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SUMMARY OF THE IMPACT ASSESSMENT

Accompanying document to the

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

A Roadmap for moving to a competitive low carbon economy in 2050

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1. PROBLEM DEFINITION

(1) To avoid dangerous impacts, the EU has a stated objective of limiting global climate change to a temperature increase of 2ºC. The Copenhagen Accord included reference to this objective. It was further confirmed within the UNFCCC in the decision of the 16th Session of the Conference of the Parties to the UNFCCC.

(2) The Intergovernmental Panel on Climate Change (IPCC) reported in 2007 that existing science indicated that developed countries would need to take a greenhouse gas emissions (GHG) reduction target within the range of 80 to 95% below 1990 emissions by 2050 to limit global climate change to a temperature increase of 2ºC compared to pre-industrial levels. The European Council and Parliament endorsed this as an EU objective, in the context of necessary reductions according to the IPCC by developed countries as a group.

(3) The EU as a whole has seen its GHG emissions (without Land Use, Land Use Change an Forestry, LULUCF) decrease over the last 2 decades. For 2009 the EEA estimated emissions levels reduced further to 17% below 1990 levels. Including aviation this reduction would be around 16% below 1990 levels. In part this is due to the impact of the economic crisis in 2009.

(4) Today, some 55% of Europe's primary energy is imported. With reduced oil and gas output in the North Sea, even with full implementation of the Climate and Energy Package this is expected to increase to 57% by 2030. While energy dependence in itself does not constitute an economic problem per se, there are several energy developments that require attention. Firstly, trends point towards continuing increased demand for oil and gas from emerging economies. Secondly, supply side investments are not in line with increasing demand. The International Energy Agency estimates that by 2035 some 75% of conventional crude oil production will have to come from fields yet to be developed or found. Thirdly, global reserves are often localised in geo-politically unstable regions and owned by state-run companies that not always can react adequately to market forces. The European economy therefore will continue to be exposed to serious risks related to energy prices, in particular the transport sector which is more than 90% dependent on oil. The Roadmap therefore considers energy developments and synergies to enhance energy security.

(5) Low carbon technology development is crucial for sustainable growth and jobs. But its development is not only hampered by market failures related to the non inclusion of GHG externalities. There is also the problem of uncertainty and knowledge spill-over in general, which may lead to lower investment in R&D than optimal. In addition, there is a commercialisation problem for capital intensive technologies where investments are marked by long lead times. It will hence be critical to foster low carbon technology development and accelerate the learning curve as cost-effectively as possible. This presents both a major challenge and an opportunity for European businesses. How the EU develops its R&D, demonstration and innovation policies, creates framework conditions inducing technological change, public acceptability and fosters the competitiveness of a wide range of key manufacturing industries of the EU is an essential consideration in the development of a low carbon economy roadmap.

(6) The transition towards a low carbon economy has important implications for the sustainable use of resources beyond energy resources, and hence the Europe 2020 Resource Efficiency Flagship. Reducing energy GHG emissions coincides with significant reductions in other air pollutants with associated health benefits. The roadmap also needs to consider industrial processes, land use, agricultural and forestry practices and the relationship with the production and consumption of food, feed and fibre (timber, pulp & paper) and the maintenance of essential ecosystem services (soil quality, water availability, biodiversity).

2. OBJECTIVES

(7) The specific objective of the Low-carbon economy roadmap 2050 is to give insight on how the EU policy framework should develop in the next 10 years and beyond to (1) enable deep reductions of greenhouse gas emissions consistent with science while at the same time (2) reducing vulnerability to oil shocks and other energy security concerns, and (3) reaping opportunities for sustainable growth and jobs (related to new low carbon technologies), while taking into account wider sustainability and resource efficiency considerations.

(8) This impact assessment aims to give information on the overall and sectoral pathways, the underlying technological and structural changes required, the investment and cost patterns, and other impacts, synergies and trade-offs related to the broader sustainability and resource efficiency agenda. It aims to give information for developing EU, national and regional climate change policies and specific sectoral roadmaps that are being developed, including outlining milestones.

3. METHODOLOGY AND SCENARIO DESCRIPTION

(9) When considering such a long time frame, it is essential to take into account various assumptions, uncertainties and different developments over time. Therefore the impact assessment considers what it would require for the EU to achieve large emissions reductions in line with the 2ºC objective under different alternative scenarios ("decarbonisation scenarios" instead of policy options) which vary for key parameters, e.g. the type of global conditions, the global energy price developments and the rate of technological innovation. The scenarios include carbon prices as a cost-effective policy driver. By comparing results from different scenarios it is possible to extract more robust conclusions, how key parameters influence results and how various parts interact.

