the potential to make a strong contribution to avoiding significant.

1 INTRODUCTION AND BACKGROUND

Climate change mitigation measures have an increasing role in EU policy. In January 2008 the European Commission (EC) released an integrated package of measures to reduce greenhouse gas (GHG) emissions by 20% by 2020, or by 30% if an international agreement on emission mitigation were to be reached. In order to meet these objectives, the EC proposed to increase the Community's share of energy from renewable sources, improve energy efficiency, reduce emissions from Emissions Trading Scheme (ETS) and non-ETS sectors, and promote new technologies and fuels like carbon capture and storage (CCS) and bio-fuels.

The impacts that these policies will have in on the environment, like the link between new technologies and energy sources on GHG reductions, have been widely discussed and, although the answer may not be straightforward, the implication of mitigation policy on the environment is broadly understood. Broad cost implications have also been estimated in many studies. However, the potential impact on specific different economic sectors is subject to much debate, and perceived in very different ways by stakeholders. Industry highlights high emission reduction costs. NGOs argue that costs will be relatively small. The repercussions on employment are yet more difficult to asses, and so far have been relatively little investigated.

This study aims to provide a useful synthesis and review of existing studies which address the impact of climate change mitigation polices – aimed at CO_2 reductions – on growth and jobs. In the review, particular attention was given to the impacts of these policies on different economic sectors.

On the basis of the assumptions and scenarios developed in a number of studies, and of the climate mitigation targets recently established by the European Commission, the study provides also some insights on the possible impacts on employment and growth related to different scenarios of mitigation, for 2020 and beyond.

Chapter 2 provides a synthesis of the literature review, which looked at the main findings highlighted in some of the most recent studies exploring the link between mitigation, growth and employment. Chapter 3 focuses on the implications for key economic sectors – namely energy, iron and steel, cement, transport and construction sectors – in the basis of existing information. Chapter 4 highlights the implications of alternative mitigation pathways and policy design on growth and jobs. Chapter 5 presents the key conclusions and recommendations. A more extensive literature review is provided in Annex 1.

2 SUMMARY LITERATURE REVIEW

The link between climate change mitigation policy, growth and jobs is a complex one. The issue is also relatively recent, hence the existing literature on the subject is not wide and there is an ‘obvious lack of knowledge’ on the relation between climate change and employment (ETUC, 2005). Nevertheless, with interest rising in climate change and in its implications, a number of studies at national and European level have recently been developed. A summary of key findings from recent publications on the issue is provided below. A more extensive overview of literature sources can be found in Annex 1, providing the key assumptions and findings of each single report.

2.1 Overall impacts of mitigation policies on growth

Most of the studies analysed suggested that climate change policies will not be detrimental to the economy. The costs of mitigation, in terms of GDP, are considered to be relatively small.

The Stern report (Stern, 2007) estimated that the annual cost of cutting total greenhouse gas (GHG) emissions to about three quarters of current levels by 2050 (consistent with a 550ppm CO_2e stabilisation level) will range between a benefit of 1.0 to a cost of 3.5% of GDP, with an average estimated cost of approximately 1% (i.e. about €350-400b). The range taken into consideration was wide because of the uncertainties as to future rates of innovation and fossil-fuel extraction costs. What the exact cost will be will depend on the future cost of low-carbon technologies (which are expected to be cheaper than currently), and also on improvements in energy efficiency.

The Joint Research Centre (JRC, 2007) estimated that, in the EU27, the climate policy repercussions in all sectors will lead to a GDP decrease of 0.19% in 2020 (per year) and of 0.24% in 2030, compared to the baseline scenario. Worldwide, the annual impact of climate policies on global GDP will be a decrease of 0.14% by 2020, and of 0.19 by 2030. Climate policies were also expected to reduce annual consumers’ welfare by 0.20% by 2020 in the EU27 (against 0.10% worldwide), and 0.26% by 2030 (against 0.15% worldwide). World average welfare reductions are smaller than EU values because it was assumed that consumers in developing regions with large reduction potential will benefit from emission trading revenues.

The recent impact assessment accompanying the Commission’s integrated package of measures on climate change, released in January 2008, calculated that, given a cost-effective emission reductions approach, the European GDP in 2020 would be on average 0.54% lower than it would otherwise be without these measures. Overall, these cost impacts are considered to be limited. If the policies were implemented the GDP is expected to grow by 37.46% over the period 2005-2020, instead of 38% as in the baseline scenario. Private consumption is also projected to decrease by a very limited extent, i.e. by 0.11% (European Commission, 2008).

2.2 Overall impacts of mitigation policies on employment

Many studies have estimated that climate policies will create new job opportunities, leading to job reallocation and, potentially, an increase in employment levels.

The Stern report highlighted that the expected growth in the markets for renewable energy generation products, stimulated by climate change policies, will be accompanied by a significant shift in employment patterns. It is expected that by 2050 the number of people working in this sector will grow from the current 1.7 million to more than 25 million worldwide (Stern, 2007).

The European Commission (2008) estimates that the impacts of mitigation policies on employment could lead to a 0.41% reduction in jobs by 2020, though this figure would be affected by different assumptions on international mitigation efforts and the use of the CDM (see table 3 in section 2.6) (European Commission, 2008).

According to the ETUC, CO_2 emission control measures can have a relatively small but positive effect on overall employment, resulting on an increase in employment of 1.5% in the EU25 in the coming 10-20 years (ETUC, 2005).

GHK, IEEP and Cambridge Econometrics (2007) find that, even if direct effects of policy options on growth and jobs may be neutral or small (reflecting quite often the substitution from 'less green' to 'greener' options), indirect effects can be much larger, generally indicating that the EU economy would gain, especially in employment terms, from the introduction of environmental polices that change current production systems.

2.3 Impacts of mitigation policies at sector level

The ETUC study highlighted that the implementation of climate policies will lead to a large-scale redistribution of jobs, but rather within than between sectors. All sectors will be affected. Jobs will be created in companies taking advantage of the opportunities created by mitigation policies, and lost in companies which will not be able to adapt (ETUC, 2005).

The Stern report also noted that it will be cheaper, per tonne of GHG, to cut emissions from some sectors rather than others, as in some there will be a larger selection of better-developed technologies. For example, the range of emission-saving technologies in the power generation sector was considered better developed than in the transport sector (Stern, 2007).

Among the major trends, transfer of jobs from the power generation sector to activities related to energy efficiency is foreseen by the ETUC. In the transport sector jobs are expected to move from goods transport by road and private car to public transport activities for freight and passengers, as a consequence of readjustments in the modes of transport and reduced activity in freight. Jobs are also expected to be created in the equipment sector for renewable sources of energy and co-generation, for energy efficiency goods and services, rolling stock and – in one of the scenarios – nuclear energy. These will gradually replace 'old' jobs related to the design, engineering and construction of equipment for power generation from fossil fuels and private road vehicles. The construction sector is also expected to be positively influenced by mitigation policies, the benefits deriving from the need for insulation and energy renovation of buildings, and from the construction of new infrastructures (e.g. for transport and energy). Overall, climate policies are expected to contribute to rising demand for increasingly educated and qualified workers (ETUC, 2005).

The Stern report also highlighted that climate policies can be a driver for a prolonged period of strong growth in the markets for low-carbon energy technology, equipment and construction. Enormous investment will be required in alternative technologies and processes. For instance, it was estimated that cumulative investments in low-carbon power generation technologies by 2050 could be over $30 trillion. The market for these technologies could be over $500b per year by then (Stern, 2007).

Despite the positive effect on some sectors, others are likely to be negatively affected by climate policies. Most likely, the cost of mitigation will be felt more strongly by GHG intensive sectors, which will require the most structural adjustments. Activities like gas supply and distribution, refined petroleum, electricity production and distribution, cement, fertilisers, fishing, together with metals, chemicals, paper/pulp and transport, have the greatest global carbon emissions from fossil fuels, and hence are likely to be most hit by climate mitigation measures (Stern, 2007).

The European Commission estimated that some 50 sub-sectors of the energy intensive industries[1] will require some increases in prices (between 0.1 and 5%) to recoup costs imposed by on carbon price. Among the these sub-sectors, cement and lime production, primary steel (blast oxygen furnace), aluminium production, production of primary container glass and some basic chemicals (ammonia, nitric acid, fertilizer production) were mentioned. Sectors most at risk were considered the aluminium production, primary steel (blast oxygen furnace) and some chemicals – due to their limited ability to pass through additional costs. It was noted that the cement sector is unlikely to be significantly exposed to international competition, due to high transportation costs. It was also estimated that increases in energy costs will be higher in the ferrous metals sector (i.e. iron and steel), but that access to CDM could reduce these impacts. The competitiveness problem for energy intensive industries hence appeared to be concentrated in a limited number of 'genuinely energy intensive industries' that are exposed to international competition (European Commission, 2008).

JRC analysed in more detail the impacts on energy intensive industries, i.e. ferrous metals, paper, mineral, non ferrous metals and chemicals products. The analysis confirmed that increases in energy costs due to mitigation policies will be higher in the ferrous metals sector (iron and steel). If guarantee of origin (GO) trading in the electricity sector were to be restricted, electricity prices could increase and further negatively affect energy intensive sectors exposed to competition. Access to CDM is expected to reduce these impacts. A summary is provided in the table below.

	Reference scenario[2]	**Reference scenario + no GO trade**	**Reference scenario + access to CDM up to 25% reduction effort**
Share RES (%)	20%	22.60%	20%
Change EU CO2 emission cf 1990 (%)	-16.80%	-16.80%	-11%
Electricity price (% change vs BAU in 2020)	22%	30.70%	13.90%
Welfare loss (% change vs BAU in 2020)	-0.69%	-0.92%	-0.51%
Ferrous metals (%)	-8	-8.5	-5.4
Paper products (%)	-1.1	-1.3	-0.7
Mineral products (%)	-2.8	-3	-1.8
Non-ferrous metals (%)	-6.5	-7.4	-4.2
Chemicals output (%)	-4.3	-4.6	-2.7

Table 1: Impact of transfers of renewable targets and JI/CDM on sector output (% change compared to BAU)

Source: Based on Pace – as in EC, 2008

[1] '*Business entities where the purchase of energy products and electricity amounts to at least 3.0% of the production value'* – according to the Energy Products Tax Directive (2003/96 EC, OJ L283 of 31.10.2003)

[2] The reference scenario is characterised by partial auctioning (20% in 2012 plus 10% per annum of allowances for all ETS sectors – i.e. full auctioning by 2020 – excluding the power sector, which is fully auctioned throughout the entire period), an efficient system-wide cap for the ETS, regionally differentiated marginal abatement cost for the non-ETS sectors and no access to JI/CDM. Guarantees of origin are tradable across EU member states. Auctioning is recycled to an economic agent representing both the government and households.

2.4 The effect of specific mitigation policies

The impact on employment and output of specific environmental policies related to climate mitigation were examined in a study by GHK, IEEP and Cambridge Econometrics (2007). The policy options looked at increased energy efficiency in the manufacturing sector and in Energy Intensive Industries (EII)[3], increase in bio-fuels in transport and increase in electricity generation from renewable energy technologies (at different levels of cost).

The overall effect on employment and output was positive in most sectors of the economy, with some jobs lost in the energy and energy-intensive sectors, but more than offset by job increases in other activities. An overview of the direct, indirect and total impacts on employment and output of the above mentioned policies is shown in table 2 below.

The direct and indirect effect of *increased energy efficiency (by 10%) in the manufacturing sector* for instance could lead to an overall output increase of €480m and to the creation of about 137,200 new jobs (taking all sectors into consideration). The large positive employment impact is mainly because there will be a relocation of workers from energy sectors (usually less labour intensive) to more labour intensive sectors. In addition, the energy sector also has a small supply chain, while the manufacturing sectors producing energy efficient technologies use inputs from a number of other sectors. This leads to a higher multiplier effect for both jobs and output.

Increased energy efficiency (by 10%) in EIIs is expected to result in a smaller, but still positive effect, leading to nearly €9 billion increase in output and 91,000 new jobs.

Increase in bio-fuels in transport (by 10%) could lead to an overall output increase of €1,500m and the creation of 139,500 new jobs. This is mainly due to the labour-intensity of the agriculture sector and the industries that supply it. Hence there will be a large direct boost to employment and on output due to the induced effect of higher income. If the cost of bio-fuels for the transport sector were to be higher than the substituted manufactured fuel, however, there would be a negative impact on profits and output of the transport sectors.

The net overall effect of an *increase in electricity generation from renewable energy technologies (by 10%)* will be an output increase of €8,613m and 58,200 new jobs. The economic impacts are positive because renewable energy requires inputs from a number of sectors at the design and installation stage. However, they require fewer inputs from other sectors (mainly fuels) and labour once they are up and running.

If the increase in electricity generation from renewable energy technologies happened *at higher cost*, the total effect could be increase in output of about €23b, and to a net increase of 58,600 jobs. The negative effects of higher energy prices (estimated at about 6%) would need to exceed this positive impact for there to be an overall net loss in GDP and employment.

[3] These include: Wood and Paper, Printing and Publishing, Pharmaceuticals, Chemicals, Rubber and Plastics, Non-Metallic Minerals Product, Basic Metals, and Metal Goods.

Policy Scenario	Net Direct Impact		Net Indirect Impact		Total Net Impact	
	Output (€ m)	Jobs (FTE)	Output (€ m)	Jobs (FTE)	Output (€ m)	Jobs (FTE)
10% energy saving in manufacturing	0	122,500	480	14,600	480	137,200
10% energy saving in EEIs	1,000	54,000	8,000	37,000	9,000	91,000
10% bio-fuels	0	108,100	1,500	31,400	1,500	139,500
10% RES	0	0	8,610	58,200	8,610	58,200
10% RES at higher prices	9,200	36,800	13,700	21,800	23,900	58,600

Table 2: The Economic Impacts of Selected Policy Scenarios
Note: Totals may not sum due to rounding
Source: adapted from GHK, IEEP and Cambridge Econometrics (2007)

2.5 The impact of the emission trading system

In the recent package of climate mitigation measures proposed by the EC in January 2008, the effort to achieve 20% GHG reduction (compared to 2005) has been split between the sectors covered by the EU ETS, which should reduced their emissions by 21%, and the sectors not covered by the ETS (such as transport, buildings, services, smaller industrial installations, agriculture and waste), whose emissions should be reduced by 10%. Although responsible for about 60% of total GHG emissions in EU, the sectors not covered by the EU ETS have been charged with a lower burden because reductions are considered more cost effective for the ETS sectors (especially the electricity sector) than for the non ETS. For the same reason, more than half of the 20% renewable energy target should be achieved by the ETS sectors (European Commission, 2008).

The European Commission also highlighted that the free allocation of ETS allowances to energy intensive industries on the basis of benchmarks can strongly contribute towards avoiding significant output losses without compromising total economy-wide performance, as CO_2 and electricity prices are hardly affected. This was considered a powerful tool to reduce carbon leakage and adverse effects on energy intensive industries, especially if free allocation would also allow for compensation due to carbon costs that arise from their electricity consumption, on the basis of appropriate benchmarks (European Commission, 2008).

2.6 The international dimension of climate policy

International decisions can significantly affect the impact of climate policies in EU growth and employment levels. First of all, GHG reduction targets may vary depending on a common international agreement on emission mitigation. This is explicitly the case in the EU, which committed to reduce GHG emissions by 20% by 2020 unilaterally, and by 30% if international agreements with appropriate reductions for other countries were to be reached.

Another international dimension is the impact of access to carbon markets on costs. The use of CDM could significantly reduce the costs of climate policy, leading to smaller GDP change (JRC, 2007). The Stern report also highlighted that international emission trading mechanisms, such as carbon trading and CDM, could limit costs substantially (Stern, 2007). According to the European Commission, access to JI or CDM up to a quarter of the GHG reduction effort may lead to reduced economy-wide welfare losses (-0.5% instead of -0.7% in the reference scenario), improving significantly the output performance of energy intensive industries and reducing the potential carbon leakage (see also Table 2 in section 2.3). The impact on economic variables (like GDP and employment) of different scenarios, including or excluding CDM and RES trade, are summarised in table 3 below (European Commission, 2008).

	Cost efficient reference scenario	Redistribution of non-ETS targets + no CDM	Redistribution of non-ETS targets + CDM	Redistribution of Non ETS targets + no CDM + redistribution RES targets + no RES trade
Carbon price ETS (€/tCO2)	39	43	30	47
Carbon price non-ETS (€/tCO2)	39	37	max 30	37
Direct costs (%GDP)	0.58	0.61	0.45	0.66
Macro economic effects				
Change in GDP (%)	-0.35	-0.34	-0.21	
Change in private consumption (%)	0.19	0.21	0.21	
Employment (%change in BAU)	-0.04	-0.09	0.05	
Sectoral Impacts (% change over BAU)				
Energy cost	6.4	6.3	4.4	6.8
Energy cost per Value Added Industry	12.6	13.5	9.6	14.3
Energy cost per Value Added Tertiary	1.7	2.2	0.7	3
Production change top 3 EEIs	-2	-2	<1.5	>-1.5

Table 3: Overview of impacts at EU level for key scenarios of impacts assessment
Source: European Commission, 2008

The JRC assessed the impacts of emission reductions by 31% (compared to 1990 levels) in case of international agreement, and of 21% and 31% in case the EU were to be the only region with emission reduction commitments. It further took into consideration the access to international markets. If an international agreement was reached and Europe cuts by 31%, mitigation policies will lead to a decrease of GDP by 2.8%. In case of no international agreement, a 21% emission reduction target was estimated to result in a 1.4% decrease in EU27 GDP by 2020, if no access to international markets were granted. A more ambitious unilateral target of 31% would lead to slightly higher costs, which were estimated to result on -2.3% GDP in case of no trade and -0.9% if access to the market was granted (JRC, 2007). The main findings are shown in figure xx.

It is interesting to note that, in the unilateral scenario (ie where only the EU is committed to emission reductions), the GDP change in case of a 31% target is lower than in the global GHG reduction scenario (2.3% versus 2.8%). This can be partially explained by the fact that the decrease of global emissions in the GHG reduction scenario is much higher than in the autonomous case (24% versus 4%), implying an effect on GDP levels of non-European countries that affects European growth via international trade effects (JRC, 2007).

	GHG reduction	Domestic emission reductions (EU27)			
	Trade	*Trade*	*No Trade*	*Trade*	*No trade*
Emission reduction by 2020 (compared to 1990)	*-31%*	*-21%*		*-31%*	
Access to global carbon market	Yes	No	Yes	No	Yes
Domestic emission reductions (compared to 1990)	-21%	-21%	4%	-31%	-7%
GDP impact in 2020 (compared to baseline)	-2.8%	-1.4%	-0.3%	-2.3%	-0.9%
GDP impact/year	-0.19%	-0.09%	-0.02%	-0.16%	-0.06%
Carbon price (€)	31	44.2	4.2	77.6	9.4
Global emission reductions (compared to baseline)	-24%	~ -3.5%		~ -4.6%	

Table 4: Impact of global and autonomous EU27 emission reductions and of the global carbon market on the EU 27 economy
Source: Elaboration from (JRC, 2007)

The Stern report noted that there is the risk that carbon intensive industries may relocate to countries where mitigation policies are not in place. It was highlighted, though, that only a small number of the sectors most affected by GHG reduction measures have internationally mobile plant and processes. In addition, where industries are internationally mobile, environmental policies will be only one determinant of relocation decisions, since other factors can play a decisive role - like the quality of capital and workforce, access to technologies and infrastructures, and market proximity. Trade diversion and relocation are also less likely if there is a strong expectation of eventual global policy action (Stern, 2007).

Sectoral agreements across segments for GHG-intensive industries were also considered to contribute to the promotion of international action for mitigating competitiveness impacts across countries (Stern, 2007). In this regard, the European Commission believes that global sectoral agreements could lead to substantially greater GHG reductions at the global level and have a small positive effect on the output performance of energy intensive industries. (European Commission, 2008)

The Commission also suggested that the inclusion of importers of energy intensive products in the EU ETS is estimated to impact positively on energy intensive industries' performance and generates some additional global GHG reductions. However, the net amount of allowances required by importers could create pressure on the ETS allowance price, which could have a negative impact on all ETS sectors and the economy as a whole. (European Commission, 2008)

3 SECTOR ANALYSIS

The following sections address economic and employment impacts of climate policy in several important sectors: energy, iron and steel, cement, transport, and construction. Analyses and scenarios are primarily drawn from ETUC (2007) and JRC (2007) to provide a consistent comparison of impacts.

3.1 The energy sector

3.1.1 Current state and trends

The energy sector in Europe (EU27) employs almost 2 million people. Its share in gross value added is 4.7% of Europe's non-financial business economy, but its share in labour is only 1.6%, making it a relatively low labour-intensive sector.[4] There are, however, marked differences between various sub-sectors such as, for example, mining and quarrying, refining and coke production, and the generation of electricity, steam and hot water (Eurostat, 2008). In 2004, total employment in the sector electricity, gas, steam and hot water supply was 1.3 million, of which almost 40% was in the 12 new Member States.

In the past decade (1996-2006), employment in the European energy sector has fallen, especially in mining and quarrying (-6.9% per annum). Although electricity generation has expanded over this period in terms of output (+2.0% per annum), its work force has decreased (-2.9% per annum) (Eurostat, 2008).

More than half of the electricity in the EU27 in 2005 was generated from fossil fuels (54%) and about a third from nuclear (30.2%). The remaining generation was in hydroelectric power (10.3%), and other renewables (biomass: 2.4%; wind: 2.1%; geothermal: 0.2%). For the EU27 as a whole, the share of renewable sources of energy in electricity generation increased by only one percent-point over the period 1995 (13%) to 2005 (14%). While some Member States saw a relatively large increase in the share of renewables in electricity generation (Denmark, Estonia, Hungary, the Netherlands), other Member States saw their shares falling (France, Portugal) (Eurostat, 2008).

3.1.2 Baseline scenarios of growth and employment in the energy sector

Baseline scenarios of the future development of the power sector in the EU, used in the ETUC and JRC studies, project a growth in the volume of electricity generated, with an annual growth between 1% and 2% (ETUC, 2007 and JRC, 2007).[5] Fossil fuels will remain the primary source, but the current trend of substitution of gas for coal will continue. The share of nuclear is expected to slightly decrease across Europe. The share of hydro is expected to remain stable, but the shares of biomass and especially wind are projected to increase substantially.[6] In the baseline scenarios, the share of renewables in electricity generation is projected to increase from 14% in 2005 to around 17% in 2020 (see Table 1).

[4] The share of the non-financial business economy in GDP is 75.7% in 2006. Hence, the share of the energy sector in GDP is 0.757 * 4.7 = 3.6%.

[5] ETUC projects an annual growth of power generation (in TWh) of 1.56% for EU25 over the period 2000-2020, while IPTS projects a growth rate of 1.12% over the period 2005-2020.

[6] ETUC projects annual growth rates of biomass and wind (in TWh) of 5% and 13%.