(10) The range for the reduction target of 80 to 95% for developed countries, as presented in the IPCC's 4th Assessment Report covers both internal reductions and the use of international credits. To assess the order of magnitude of the required EU's internal reductions by 2050, a review of recent science is presented together with projections of the POLES model in line with the 2ºC objective, i.e. halving of global emissions by 2050 compared to 1990.

(11) Fossil fuel prices are important when assessing the impacts of reducing GHG emissions but they are largely determined by global markets. In addition, global action on climate change can impact the prices of fossil fuels. Using the global POLES

model the interaction of climate action and fossil fuel prices was analysed through 3 scenarios:

- *Global baseline*: globally no additional climate action is undertaken up to 2050.
- *Global Action*: global action halving global emissions by 2050 compared to 1990.
- *Fragmented Action*: EU pursues a decarbonisation strategy but other countries do not follow. They only comply with the lower end of the Copenhagen Accord pledges until 2020 and undertake no additional efforts after 2020.

This model projection was extended to include global agriculture and land use change projections using the GLOBIOM an G4M models.

(12) For the EU modelling, PRIMES, an energy system model was used in combination with the GAINS model for projections of EU Non CO_2 emissions. Also at the EU scale, the relationship between energy and LULUCF has been analysed with the G4M and GLOBIOM models. Decarbonisation is driven mainly by carbon prices relating to CO_2 and Non CO_2 emissions.

(13) The scenarios projected at EU level are:

- A reference scenario that reflects implementation and continuation of existing policies (i.e. the Climate and Energy Package up to 2020).
- A number of decarbonisation scenarios that reflect an internal EU reduction of 80% in 2050 compared to 1990, except for one fragmented action scenario where additional measures are taken to protect the international competitiveness of energy intensive industries.
- Decarbonisation scenarios are differentiated according to fossil fuel energy prices in line with the results of global analysis with the POLES model:

– scenarios with low energy prices staying relatively stable (oil prices in real terms in 2050 at around 70$_{2008}$/barrel), likely to occur with Global Action.

– scenarios with oil prices gradually doubling (increasing to 127$_{2008}$/barrel in 2050), as in the reference scenario, likely to occur with Fragmented Action.

– scenarios with a temporary oil shock or continued high energy prices from 2030 onwards (doubling to 212$_{2008}$/barrel in 2030), for which a real risk remains with Fragmented Action.

- Decarbonisation scenarios are differentiated according to assumptions on technological developments:

– effective technology scenarios to represent successful enabling of efficient and low carbon technologies

– 'delayed CCS' and 'delayed electrification scenarios' to assess sensitivities regarding the availability of certain technology pathways.

– a sensitivity analysis on delayed climate action that assumes no new and additional climate policies before 2030.

(14) Future modelling improvements could take into account the impact of climate change itself, for instance, on agricultural and energy production and consumption. Further improving the modelling of energy storage and smart grid solutions could better project the deployment of distributed generation.

4. RESULTS FROM THE GLOBAL ANALYSIS

Global reduction efforts, and the EU contribution

(15) The review of the latest scientific literature and the model projections by the POLES model show that the EU would need to reduce its greenhouse gas emissions internally by at least 75%, 80% or more by 2050 compared to 1990.

(16) A global effort consistent with 2°C would imply that other developed countries take action with the same stringency as the EU modelled through an equal carbon price signal. Emerging countries would do so gradually, simulated through a gradual developing carbon market with carbon prices equal in developed and emerging countries by 2030. This results in a reduction of developing countries GHG emissions by 80% in 2050 compared to baseline, back to or even below 1990 emissions. This implies that in case of global action, international credits are not cheaply available and large-scale offsetting is not an alternative to domestic action. The 80 to 95% reduction objective in the EU will largely need to be met internally, also from a cost-effectiveness perspective. Emissions per capita would converge over time with absolute differences by 2050 significantly smaller, even though per capita emissions remain higher in developed countries.

The link between climate action and global fossil fuel prices

(17) The analysis with POLES demonstrates the interaction between global action on climate change and future fossil fuel prices. While baseline projections for oil prices almost double, oil prices in a world of global climate action in 2050 would remain stable compared to today. These relative reductions would result from reduced energy demand and a shift towards low carbon fuels. Essentially, a world of Global Action is characterised by lower fossil fuel prices and high carbon prices.