ETUC projects an increase in jobs[7] of 23% in the electricity sector over the period 2000-2020, or +1.0% per year. In percentage terms, the increase is higher in the renewables sector (+1.9% per year) than in the conventional sector (+0.7% per year). In addition, the JRC baseline scenario foresees a lower rate of growth in electricity generation. This may result in an approximately proportionally lower rate of employment growth.[8]

3.1.3 The impact of climate change policies on growth and jobs in the energy sector

The effect of climate policies and measures on employment in the energy sector can be decomposed into output and input-substitution effects. All else being equal, climate policies and measures will, by stimulating energy efficiency and conservation, reduce the demand for electricity and therefore its supply and its associated employment. However, climate policies also promote the substitution of CO_2 intensive inputs (like coal) for less CO_2 intensive inputs (such as solar, wind, hydro and biomass).

In the JRC greenhouse gas reduction scenario, total electricity generation in 2020 is 13% lower than in the baseline, while the share of renewables (including hydro) increases from 19% to 23%. In the ETUC WWF/WI scenario, total electricity generation is 16% lower than in the baseline due to increased energy efficiency, while the share of renewables increases to 38%. In the ETUC EEA Nuclear scenario total electricity generation is only 0.3% per year below baseline, while the CO_2 reduction target is met by an increase in the share of nuclear to 30%, and an increase in renewables to 27% (see Table 5).

Scenario	Description and targets	Timescale
BAU	GDP: +2.4%/year $CO_{2:}$ +0.44%/year Electricity demand: +1.6%/year Electricity mix: 21% Nuclear; 17% RES Nuclear plant: existing exit decisions	2020 2020 2020 2020
WWF/W1	GDP: +2.4%/year $CO_{2:}$ – 1.78%/year (or – 40% wrt 1990) Electricity demand: +0.7%/year Electricity mix: 24% Nuclear; 38% RES Nuclear plants: no additional plants	2020 2020 2020 2020
EEA nuclear*	GDP: +2.4%/year $CO_{2:}$ – 0.42%/year (or –20% wrt 1990) Electricity demand: + 1.3%/year Electricity: 30% Nuclear; 27% RES Nuclear plants: additional 40-50 plants	2020 2020 2020 2020 By 2030

Table 5: A summary of assumptions of the three scenarios in the ETUC report

** The planning horizon of EEA Nuclear is 2030, but the Annex to the ETUC report describes the scenario to the planning horizon of 2020.*

In the ETUC WWF/WI scenario, direct employment in the electricity sector in 2020 is 19.8% below employment level in the baseline. This total employment change is the result of a reduction of employment in the conventional electricity sector (fossil and nuclear) of 35% and an increase of employment in the renewable electricity sector of 61%. Compared to 2000, direct employment in the electricity sector would remain almost constant (-0.1%).

[7] Measured in full time equivalents (fte).

[8] Proportionality factor based on TWh growth factors is 1.12/1.56 = 0.7. Hence, in the IPTS baseline scenario, the increase in employment would be 70% of the increase in the ETUC scenario.

In the ETUC EEA Nuclear scenario, the effects on total employment would be minimal (-3.8% compared to baseline in 2030). There would be a shift in employment from fossil to nuclear and, to a lesser extent, renewables.

The IPTS/JCR reduction scenario, which is closest to the 2008 proposal by the European Commission, foresees a reduction in electricity consumption of 13% compared to baseline. This scenario is likely to have employment effects somewhere between these two extreme ETUC scenarios. The total effect on employment would be less than the WWF/WI scenario and also the shift in employment from conventional to renewable technologies would be less. As a fist approximation, the effect on total direct employment could be estimated by multiplying the relative change of employment in the WWF/WI scenario (19.8%) by the ratio between the relative changes in electricity output in the JRC and the WWF/WI scenarios (13/16). Using this approximation, the relative change in employment in the JRC scenario would be 16.1%. That is, total direct employment in the electricity sector in EU25 could be somewhere around 16% below baseline in 2020. Compared to 2000, a small increase in employment (+3.5%) in the electricity sector in Europe would still be possible. The increase in employment would, of course, be associated with the generation of electricity from renewable sources. Employment associated with the generation of electricity from conventional sources would fall by around 18%.[9]

There is limited evidence on the relative labour intensities between conventional and renewable energies. GHK et al. (2007) assume that the direct labour intensities are similar between the two technologies.[10] However, GHK et al. argue that renewable energies require more labour services from other sectors of the European economy (indirect labour) than conventional energies. They estimate, for EU27, so-called employment multipliers that measure the change in total employment (direct and indirect) between different technologies. They estimate that, for the EU27 on average, a substitution of 10% of output of the renewable electricity sector (€16b in value) for output from the non-renewable (conventional) electricity sector, will, on balance, increase indirect employment by 58,000 jobs. The indirect employment is especially forthcoming in the design and installation stages of new renewable capacities. This result illustrates the overall finding of this report that climate change policies are more likely to lead to a redistribution of jobs within and across sectors than to changes in absolute employment levels.[11]

3.1.4 Summary

While the output of electricity in Europe has increased in the last decade, employment has fallen. For the near to medium future, projections of economic growth and employment in the electricity sector suggest a growth of both output and employment, especially in the area of renewables.

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9 Estimated on the basis of the ETUC WWF/WI scenario, taking into account the differences in the effects of policies on total electricity generation and a shift to renewables.

10 Labour intensity can be measured as fte per TWh. In 2020, the labour intensity of electricity generation in Europe is expected to be around 86 fte/TWh.

11 It should be noted, however, that although employment multipliers are informative, they are of limited use in quantitatively assessing total employment effects of policies. This is because employment multipliers are typically partial equilibrium concepts that do not fully take account of macroeconomic adjustments because of changes in the relative prices of goods and factor of production (including labour). To take these adjustments into account would require the use of a detailed (general equilibrium) macroeconomic model of EU27 with a full representation of the relevant labour markets.

Climate change policies are expected to have an impact on growth and employment, but the extent of their effect depends on the stringency and the design of the policies. Previous scenario studies have predicted impacts on the volume of electricity generation in 2020 between -3% and -16%, and on associated (direct) employment between -4% and -20%. The JRC scenario, which is closest to the climate change policy proposal of the Commission, is in-between these extremes. In the JRC scenario, the volume of electricity generation in 2020 is 13% less than it would have been without (additional) policies. While the IPTS/JRC scenario does not report employment effects, extrapolation from the ETUC scenarios suggest that direct employment in the electricity sector could be around 16% below baseline in 2020. Compared to the year 2000, a small increase in employment (+3.5%) in the electricity sector in Europe would still be possible.

The overall effects of mitigation policies on growth and employment in the energy sector are expected to be negative, although they may be more a reduction of growth than an absolute decline. Depending on the scenario chosen, a larger or lesser growth of employment is projected for electricity generation from renewable sources, especially from biomass and wind. This should compensate to some extent for job losses in electricity generation from non-renewable sources – which are likely to be negatively affected by climate policies.

3.2 The iron and steel sector

3.2.1 Current state and trends

Over the past decade, the iron and steel sector in Europe has been subject to deregulation, privatisation, concentration, modernisation, and globalisation. Due to its particular circumstances, the transformation of the iron and steel sector in Eastern Europe was particularly dramatic and is still continuing. The production volume of the European iron and steel industry (in tonnes) shows a stable trend (200 MT per year), but there is continued increase in the value added per tonne produced. Labour productivity in the sector has increased dramatically (tonnes of raw steel per employee), so, because of the non-increasing volume of production, total employment in the sector has fallen. Over the last decade, employment in Western Europe has fallen from 330,000 to 250,000 jobs. Employment in EU25 is about 350,000 (250,000 in the West and 100,000 in the East).

There are two major technological routes for the production of steel. The first is the pig-iron route, where as a first step of steel making, pig iron is produced from ore and coke in a blast furnace. In the second step of the pig-iron route, the impurities are removed from the pig iron and alloying elements are added. The second major technological route for steel making is the electric route, whereby ferrous scrap is recycled to secondary steel in an electric arc furnace. In Europe, 60% of steel is made thought the pig-iron route, while 40% is made through the electric route. The electric route is far less CO_2-intensive than the pig-iron route,[12] but unfortunately it does not seem to be possible to increase the share of the electric route in Europe because of the increasing unavailability of scrap (ETUC et al. 2007). After this hot, liquid phase of steel making, steel slabs and billets are converted into products by so-called cold transformations. It is estimated that around 50% of the jobs in the sector are directly or indirectly linked to the hot or liquid phase of steel making (ETUC et al., 2007).

12 The pig-iron route emits 2 tonnes of CO_2 per tonne of steel, while the electric route only emits 150 kg CO_2 per tonne of steel (ETUC et al., 2007).

3.2.2 Baseline scenarios of growth and employment in the iron and steel sector

The baseline scenario of growth in the iron and steel sector in Europe is one of stabilisation of the volume of production in association with an increase in value added per tonne of steel produced (especially in the cold phase of steel production). In terms of international competitiveness, no increase in exports is expected. There is rather a substantial risk that domestic production is substituted for by increased imports from Brazil, Russia and India (ETUC et al., 2007). It is not clear from the available literature, what this baseline scenario would mean in terms of employment, but given recent trends, a gradual reduction of employment may be expected.

3.2.3 The impact of climate change policies on growth and jobs in the iron and steel sector

The impact assessment of the Commission's implementation package on climate change and renewable energy includes an assessment of the impact of this package on the competitiveness of the iron and steel (ferrous metals) sector.[13] According to the PACE model, the output of the ferrous metals sector in 2020 is between 5.4% and 8.5% lower than in the business-as-usual (BAU) scenario, depending on access to CDM and the possibility of trading in Guarantees of Origin in the electricity sector (EC, 2008).

According to the Impact Assessment, there are several measures, apart from the access to CDM that could reduce the negative impact on sector output to about 4.8%. Although the impact assessment does not address employment explicitly, it may be assumed that the impact on employment is proportional to the impact on output.

The results of the Impact Assessment are in line with results of a recent paper by Demailly and Quirion (2007). This paper explicitly addressed the impacts of the EU ETS on competitiveness of the European iron and steel industry in the period 2008-2012. The authors assessed both the impact of EU ETS on *output* and on *profits*.[14] They argued that the EU ETS might impact these variables in very different ways. Their main conclusion was that, under a wide range of parameter assumptions, the expected loss of output is very likely to stay under 2%, well within the range of 'normal' inter-annual fluctuations. The effect on profits crucially depends on the way of allocation of allowances. The authors argue that, roughly speaking, allocating half of the allowances for free would maintain profits, whatever the price of CO_2.

ETUC et al. (2007) developed two scenarios for the impacts of climate change policies on the iron and steel sector. Their results differ from the assessments presented above. In the fist scenario, climate change policies are implemented through a continuously stricter carbon constraint on the sector, without flanking and compensating measures. By 2030, this could mean the delocalisation of 50 to 75 MT of slabs outside the EU (25% to 37% of current production), threatening 54,000 to 80,000 jobs (direct, internal and outsourced) may be at stake. The second scenario includes various measures to protect the European iron and steel sector. The measures include the free allocation of quota on the basis of benchmark CO_2 rates for pig-iron and electric steel, respectively; the offsetting of electricity price increases; and a carbon-equalisation mechanism for competing imports. In this second scenario, about 34,000 to 50,000 jobs could be saved (ETUC et al., 2007).

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13 The PACE model is a general equilibrium model with electricity sector detail, developed by Christopher Böhringer and others.

14 Profits are defined as earnings before interests, taxes, debt, and amortization (EBITDA).

3.2.4 Summary

Europe's iron and steel sector has gone through a massive transformation in the past decade and is still subject to uncertain developments at the global level. Under these circumstances it is not easy to define a business-as-usual scenario, let alone to assess the additional impacts of climate policies. As a result, the assessment of these impacts differs widely across sources. In the Commission's Impact Assessment, the impact of climate policies on the output of the iron and steel sector could be between 5 and 8 % in 2020 (in comparison to BAU). The impact on employment would be roughly in the same order of magnitude. In the most pessimistic ETUC scenario, however, the impact of climate policies could be up to 37% of current and baseline production, endangering the employment of 80,000 people.

3.3 The cement sector

3.3.1 Current state and trends

Over the past decade, the cement sector in Europe has been subject to a process of restructuring and rationalisation, resulting in the closure of 27 cement works in EU25 (or 10% of European capacity).[15] At the moment, six countries dominate cement production in Europe.[16] The recent growth in consumption of cement has only partially been matched by domestic production, the gap between demand and supply being filled by increasing imports, especially from countries in the Mediterranean basin (Turkey, Morocco). In 2003, imports covered 14% of domestic consumption. Between 1999 and 2005, employment in Western Europe has fallen by 6,290 jobs (-13.1%). In the period 2003-2005, employment in EU25 also fell by 3,650 jobs (-6.4%). The production of cement in EU25 in 2005 is 239 million tonnes, sustaining 53,300 jobs. The financial position of the sector is considered to be solid (ETUC et al., 2007).

3.3.2 Baseline scenarios of growth and employment in the cement sector

In the baseline scenario of growth and employment, ETUC et al. (2007) assume a continuing growth of consumption by 1% or 2% per year. With rising labour productivity, employment remains stable at the current 53,300 jobs. CO_2 emissions from the sector rise by 2.6% in 2012, and by 5.2% in 2030, compared to emissions in 1990.

3.3.3 The impact of climate change policies on growth and jobs in the cement sector

The impact assessment of the Commission's implementation package on climate change and renewable energy includes an assessment of the impact of this package on the competitiveness of the minerals sector (including cement). According to the PACE model, the output of the minerals sector in 2020 is between -1.8% and -3.0% lower than in the business-as-usual (BAU) scenario, depending on access to CDM and the possibility of trading in Guarantees of Origin in the electricity sector (EC, 2008). The Impact Assessment adds that the cement industry is unlikely to be significantly affected by international competition due to high transportation costs, although there is a marked increase in trade in the Mediterranean basin. Being less exposed to international competition means that it is easier for the sector to pass on increased CO_2 costs to its customers.

15 In this period only 2 new cement works were built (in Ireland).

16 Together, Spain, Italy, Germany, United Kingdom, France, and Poland have 73% of the production capacity in Europe (ETUC et al., 2007).

ETUC et al. (2007) developed two scenarios for the impacts of climate change policies on the cement sector. In the fist scenario, climate change policies are implemented through a continuously stricter carbon constraint on the sector, without flanking and compensating measures. Emissions in 2012 are -8% below 1990 emissions; in 2030 they are -30% below 1990 emissions. On the basis of a technical assessment of mitigation options, ETUC et al. (2007) assume that a reduction of 30% is feasible through the implementation of relatively inexpensive conventional measures. The effects on activity and employment in the sector (relative to baseline) are estimated to be around -4% in 2012 and -15% in 2030. This would translate into job losses of 2,100 in 2012 and 8,000 in 2030.The second scenario includes various measures to protect the European cement sector, a carbon-equalisation mechanism for competing imports and a publicly-funded R&D programme. In this second scenario, the levels of activities and employment would only experience a slight drop (-1.2%).

3.3.4 Summary

The European cement sector has been subject to a process of restructuring and rationalisation, resulting in a loss of employment, both in East and Western Europe. Currently, the sector provides 53,300 jobs. Future growth in production is expected to roughly follow growth in consumption in EU25 (1% a 2% per year), with a stable labour force. Across most studies, the impacts of climate change policies on future activity and employment in the sector are assessed to be limited, in the order of magnitude of a few percent. In the worst-case scenario, employment could fall by 8,000 (-15%) in 2030.

3.4 The transport sector

3.4.1 Current state and trends

The transport sector in Europe shows a healthy growth, at a rate of 2.8% per year - that exceeds the growth of total economic activity as measured by GDP (2.3% per year). The transport sector employs about 7.5 million people in EU25. Employment is increasing in transport, especially in the road-freight sector. Within the transport sector, employment in rail traffic is declining, both in the West and the East.

3.4.2 Baseline scenarios of growth and employment in the transport sector

A baseline scenario of growth and employment was developed by the Commission’s DG-TREN for its 2001 White Paper (ETUC et al., 2007). Passenger transport is projected to increase from 5893 billion person-kilometres in 2005 to 7407 billion person-kilometres in 2020 (+26%). Freight transport is projected to increase by 31% (to 3049 billion tonne-kilometres). Between the different modes of transport, aviation is projected to increase fastest, while train and bus are projected to increase at the slowest rates. Overall, for the period 2000-2030, employment generated by private passenger transport would increase by 1.6% per year; employment by rail passenger transport would increase by 0.8% per year; employment by road freight transport would increase by 2% per year; and employment by rail freight transport would increase by 0.5% per year.

3.4.3 The impact of climate change policies on growth and jobs in the transport sector

An important element of climate change policy in the transport sector concerns the recent regulation to limit CO_2 emissions from passenger cars. The objective of this regulation is to limit average CO_2 emissions by new passenger cars sold in 2012 to 120 g CO_2 per km. The Impact Assessment accompanying the proposal examined impacts on growth and jobs in the automobile industry (European Commission, 2007).

The Impact Assessment first estimated that the proposed fuel efficiency measures[17] could lead to a 6% increase in retail price. Because of the fairly inelastic price elasticity for new car sales, this would lead to a less than six percent reduction in sales, and an increase in the *value* of sales. The effects on direct employment were assessed to be relatively marginal. The effects on growth and employment of upstream component suppliers in Europe could be positive, as the measures could offer them new opportunities to market high-value added and innovative technologies. The fear of relocation of manufacturing capacity outside Europe is dampened by the observations that car manufactures tend to locate new production facilities near the location of demand and that both domestic and foreign manufacturers are subject to the same regulation (European Commission, 2007: 63).

While air transport accounts for 0.6% of EU's value added, it accounts for 3% of EU greenhouse gas emissions (European Commission, 2006). So far, aviation has not been subject to climate change policies. Therefore, the Commission has proposed to include aviation in the European Emissions Trading Scheme (EU ETS). According the Commission's Impact Assessment this could reduce aviation's emissions by 45-46% below baseline emissions in 2020. The impact on growth is expected to be small, at maximum a reduction of growth from 142% in the baseline to 135% in the ETS policy scenario. The small impact on growth reflects the fact that demand for aviation is, in general, not very price sensitive. It is also expected that competition between airlines would not be significantly affected. The policy-induced cost increase could increase public expenditures for maintaining air connections to ultra-peripheral regions (UPRs), especially for Italy (European Commission, 2006).

ETUC et al. (2007) report that policies aiming at the one hand to restrict transport activity and on the other hand rebalance transport modes in favour of rail, would lead to an overall growth in employment of around 2% on average per year for passenger transport and 1.25% for freight transport. Employment in the automobile branch would remain stable as a result of the increased added value linked to the spread of clean technologies. A reduction of employees in road transport (because of the rebalancing towards public transport), would pose the question of social support for the affected employees.

3.4.4 Summary

The effect of climate change policies on growth and employment of the European transport sector is ambiguous. Fuel efficiency measures for passenger cars to reduce CO_2 emissions per km are assumed to have a relatively marginal impact on growth and direct employment in the automobile sector, while they could stimulate growth and employment in the upstream component supply sectors. The economic and social impacts of bringing aviation under the EU ETS were assessed to be minor, while the environmental benefits might be substantial. With respect to policies that affect the relative prices of transport modes, some modes will lose while others might win. Overall it may well be that employment is positively stimulated by policies that rebalance transport modes in favour of less-emitting modes (rail), and that stimulate clean technologies in all forms of transport.

[17] Fuel efficiency measures would need to reduce CO_2 emissions to 130 g/km, while other measures (including an increased share of biofuels) would need to reduce emissions further to 120 g/km (European Commission, 2007).

3.5 The construction sector

3.5.1 Current state and trends

The turnover in construction in EU25 was €955 billion in 2004, corresponding to 13.2 million jobs.[18] Employment in the 10 new Member States was 1.5 million jobs.

3.5.2 Baseline scenarios of growth and employment in the construction sector

The baseline scenario assumes the implementation and strict application of two existing European directives: the directive relating to energy performance of buildings (EPBD) and the directive on the final uses of energy and energy services. According to ETUC et al. (2007), the implementation of these directives will require additional investments of 12 billion per year in the residential sector, creating additional employment of almost 110,000 jobs (of which 45,000 in the new Member States).

3.5.3 The impact of climate change policies on growth and jobs in the construction sector

Climate change policies could substantially increase turnover and employment in the construction sector. ETUC et al. (2007) discuss two scenarios that aim to further reduce emissions from buildings. The first based on the suggestion of the European Insulation Manufacturers' Association (Eurima) to extend the field of applicability of the EPBD directive to all dwellings in the EU (saving an estimated 70 million tonnes of CO_2 per year, or 16% of baseline emissions), and the second is called the 'Factor 4' scenario that aims at a reduction of 75% of emissions from the residential sector in the long term (2030 or 2050).

The Eurima scenario requires additional investments of €30 billion up and above the baseline, generating additional employment of up to 285,000 jobs in construction. The 'Factor 4' scenario could generate between 146,000 and 456,250 jobs (if the CO_2 reduction target should be met in 2050), or even much more if the reduction target should be met in 2030.

3.5.4 Summary

The construction sector is expected to be a big winner for climate change policies, both in terms of turnover and in terms of employment. Employment is already stimulated by existing policies aiming at energy efficiency in the buildings, increasing the overall demand for construction workers by almost 1%. Additional policies and measures have great potentials in terms of energy savings, CO_2 reduction, and employment, especially in the new Member States of the European Union. These policies and measures could increase growth and employment in the construction sector by an additional 3 percent.

[18] In full-time-equivalent (fte).

4 SYNTHESIS OF SCENARIOS AND POLICY OPTIONS

SECTORS	Models and scenarios				
Energy/ electricity	ETUC			JRC/EC	GHK
	Base case	*WWF1*	*Nuclear*		
Employment	+23% in 2020 (over 2000 levels, i.e. +1%/yr)	-19.8% compared to 2020 in BAU, which is -0.1% compared to 2000 levels	- 3.8% compared to base case	- 16.1% (compared to ETUC base case)*, +3.5% on 2000 levels*	+58,000 jobs compared to BAU
Iron & Steel	ETUC			IA Energy package	Demaillly &Quirion
	Base case	*Emission reduction without flanking measures*	*With flanking measures*		
Employment	Gradual reduction of employment*	-54,000 to -80,000 jobs by 2030	34,000 to 50,000 jobs saved compared to no measures		
Output				-5.4% to -8.5% (compared to BAU). If measures in place: -4.8%	-2% (in 2008-2012) compared to baseline
Cement	ETUC				
	Base case	*Emission reduction without flanking measures*	*With flanking measures*		
Employment	Stable at current 53,000 jobs	-15% (below BAU), ie -8,000 jobs in 2030	-1.2% (to BAU, ie - 640 jobs* in 2030		
Transport	ETUC		IA CO_2 cars	IA aviation ETS	
	Base case	*Restrict transp. & increase rail*			
Employment	in 2000-2030 *passenger:* +1.6%/yr private transp, +0.8%rail *freight:* +2% road, +0.5% rail	Passenger: +2%/yr transport Freight: +1.25%/yr; Reduction in road transport; Stable in automobile branch	Marginal effect		
Output				-7% growth (compared to base case) in 2020	
Building	ETUC				
	Base case	*Eurima*	*Factor 4*		
Employment	+110,000 jobs	+285,000 jobs compared to base case	+146,000 to 456,000 jobs if emission reductions met in 2050, or more if in 2030		

*own estimate

Table 6: Summary table of sectors and scenarios/approaches

The scenarios in the ETUC and JRC highlight the economic and employment effects under different scenarios with varying mitigation goals and technology approaches. Their findings are consistent with other mitigation models at international scale, including those of the IPCC, the IEA and the EC's World Energy Technology Outlook.

The IPCC's fourth assessment report (IPCC, 2007) found there is a broad range of technology and sectoral mitigation options to achieve similar reduction levels (as in the comparison of four different models in Figure 1).

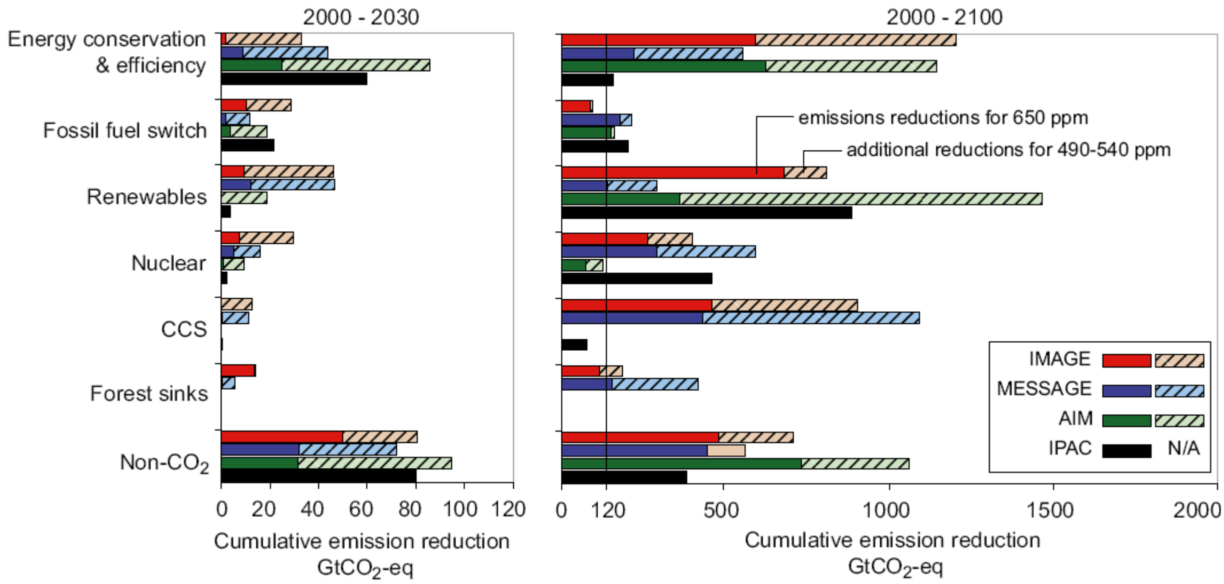

Figure 1: Mitigation potential in achieving 650 ppm stabilisation (solid colours) and 490-540 ppm stabilisation (hatched lines) at two time periods (to 2030 and to 2100) across various sectors as estimated by four different models (IPCC, 2007).

These models indicate that there is a wide potential range in the contribution of different technologies and sectors, where one can compensate for another. What is common to all of them, however, is the central importance of energy efficiency.

In its report 'Energy Technology Perspectives 2006', the IEA modelled several scenarios that roughly stabilise emissions at current levels by 2050 rather than more than doubling under the baseline. In addition to a central 'MAP' scenario, several others were generated that show greater or lesser emphasis of particular options – less nuclear, less renewable energy, no CCS, less efficiency, and a ('tech Plus') scenario with more optimistic assumptions about energy supply technologies.

The mitigation effect of these various scenarios are roughly similar in cases where lower levels of nuclear and renewables are modelled, with less mitigation where CCS is left out of the mix, or more importantly, less efficiency is achieved (Table 7).

Shares of CO_2 emission reductions in 2050 by contributing factor (%)						
Scenarios	Map	Low Nuclear	Low Renewables	No CCS	Low Efficiency	TECH Plus
Fossil fuel mix in power generation	5.1	4.6	5.2	5.9	6.7	5.3
Fossil fuel generation efficiency	0.8	0.9	1.0	2.9	1.4	0.7
Nuclear	6.0	1.9	6.8	10.3	7.3	7.2
Hydropower	1.6	1.6	0.1	2.1	1.4	1.2
Biomass power generation	1.7	1.8	0.3	2.6	2.1	1.5
Other renewables power generation	6.1	6.6	4.5	11.3	7.2	7.2
CCS power generation	12.4	14.3	14.3	0.0	17.9	11.7
CCS coal-to-liquids	3.3	3.4	3.3	0.0	4.2	4.6
CCS industry	4.6	4.7	4.7	0.0	5.5	3.9
Fuel mix buildings and industry	7.7	7.5	7.4	5.5	9.6	7.3
Increased use of biofuels in transport	5.6	5.8	5.7	6.4	6.0	6.2
Hydrogen and fuel cells in transport	0.0	0.0	0.0	0.0	0.0	4.1
End-use efficiency	45.2	46.9	46.6	53.1	30.7	39.2
Total	**100**	**100**	**100**	**100**	**100**	**100**

Table 7: Shares of CO_2 emission reductions in 2050 by contributing factor (IEA, 2006).

The World Energy, Technology and Climate Policy Outlook to 2030 from the European Commission (2003) creates a ‘reference’ scenario to 2030, a central ‘Carbon Abatement (CA)’ scenario with a mix of energy technologies, and scenarios where more emphasis is placed on (or there is more success in achieving) specific technologies, but which achieve *roughly* the same mitigation outcome.

	Electricity generation						Total
	based on						
changes as compared to Reference in 2030	Gas	Coal	Nuclear	Renewables	Total generation	CO_2 emissions	CO_2 emissions
Gas case	**21.6%**	-12.2%	-5.3%	-10.5%	0.3%	-7.2%	-1.6%
Coal case	-16.0%	**15.0%**	-6.5%	-10.2%	1.1%	0.3%	0.0%
Nuclear case	-7.1%	-8.1%	**77.5%**	-9.9%	0.6%	-7.3%	-2.8%
Renewable case	-12.3%	-8.8%	-2.4%	**132.0%**	-2.2%	-8.9%	-3.0%

Table 8: Four alternative WETO abatement cases with varying emphasis on different technologies (European Commission, 2003).

The main message is that, although carbon abatement is similar in all cases, the differences in technology deployment are very large indeed: where one focuses on nuclear, the need for renewables is relatively reduced, whereas to achieve the same reduction with renewables the needed increase in capacity is more than double the base case.

What these models confirm from the ETUC and JRC analyses is that there are options for mitigation, which come paired with explicit choices – such as the decisions whether or not to exploit nuclear or CCS, and to what degree to emphasise efficiency or renewables. The choices will affect growth and jobs, but are in a broader context of discussions about societal acceptance of certain technologies, energy security, and other considerations.

It may well be that the combination of technologies and sectoral mitigation strategies that maximize growth and or employment have other downsides – or that they do not emerge either by design or as a result of market and other forces. Hence it is useful to consider the options for enhancing positive effects and minimizing the negative outcomes.

In its impact assessment of the climate and energy package of legislation, the European Commission (2008) considered options to introduce flexibility or mitigate costs to meet the proposed target of 20% below 1990 levels by 2020.

What the table below shows is that there are several options considered, but they do not offer particularly large differences in impacts on specific industries which are at greater risk, with ferrous metals the most responsive to certain options.

	Ref scenario	**Ref scenario + access to CDM up to 25%**	**Ref scenario + internat sector agreem.**	**Ref scenario + internat sector agreem. + free allocation for EIS**	**Ref scenario + internat sector agreem. + inclusion of importers in ETS**	**Ref scenario + internat sector agreem. + inclusion of indir. emissions**
Share of **RES**	20	20	20	20	20	20
Change in **EU CO_2** vs 1990 (%)	-16.8	-11	-16.8	-16.8	-16.8	-16.8
Electricity price (% change vs BAU in 2020)	22	13.9	22.3	22.8	22.5	22.9
Welfare (% change in GDP vs BAU in 2020)	-0.69	-0.51	-0.69	-0.69	-0.66	-0.69
Sectors output (% change vs BAU)						
Ferrous metals	-8	-5.4	-7.4	-4.8	-6.8	-4.5
Paper products	-1.1	-0.7	-1	-1.1	-1	-1.1
Mineral products	-2.8	-1.8	-2.6	-2.3	-2.4	-2.4
Non-ferrous metals	-6.5	-4.2	-6.4	-6	-6.2	-5
Chemicals	-4.3	-2.7	-4	-3.7	-3.7	-3.9

Table 9: Impact of sector specific measures to compensate loss of competitiveness

5 CONCLUSIONS AND RECOMMENDATIONS

In light of the literature review and of the related sector analysis, the following conclusions can be drawn.

Employment: mitigation policy will lead to job creation in some sectors (e.g. related to RES, energy efficiency, CCS, etc), while some jobs will be lost in others (e.g. related to fossil fuels and production of inefficient products). In general, many studies highlight that the overall net effect is likely to be positive, as jobs in less labour intensive industries could be replaced by jobs in more labour intensive ones, or in sectors with longer value chains – hence having wider effects in the economy. The ETUC foresees a small but positive job increase by 1.5% in the coming 10-20 years.

Growth: At macroeconomic level, the average cost of mitigation is usually considered relatively small, in the order of no more than 1% GDP (Stern, 2007) (with changes to assumptions providing a range higher and lower). This is generally considered small compared to the costs that climate change may imply. According to some, under certain assumptions aggregated EU GDP could even slightly increase thanks to positive restructuring of the economy, like the opening of profitable new markets (e.g. RES, CCS technologies, fuel efficient vehicles, and others).

Sectoral impacts: it is expected that most job reallocation will happen within rather than across sectors. The sectors that will need major restructuring will be the GHG-intensive sectors, especially the energy and energy intensive industries. Coal and oil industries for instance are likely to experience significant job losses, but these should be more than offset by the creation of jobs in renewable energy related sectors. The production of cement and lime, steel, aluminium, primary container glass and some basic chemicals were expected be among the activities most hit by climate policies. At the same time, the construction sector is expected to experience significant job creation, thanks to the increased need for energy efficient building and new infrastructures. The transport sector is likely to experience significant reallocation from road freight transport and private car use to public transport modes.

Competitiveness: In some cases energy savings lead by climate policies can actually result in lower costs for industries, leading to competitiveness advantages. In most cases, though, it is expected that mitigation policies will negatively affect the competitiveness of industries exposed to international markets which do not have similar policies. There is the risk that some carbon intensive industries will be relocated abroad, where climate policies are less stringent and hence less expensive. It was highlighted, however, that only a small number of the sectors most affected by GHG reduction measures may risk to be actually be relocated. Some for instance do not have internationally mobile plants and processes. Others are less exposed to competition, like the cement sector – due to high transportation costs. Also, other factors may come into play in the decision to reallocate, like quality of capital and workforce, access to technologies and infrastructures and so on, which may be more relevant than emission reduction costs.

Sectoral agreements: In order to mitigate competitiveness impacts across countries, sectoral agreements across segments for GHG-intensive industries are often proposed. According to the European Commission, global sectoral agreements could lead to substantially greater GHG reductions at the global level and have a small positive effect on the output performance of energy intensive industries (European Commission, 2008).

CDM/JI: access to international carbon credits can significantly reduce the cost of emission abatements, leading to reduced impacts to the economy. This implies lower costs for industries, hence reduced job losses, including for GHG-intensive sectors, which can abate their emissions more cheaply buying credits abroad. This, though, will likely lead to lower emission reductions within the EU. As noted by the EC, this may in turn imply that no significant changes in the EU energy system would be achieved, that oil and gas savings would not materialise and technological innovation would not be spurred within the EU (European Commission, 2008). In fact, the possibility to reduce emissions cheaply elsewhere will reduce the emphasis on developing mitigation solutions domestically. As a consequence, investment on R&D will be lower than if no access to CDM was allowed, and some opportunities to develop leadership in green technologies may be lost, also hurting medium and long-term industrial development and employment in Europe. The Commission suggests that CDM should contribute to the achievement of the EU's emission reduction targets, but with some limitation – so that carbon price remain high enough to stimulate innovation internally.

ETS: In order to reduce the burden on the sectors most hit by climate policies, free allocation of ETS allowances to energy intensive industries on the basis of benchmarks have the potential to strongly contribute towards avoiding significant output losses, without compromising total economy-wide performance, as CO_2 and electricity prices are hardly affected. The EC considers this a powerful tool to reduce carbon leakage and adverse effects on energy intensive industries, especially if free allocation also allow for the compensation due to carbon costs that arise from their electricity consumption for indirect costs arising from the CO_2 content of energy intensive industries' intermediate energy consumption (e.g. electricity), on the basis of appropriate benchmarks (European Commission, 2008).

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ACRONYMS

BAU	Business As Usual
CA	Carbon Abatement
CDM	Clean Development Mechanism
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
EC	European Commission
EEA	European Environment Agency
EII	Energy Intensive Industries
EPBD	Energy Performance of Buildings Directive
ETS	Emissions Trading Scheme
ETUC	European Trade Union Confederation
Eurima	European Manufacturers' Association
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IA	Impact Assessment
JI	Joint Implementation
JRC	Joint Research Centre

ANNEX 1 – LITERATURE REVIEW

ETUC, ISTAS, SDA, Syndex and Wuppertal Institute (2005) Climate Change and employment

This report is one of the most recent and extensive studies on the implications of climate change mitigation measures on employment, and reveals that information on this subject has been little investigated until now. The study analysed the foreseeable effects of climate change and of CO_2 emission reduction measures on employment in EU25, focusing in particular on the impacts on four broad sectors: energy production (electricity generation and petroleum), transport, manufacturing (iron and steel and cement) and construction.

The study assumed that the Kyoto emission reduction targets would be met in the EU – corresponding to a reduction of 8% over 1990 levels in 2008-2012. It also assumed that a reduction of 30% to 50% from 1990 levels would be achieved by 2030 – on the basis of the figures advanced by the European Council and the Environmental Council of March 2005[19].

In order to estimate the consequences of mitigation policies, the report combined the analysis of case studies in eleven Member States with the production of sectoral employment projections in light of a number of scenarios (these have been explained in more detail in the sectoral analysis in Chapter 3).

The main finding of the study was that CO_2 emission control measures can have a small positive effect on overall employment – in the order of 1.5% – provided that appropriate economic policies are put in place.

The study also highlighted that the implementation of climate policies will lead to a large-scale redistribution of jobs, but rather within than between sectors – which should make it easier for workers to find a new job. All sectors will be affected, as jobs will be created in companies taking advantage of the opportunities created by mitigation policies, and lost in companies which will not be able to adapt. It was noted that unemployment of displaced workers could become structural if developments are not correctly anticipated and followed up. The potential 'winning' sectors are expected to be building, electrical equipment manufacturing, renewable energy, logistics and intermodal transport.

Among the major trends, the transfer of jobs from the power generation sector to activities related to energy efficiency is foreseen. In the transport sector jobs are expected to move from freight transport by road and private car to public transport, as a readjustment in the modes of transport and reduced freight activity. Jobs are also expected to be created in the equipment sector for renewable sources of energy and co-generation, for energy efficiency goods and services, rolling stock and – in one of the scenarios – nuclear energy. These will gradually replace 'old' jobs related to the design, engineering and construction of equipment for power generation from fossil fuels and to private road vehicles. Overall, climate policies are expected to contribute to rising demand for increasingly educated and qualified workers.

[19] -15% to -30% in 2020 and -60% to -80% in 2050

Findings by sector:

- *Electricity generation:* This sector has already undergone major restructuring in the past, reducing significantly its staff, and is expected to experience further significant changes due to climate polices. A reduction in energy demand of 16% compared to the reference scenario can cause the loss of 20% direct jobs, whereas jobs related to renewable sources are expected to grow by 50%. Gas and nuclear energy employment levels could remain stable or grow, depending on the scenario chosen.

  If indirect jobs (e.g. related to the construction of power plants or to equipment manufacturing) are taken into consideration, all sectors' employment level is expected to grow by 23% compared to the reference scenario.

  It is still unclear what effect the increasing demand for energy efficiency related services can have on employment, as well as what the impact on the coal sector will be of the introduction of carbon capture and storage (CCS) technologies. Overall, the net impact of energy saving on employment is expected to be positive. The jobs lost in the coal sector are expected to be compensated by employment gains from the options that allow energy savings, given the high capital and low labour intensity of the sector. In addition, employment will benefit from savings in the energy bills of businesses and households.

- *Oil:* The oil sector is expected to experience a significant decline in employment, ranging from 20,000 to 120,000 jobs lost. The sector could react by relocating production and increasing imports (especially of diesel)

- *Energy-intensive industry:* The energy-intensive sector is one of the most vulnerable to climate policies, and hence deserves specific attention.

  The steel industry for instance could loose from 50,000 to 350,000 jobs as a result of relocations of the liquid phase to low-cost countries – leading to carbon leakage as well – or due to lack of new investments in Europe.

- *Transport:* The transport sector is a sensitive one, due to its high employment level (around 15 million jobs are related directly or indirectly to the sector, i.e. 7% of employment in EU25), and its growing CO_2 emissions. A large potential for job creation was expected from alternative means to road transport. It was estimated that stabilising transport emissions by 2030 (compared to 1990 levels) could create 20% more jobs overall. The reduction of traffic by 10% and the increased use of rail and public transport could increase direct and indirect jobs fourfold compared to the reference scenario. On the other hand, the automobile sector and road freight could suffer from mitigation policies. Employment in road freight transport – although still positive – is expected to be 50% less than in the reference scenario. Employment in the automotive sector could remain stable, also due to the positive effect of the dissemination of clean technologies; nevertheless this could be 60% lower than in the reference scenario. The majority of the direct jobs created will be of relatively low qualification level, but training in 'sustainable construction' will be important.

- *Construction:* Climate change prevention could largely benefit the building sector. Benefits will mainly derive from the needs linked to the insulation and energy renovation of buildings for energy-saving purposes, and from the construction and installation of the infrastructure needed to cope with changing transport and energy demand. For instance, thermal renovation of existing buildings is labour intensive and connected to local/national markets, hence mostly non vulnerable to relocation. The extension of the scope of the Energy Performance of Buildings Directive is expected to create 30,000 to 90,000 man years in the EU15 compared to the reference scenario, and additional 90,000 man years in the EU10. Insulation works and the installation of low-energy consumption heating equipment aiming to reduce dwellings' consumption to one fourth (i.e. from 200 kWh/m^2 to 50 kWh/m^2) could create up to one million jobs compared to the reference scenario, i.e. 10% of European employment in the sector.

GHK, IEEP and Cambridge Econometrics (2007) Links between the environment, economy and jobs

The main purpose of this study was to evaluate the economic significance of the environment in terms of European jobs, output (turnover) and gross value added (GVA) associated with the range of activities that make use of, or contribute to, environmental resources. In addition to the direct economic impacts, input-output (I-O) tables for each Member State have been used to estimate the indirect and hence total economic impacts of defined activities that are linked with the use of environmental resources.

The study looked at three broad environment-economic categories: activities where the environment is a primary natural resource or input into the economic process (agriculture, forestry, mining, electricity generation and water supply); activities concerned with protection and management of the environment (waste recycling, pollution and sewage control, environmental management); and activities dependent on environmental quality (environment related tourism).

The study also considered the linkages between environmental policy and the economy, by examining the impact on employment of selected examples of policy intervention aimed at improving resource efficiency (e.g. water, energy, waste). Some of the policies analysed were related to climate mitigation, such as a more extensive use of renewables, bio-fuels and energy efficiency technologies. The study hence provides relevant information on the link between climate measures, employment and growth.

Direct and indirect economic impacts of environmental policy options were examined using the I-O framework in the E3ME model developed for the quantification of environment-economy linkages. The aim was to demonstrate the economic impact of the change towards a more sustainable mix of inputs, directly on the firms subject to the intervention, and indirectly on the economy as a whole.

Whilst the scenarios were fairly simple and the economic assessment only indicative, they revealed that, even if direct effects of policy options may be neutral or small (reflecting quite often the substitution from 'less green' to 'greener' options), the indirect effects are often much larger and generally indicate that the EU economy would gain, especially in employment terms, from the introduction of environmental polices that change current production systems – especially policies that, among others, encourage the switch to renewable energy and resource efficient technologies.

The analysis took into consideration the quantity substitution effect, i.e. modelling the substitution of inputs from one sector for another. It also allowed some indication of the scale of negative economic impacts of higher input prices (e.g. energy prices).

The most relevant scenarios related to climate change mitigation discussed in the report are presented below. Table xx summarises data on the key economic impacts.

- *Increased energy efficiency in the manufacturing sector.* The scenario explores the reduction in purchases of 10% by value (€) of inputs from the energy sector[20]. It is assumed that investment costs are no greater than energy savings.

  The direct effect of this policy is expected to lead to an output decrease of about €19,300m in the energy sector in the EU27, and to an equivalent increase in all the other sectors - the net effect being zero. As a consequence, it is estimated that, while the energy sector will loose about 56,500 jobs, other sectors will gain more than 179,000. The net direct effect is expected to lead to the creation of more than 122,500 new jobs.

  If indirect effects are taken into account, the energy sector is expected to loose an additional €5,200m and almost 32,000 jobs, while other sectors will gain an additional €5,700m (through decreased energy expenditure) and more than 46,500 jobs. The net indirect effect will be an output increase of €482m and almost 14,600 new jobs.

  Overall, the policy is expected to lead to an output increase of €480m and to the creation of about 137,200 new jobs. The large positive employment impact is mainly because the energy sectors are less labour intensive with low employment-output ratios. In addition, the energy sector also has a small supply chain, while the manufacturing sectors producing the energy efficient technologies use inputs from a number of other sectors. This leads to a higher multiplier effect for both jobs and output.

- *Increased energy efficiency in the Energy Intensive Industries (EIIs)*[21]. This scenario looked at the effects of a 10% reduction in energy inputs for the EIIs substituted with an increase in investment in energy efficient technologies of energy savings plus 10% increase in these investment costs. The scenario assumed that investment costs for new technologies are greater those for conventional technologies.

  As a direct effect, the EII output is expected to decrease by €8,000m, leading to the loss of 29,600 jobs. An output increase of €9,000m is estimated in all other sectors, leading to the creation of about 83,500 new jobs. The net direct effect on output hence would be an increase of € 1,000m and the creation of about 54,900 jobs.

[20] Output is assumed to fall by the same proportion in the following sectors: Coal, Oil & Gas, Manufactured Fuels, Renewable Electricity, Non-Renewable Electricity, and Gas Supply.

[21] These include: Wood and Paper, Printing and Publishing, Pharmaceuticals, Chemicals, Rubber and Plastics, Non-Metallic Minerals Product, Basic Metals, and Metal Goods

Among the indirect effect, the policy is expected to lead to a fall in demand for inputs to the energy sector, and a subsequent fall in output from suppliers to the energy sector. A fall in demand from consumers of EII products due to higher prices driven by higher investment costs (over energy savings) is also expected. These indirect effects could lead to a decrease of the EEI output of almost €2,400m, and to a loss of about 15,400 jobs. Other sectors though are expected to gain €10,300m and 52,400 jobs. The total net effect was estimated to lead to an output increase of almost €8,000m and to 37,000 new jobs.

Overall, the measure is expected to result in nearly €9b increase in output and 91,000 new jobs.

- *Increase in bio-fuels in transport.* The scenario examines the effect of a 10% increase in the use of bio-fuels by the transport sector as a substitution for conventional transport fuels (petrol/diesel), with no effect on overall input costs. The effects on land and the supply of agricultural products due to the competition for agricultural inputs attributable to bio-fuels are not included.

  The direct effects on the agricultural sector are expected to lead to an output increase of about €2,500m and to more than 110,400 new jobs. The manufactured fuel sector instead is expected to loose €2,500m and 2,300 jobs. The net direct effect on overall employment was estimated to result in about 108,100 jobs (the effect on output being zero).

  The indirect effects are estimate to lead to an additional increase of the agricultural sector output of about €2,300m and to more than 33,100 new jobs. The manufactured fuel sector instead is expected to loose an additional €810m and 1,700 jobs. The net indirect effect will be an output increase of €1,500m and the creation of 31,400 jobs.

  Overall, the policy will lead to and output increase of €1,500m and the creation of 139,500 new jobs. This is mainly due to the labour-intensity of the agriculture sector and the industries that supply it. Hence there is a large direct boost to employment and on output due to the induced effect of higher income. If the cost of bio-fuels for the transport sector though were to be higher than the substituted manufactured fuel, there would be a negative impact on profits and output of the transport sectors.

- *Increase in Electricity Generation from Renewable Energy Technologies.* The scenario describes the impact of an increase of 10% in output of electricity from the renewables sector, with a commensurate reduction, by output value, from the non-renewable sector.

  The direct impact will be an output increase in the renewable sector of €16,000m and 64,100 new jobs, offset by an identical decrease in output and employment in the non-renewable electricity sector. The net direct effect will hence be zero.

  Indirect effects will lead to an output increase of about €14,800m and 118,600 jobs in the renewable sector, and an output decrease of about €6,200m and the loss of 60,400 jobs in the non renewable electricity sector.

  The net overall effect (equal to the indirect net effect) will be €8,613m in terms of output and 58,200 new jobs. The economic impacts are positive because renewable energy requires inputs from a number of sectors at the design and installation stage. However, they require fewer inputs from other sectors (mainly fuels) and labour once they are up and running.

- *Increase in Electricity Generation from Renewable Energy Technologies at Higher Costs.* The scenario examines the same substitution of electricity from renewables for non-renewables, but assumes that the substitution leads to a 10% increase in electricity prices to reflect the assumed higher cost of supply from renewables. The overall effects include greater income for the renewables sector (which is assumed to be invested in other sectors – especially those producing capital goods such as producers of construction and engineering products), higher costs to energy users and knock-on effects.

  Direct effects of the measures are expected to lead to a loss of output from the non renewable sector of €16,000m, and the loss of more than 64,000 jobs. The output of the renewable sector is instead estimated to increase by €25,200m, reflecting the increase in the cost of renewable energy sources. Employment in the sector is expected to increase by about 100,900 units. The net direct increase in output will be of €9,200m, and about 36,800 jobs will be created.

  The indirect impacts will result in an additional output reduction of €6,200m and 59,400 jobs lost in the non renewable electricity sector. The renewable sector instead will benefit from an additional output increase of about €19,900m and about 81,200 new jobs. The net indirect effect was estimated to lead to an increase of €13,700m in terms of output, and the creation of more than 21,800 jobs.

  The total effect was expected to lead to an increase in output of about €23b, and to a net increase of 58,600 jobs. The negative effects of higher energy prices (estimated at about 6%) would need to exceed this positive impact for there to be an overall net loss in GDP and employment.

Policy Scenario	**Net Direct Impact**		**Net Indirect Impact**		**Total Impact**	
	Output (€ m)	Jobs (FTE)	Output (€ m)	Jobs (FTE)	Output (€ m)	Jobs (FTE)
10% energy saving in manufacturing	0	122,500	480	14,600	480	137,200
10% energy saving in EEIs	1,000	54,000	8,000	37,000	9,000	91,000
10% bio-fuels	0	108,100	1,500	31,400	1,500	139,500
10% RES	0	0	8,610	58,200	8,610	58,200
10% RES at higher prices	9,200	36,800	13,700	21,800	23,900	58,600

Table 10: The Economic Impacts of Selected Policy Scenarios
Note: Totals may not sum due to rounding
Source: adapted from GHK, IEEP and Cambridge Econometrics (2007)

JRC/IPTS (2007) Global Climate Policy Scenarios for 2030 and Beyond

The report presents the scenario analysis contributing to the European Commission's Communication of January 2007 on 'Limiting global climate change to 2 degrees Celsius – The way ahead for 2020 and beyond' (European Commission, 2007) and its accompanying impact assessment. Following this Communication, the European Council endorsed a commitment to cut GHG emissions by at least 20% by 2020 compared to 1990 levels (European Council, 2007). The target will become 30% in case of a comprehensive international agreement. In addition, the Council committed to a 20% renewable energy target by 2020, improvements in energy efficiency and increases in low carbon sources, which should help in achieving the required emission reductions[22].

[22] As set in the document 'An Energy Policy for Europe'.

In order to assess the technological and economic options for reducing GHG emissions, the JRC study developed scenarios using 2 models: the partial equilibrium energy model POLES, which provided insights on the response of the energy sector to policy measures; and the multi-sectoral general equilibrium model GEM-3, which analysed the adjustments in the whole economy.

Two main scenarios were modelled:

- the BAU (Business As Usual) scenario
- the GHG reduction scenario: it included energy efficiency and climate change policies aiming at global emission reductions of 25% by 2050 compared to 1990 levels. For developed countries, the target was set at -30% by 2020 and -50% by 2030. The use of flexible mechanisms was also taken into account. The scenario also assumed the existence of an international emission trading market, though not including road transport, residential and tertiary sector emissions. Clusters of countries were assumed to enter the market at different points in time (stepwise entry).

Half of the emission reductions were expected to be achieved though energy savings, especially in the residential, tertiary and transport sectors. Efficiency improvements in industry and power generation were expected to be mobilised by the carbon price – which was expected to be in the range of €30-40/tCO_2-equivalent by 2030 €65/t CO_2-equivalent by 2030. Emission reductions were also assumed to be achieved by switching to low or non-carbon fuels and CO_2 emission capturing, particularly in the power sector. Renewables and nuclear power were expected to increase their share to cover 23% of electricity generation (18% of energy) in 2020, 32% (25% of energy) in 2030 and 43% (39% of energy) in 2050 in the EU25. More than 90% of all coal-fired electricity generation and 70% of all gas-fired electricity generation were projected to take place in plants equipped with carbon capture and storage (CCS) technology by 2050. CCS was expected to contribute to 14% of the global GHG emission reductions by 2030, shrinking to 9% by 2050 (due to a lower number of large emitting sources). Nuclear power in the EU was expected to decrease in the short term, and revive after 2020.

The average annual direct cost needed for the restructuring of the global energy system was estimated though the POLES model at 0.4% of global GDP for the period 2013-2030, assuming carbon trade between developed and developing countries. If trade would not be possible, attaining the target would be more expensive, i.e. almost 1.2% of GDP by 2030.

In the EU27 the annual change in GDP due climate policy repercussions in all sectors (calculated through the GEM-E3 model) was estimated to be -0.19% in 2020 and -0.24% in 2030, compared to the baseline scenario. The annual impact of climate policies on the world GDP was estimated at -0.14% by 2020, and -0.19% by 2030.

The cost of emission reduction targets was also assessed in terms of welfare, taking into consideration the utility of the representative consumers – which is a function of consumption, leisure and the value of savings in terms of discounted future consumption. In the EU27 the impact of climate policies were estimated to result in an annual -0.20% change in welfare by 2020 (against -0.10% worldwide), and -0.26% by 2030 (against -0.15% worldwide). The higher impact in Europe compared to the world average was explained by the fact that consumers in developing regions with large reduction potential and hence greater export of emission permits will improve their welfare levels through the revenue of emissions trading.

If no international agreement was achieved, i.e. if the EU were to be the only region with emission reduction commitments, two emission reduction targets have been considered: 21% and 31% reduction by 2020 (compared to 1990 levels). Furthermore, the effect of access to the global carbon market (though CDM type instruments) was also assessed, taking into consideration a scenario with full access and one with no access. The impact of a 21% target, in case of no access to global markets, was estimated to result in a 1.4% decrease in EU27 GDP by 2020. The use of CDM could significantly reduce the costs of climate policy, leading to smaller GDP change (-0.3%). A more ambitious target of 31% would lead to slightly higher costs, which were estimated to result in -2.3% GDP in case of no trade and -0.9% if access to the market was granted.

These results were also compared with the estimates made in the case of global commitments in the GHG reduction scenario (see table below). It should be noted that, in the autonomous scenario (ie where only the EU is committed to emission reductions), the GDP change in case of a 31% target is lower than in the global GHG reduction scenario (2.3% versus 2.8%). This was partially explained because the decrease of global emissions in the GHG reduction scenario is much higher than in the autonomous case (24% versus 4%), implying an effect on GDP levels of non-European countries affecting European growth via international trade effects.

	GHG reduction	**Domestic emission reductions (EU27)**			
	Trade	*Trade*	*No Trade*	*Trade*	*No trade*
Emission reduction by 2020 (compared to 1990)	***-31%***	***-21%***		***-31%***	
Access to global carbon market	Yes	No	Yes	No	Yes
Domestic emission reductions (compared to 1990)	-21%	-21%	4%	-31%	-7%
GDP impact in 2020 (compared to baseline)	-2.8%	-1.4%	-0.3%	-2.3%	-0.9%
GDP impact/year	-0.19%	-0.09%	-0.02%	-0.16%	-0.06%
Carbon price (€)	31	44.2	4.2	77.6	9.4
Global emission reductions (compared to baseline)	-24%	~ -3.5%		~ -4.6%	

Table 11: Impact of global and autonomous EU27 emission reductions and of the global carbon market on the EU27 economy
Source: Elaboration from (JRC)

European Commission (2008) Impact Assessment accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020

This Impact Assessment (IA) accompanies the 'package' of measures on climate change mitigation, released by the European Commission on 23 January 2008.[23] The IA covers three policy proposals, related to amendments to the EU ETS Directive, a decision on MS sharing of efforts to meet the GHG reduction commitments in sectors not covered by the EU ETS, and a directive on the promotion of renewable energy.

Among the potential impacts of these policies, the document explores also issues related to competitiveness and innovation. Some lessons on the impacts of the proposed mitigation policies on growth can hence be extrapolated from this impact assessment.

[23] http://ec.europa.eu/energy/climate_actions/index_en.htm

In the impact assessment, and in the proposed legislation, the year 2005 has been used as the base year. This period was considered the best reference year, as 2005 is the only year for which reliable verified emissions data are available for both ETS sectors and MS (as reported by the UNFCCC). It will be important to keep in mind and understand the difference in base years when comparing the findings of other studies with the objective set by these recent proposals – as for instance previous climate policies and a number of studies related to climate change, which use 1990 as a base year.

The effort to achieve 20% GHG reduction commitment (compared to 2005) has been split between the sectors covered by the EU ETS , which should reduce their emission by 21%, and the sectors not covered by the ETS (such as transport, buildings, services, smaller industrial installations, agriculture and waste), whose emissions should be reduced by 10%.

Although responsible for about 60% of total GHG emissions in EU, the sectors not covered by the EU ETS have been charged with a lower burden as it is considered that emission reductions are more cost effective for the ETS sectors (especially the electricity sector) than for the non ETS. For the same reason, more than half of the 20% renewable energy target should be achieved by the ETS sectors.

It is estimated that, when emissions would be reduced cost-effectively in the entire EU, the European GDP in 2020 would be 0.54% lower than it would otherwise be without these measures. Overall, these cost impacts are considered to be limited. If the policies were implemented the GDP is expected to grow by 37.46% over the period 2005-2020, instead of 38% as in the baseline scenario. The impacts, in terms of GDP in Member States with a lower than average GDP per capita, are expected to be higher than the EU average, since these countries have a smaller capacity to invest in GHG mitigation and renewable energy. For this reason Member States' targets for emission reductions in non-ETS sectors and for renewables have been differentiated on the basis of their GDP per capita.

Private consumption is also projected to decrease by a very limited extent, i.e. by 0.11%. Impacts on employment are estimated to lead to a 0.41% reduction in jobs by 2020. Nuanced results, in light of different scenarios, the access or non-access to CDM and RES trade, are summarised in the table below (European Commission, 2008).

	Cost efficient reference scenario	Redistribution of non-ETS targets + no CDM	Redistribution of non-ETS targets + CDM	Redistribution of Non ETS targets + no CDM + redistribution RES targets + no RES trade
Carbon price ETS (€/tCO2)	39	43	30	47
Carbon price non-ETS (€/tCO2)	39	37	max 30	37
Direct costs (%GDP)	0.58	0.61	0.45	0.66
Macro economic effects				
Change in GDP (%)	-0.35	-0.34	-0.21	
Change in private consumption (%)	0.19	0.21	0.21	
Employment (%change in BAU)	-0.04	-0.09	0.05	
Sectoral Impacts (% change over BAU)				
Energy cost	6.4	6.3	4.4	6.8
Energy cost per Value Added Industry	12.6	13.5	9.6	14.3
Energy cost per Value Added Tertiary	1.7	2.2	0.7	3
Production change top 3 EEIs	-2	-2	<1.5	>-1.5

Table 12: Overview of impacts at EU level for key scenarios of impacts assessment
Source: European Commission, 2008

It was estimated that some 50 sub-sectors of the energy intensive industries[24] might require some increases in prices (between 0.1 and 5%) to recoup costs imposed by on carbon price. Among the these sub-sectors, cement and lime production, primary steel (blast oxygen furnace), aluminium production, production of primary container glass and some basic chemicals (ammonia, nitric acid, fertilizer production) were mentioned. Sectors most at risk are the aluminium production, primary steel (blast oxygen furnace) and some chemicals – due to their limited ability to pass through additional costs. It was noted that the cement sector is unlikely to be significantly exposed to international competition, due to high transportation costs. The competitiveness problem for energy intensive industries hence appears to be concentrated in a limited number of 'genuinely energy intensive industries' that are exposed to international competition.

The PACE model used in this impact assessment estimated the impact of the 20% GHG target plus a renewable target for electricity of 30% (consistent with the 20% renewable target). The model highlighted that, if trading of Guarantees of Origin (GO) in the electricity sector were restricted, electricity prices could increase and consequently impose additional negative impacts on energy intensive sectors exposed to international competition (ferrous metals, paper products, mineral products, non-ferrous metals and chemicals), also leading to increased carbon leakage.

24 '*Business entities where the purchase of energy products and electricity amounts to at least 3.0% of the production value'* – according to the Energy Products Tax Directive (2003/96 EC, OJ L283 of 31.10.2003).

Access to JI or CDM for up to a quarter of the GHG reduction effort are expected though to reduce substantially the pressure on CO_2 and electricity prices, and hence the cost of reaching the targets. This may lead to reduced economy-wide welfare losses (-0.5% instead of -0.7% in the reference scenario), improving significantly the output performance of energy intensive industries and reducing the potential carbon leakage (see table 13).

	Reference scenario[25]	**Reference scenario + no GO trade**	**Reference scenario + access to CDM up to 25% reduction effort**
Share RES (%)	20%	22.60%	20%
Change EU CO2 emission cf 1990 (%)	-16.80%	-16.80%	-11%
Electricity price (% change vs BAU in 2020)	22%	30.70%	13.90%
Welfare loss (% change vs BAU in 2020)	-0.69%	-0.92%	-0.51%
Ferrous metals (%)	-8	-8.5	-5.4
Paper products (%)	-1.1	-1.3	-0.7
Mineral products (%)	-2.8	-3	-1.8
Non-ferrous metals (%)	-6.5	-7.4	-4.2
Chemicals output (%)	-4.3	-4.6	-2.7

Table 13 –Impact of transfers of renewable targets and JI/CDM on sector output (% change compared to BAU)
Source: Based on Pace – as in EC, 2008

The expected energy costs impacts for energy intensive sectors were analysed in more detail through the PRIMES model. The analysis confirmed that increases in energy costs will be higher in the ferrous metals sector (i.e. iron and steel), but that access to CDM could reduce these impacts.

The assessment also analysed the impact of other sector specific measures (and combinations of them) to compensate competitiveness losses, such as international sectoral agreement, free allocation though benchmarking for energy intensive sectors, inclusion of importers in the EU ETS and inclusion of indirect emissions.

Global sectoral agreements for instance could lead to substantially greater GHG reductions at the global level and have a small positive effect on the output performance of energy intensive industries. The overall economic effects (in terms of GDP) of the EU's GHG/renewables package would, however, not be much affected.

Free allocation of ETS allowances to energy intensive industries on the basis of benchmarks contributes very strongly towards avoiding significant output losses without compromising total economy-wide performance, as CO_2 and electricity prices are hardly affected. This could be a powerful tool to reduce carbon leakage and adverse effects on energy intensive industries, especially if free allocation would also allow for the compensation for indirect costs arising from the CO_2 content of energy intensive industries' intermediate energy consumption (e.g. electricity) on the basis of appropriate benchmarks.

[25] The reference scenario is characterised by partial auctioning (20% in 2012 plus 10% per annum of allowances for all ETS sectors – i.e. full auctioning by 2020 – excluding the power sector, which is fully auctioned throughout the entire period), an efficient system-wide cap for the ETS, regionally differentiated marginal abatement cost for the non-ETS sectors and no access to JI/CDM. Guarantees of origin are tradable across EU member states. Auctioning is recycled to an economic agent representing both the government and households.

The inclusion of importers of energy intensive products in the EU ETS is estimated to impact positively on the performance of energy intensive industries and to generate some additional global GHG reductions. However, the net amount of allowances required by importers can create pressure on the ETS allowance price, which could have a negative impact on all ETS sectors and the economy as a whole.

Access to CDM is expected to significantly limit the output losses of the energy intensive industries and might reduce carbon leakage considerably. Furthermore it is expected to have a positive impact on overall welfare costs – reducing the impact on energy intensive industries.

A summary table is provided below.

	Ref scenario	**Ref scenario + access to CDM up to 25%**	**Ref scenario + internat sector agreem.**	**Ref scenario + internat sector agreem. + free allocation for EIS**	**Ref scenario + internat sector agreem. + inclusion of importers in ETS**	**Ref scenario + internat sector agreem. + inclusion of indir. emissions**
Share of **RES**	20	20	20	20	20	20
Change in **EU CO_2** vs 1990 (%)	-16.8	-11	-16.8	-16.8	-16.8	-16.8
Electricity price (% change vs BAU in 2020)	22	13.9	22.3	22.8	22.5	22.9
Welfare (% change in GDP vs BAU in 2020)	-0.69	-0.51	-0.69	-0.69	-0.66	-0.69
Sectors output (% change vs BAU)						
Ferrous metals	-8	-5.4	-7.4	-4.8	-6.8	-4.5
Paper products	-1.1	-0.7	-1	-1.1	-1	-1.1
Mineral products	-2.8	-1.8	-2.6	-2.3	-2.4	-2.4
Non-ferrous metals	-6.5	-4.2	-6.4	-6	-6.2	-5
Chemicals	-4.3	-2.7	-4	-3.7	-3.7	-3.9

Table 14: Impact of sector specific measures to compensate loss of competitiveness
Source: EC, 2008

Stern, N. (2007) The Economics of Climate Change

The study, also know as the 'Stern Report', aimed to assess the economics of moving to a low-carbon global economy, focusing on the medium to long-term perspective. It also explored the potential of different approaches for adaptation to changes in the climate, and drew specific lessons for the UK climate policy.

The report estimated that the annual cost of cutting total GHG to about three quarters of current levels by 2050 (consistent with a 550ppm CO_2e stabilisation level) will range between -1.0 to +3.5% of GDP, with an average estimate of approximately 1% (i.e. about €350-400b). What the exact cost will be will depend on the future cost of low-carbon technologies (which are expected to be cheaper than the current ones), and on improvements in energy efficiency. The range taken into consideration was wide because of the uncertainties as to future rates of innovation and fossil-fuel extraction costs.

Calculations also suggested that the inclusion of induced technology, averted non-climate change damages (e.g. air pollution) and international emissions trading mechanisms (such as carbon trading and CDM) could limit costs substantially.

According to the study, the implementation of mitigation policies will make emission-intensive products either more expensive or impossible to buy. The cost of adjusting industrial structures is expected to be reflected in pay and profits – with opportunities for new activities and challenges for old. More investments will be made to improve emission intensive products, hence it is expected that fewer resources will be available for creating other goods and services.

It was noted that it will be cheaper, per tonne of GHG, to cut emissions from some sectors rather than others, as in some of them there will be a larger selection of better-developed technologies. For example, the range of emission-saving technologies in the power generation sector is currently better developed than in the transport sector. The potential for cost-effective emission saving is also likely to be less in those sectors in which low-cost mitigation options have already been undertaken.

In terms of competitiveness, the report revealed that the cost of mitigation will be felt more strongly by GHG intensive sectors, which will require the most structural adjustments. Using the UK as a case study, the report estimated that the overall impact of higher carbon prices (assumed at \$30/t CO_2) will lead to an increase of consumer prices by just over 1%, on the assumption of a full cost pass-through. However, the impact on cost and prices on the most carbon intensive industries – especially through their consumption of electricity – is expected to be considerably higher. For instance, prices are expected to rise by 25% in the gas supply and distribution sector to keep their profits unchanged in the UK. Prices are also expected to rise significantly in the refined petroleum (24%), electricity production and distribution (16%), cement (9%), fertilisers (5%) and fishing (5%) sectors. As a matter of fact these industries, together with metals, chemicals, paper/pulp and transport, have the greatest global carbon emissions from fossil fuels, and hence are likely to be most hit by climate mitigation measures. The competitiveness impacts in these sectors though will be reduced to the extent that the goods/services they provide are not highly traded. Electricity and gas distribution for example are almost entirely domestic, or to the extent they trade, this is mostly within the EU.

Nevertheless, it was noted that there is the actual risk that carbon intensive industries relocate in countries where mitigation policies are not in place. It was highlighted though that only a small number of the sectors most affected by GHG reduction measures have internationally mobile plant and processes. In addition, where industries are internationally mobile, environmental policies are only one determinant of relocation decisions, since other factors can play a decisive role – like quality of capital and workforce, access to technologies and infrastructures, market proximity and so on. Trade diversion and relocation are also less likely if there is a strong expectation of eventual global policy action. Furthermore, sectoral agreements across segments for GHG-intensive industries can contribute to the promotion of international action for mitigating competitiveness impacts across countries.

The report also highlighted that climate policies could bring significant business opportunities from growing markets. Policies to tackle climate change are expected to be a driver for a prolonged period of strong growth in the markets for low-carbon energy technology, equipment and construction. Enormous investment will be required in alternative technologies and processes, leading to the creation of fast growing markets, which can be potential sources of growth for companies, sectors and countries. For instance, the current size of the market for renewable energy generation products was estimated at €38 billion, providing employment to around 1.7 million people. It was estimated that cumulative investments in low-carbon power generation technologies by 2050 could be over $30 trillion. The market for these technologies could hence be over $500b per year by then, and likely accompanied by a significant shift in employment patterns. It is expected that by 2050 more than 25 million people will be working in these sectors worldwide.