(18) The analysis shows that in a world of 'Fragmented Action', oil prices reduce only 15% compared to baseline levels. These results are broadly consistent with the World Energy Outlook 2010 of the International Energy Agency. The IEA data indicate clear energy security risks related to the combination of rising demand, difficulties in terms of supply and geopolitical risks in oil and gas exporting regions.

(19) Changes in prices for energy sources will results in changes in income of countries that export these goods. But these impacts are manageable. Annual revenues for OPEC are projected to be much higher in the next 20 years compared to the previous 20 years, even in the case of Global Action.

The global contribution from agriculture and forestry and the link with bio-energy

(20) As part of a global effort consistent with 2°C, also the contribution of agriculture and LULUCF and the correlation with the energy sector on a global scale was analysed, taking into account:

(a) the need to ensure food security to feed the increasing global population

(b) the EU objective to reduce global deforestation, in particular in developing countries, and stop global forest cover loss by 2030

(c) efforts to reduce agricultural emissions

(d) increased biomass use for energy in case of climate change action

(e) Dietary habits remain the same with changes towards more carbon intensive food due to welfare increases.

From the analysis, it is concluded that agriculture and forestry can achieve the above requirements by 2050 if appropriate incentives are set, but productivity improvements on a global scale will be crucial. If these improvements cannot be achieved, the above listed goals are simply not met or can only through significant food price increases.

Reversing existing trends, towards more carbon intensive food, could also contribute, but this has not been analysed. Lifestyle and behavioural changes, could increase the likelihood of meeting deep reduction objectives as well as the overall cost-effectiveness of action by helping to avoid more expensive mitigation options in other sectors. Biodiversity will benefit majorly from limiting global climate change to 2ºC by preserving tropical forests which exhibit very high biodiversity values, but care should be taken that increased productivity in agriculture/forestry is not leading to reduced biodiversity, increased depletion of water resources or cause other environmental problems.

5. RESULTS FROM THE EU ANALYSIS

Overall EU reduction pathways, and sectoral contributions

(21) The analysis of the projections of the different EU decarbonisation scenarios show that by 2050, an 80% EU internal reduction compared to 1990 is technically feasible with proven technologies if a sufficiently strong carbon price incentive is applied across all sectors (range of around € 100 to €370 per ton of $CO_{2\text{-eq. by}}$ 2050). This will require substantial continued innovation in existing technologies but is possible without the deployment of break-through technologies, such as nuclear fusion, hydrogen and fuel cells, or an electricity grid with wide scale application of distributed energy storage, and without major lifestyle changes (e.g. dietary changes, strong changes in mobility patterns). Such developments could further facilitate a low carbon economy, but were not included in the analysis considering the uncertainties of their technical and economic feasibility and because of the difficulties of including them in the modelling tools.

(22) Despite the significant variations in technological and fossil fuel price assumptions across the different scenarios, the results are robust in terms of the speed and magnitude of emission reductions with variations at sectoral level a bit larger.

GHG reductions compared to 1990	**2005**	**2030**	**2050**
Total	-7%	-40 to -44%	-79 to -82%
Sectors			
Power (CO2)	-7%	-54 to -68%	-93 to -99%
Industry (CO2)	-20%	-34 to -40%	-83 to -87%[1]
Transport (incl. aviation, excl. maritime) (CO2)	+30%	+20 to -9%	-54 to -67%
Transport excl. aviation, excl. maritime	*+25%*	*+8 to -17%*	*-61 to -74%*
Residential and services (CO2)	-12%	-37 to -53%	-88 to -91%
Agriculture (Non CO2)	-20%	-36 to -37%	-42 to -49%
Other Non CO2 emissions	-30%	-71.5 to -72.5%	-70 to -78%

Source: PRIMES, GAINS

(23) Total GHG emissions reduce in 2030 by around 40%, compared to 1990 except in the case of high oil prices by 2030, which would result in reductions of 44%. Further intermediate steps of a low cost pathway would be decreases of around 25 % by 2020 and around 60% by 2040.

(24) With equal economic reduction incentives across sectors, a larger contribution by the sectors covered by the EU Emissions Trading System (ETS) would continue to be cost-effective. Emission reductions of already around 45% by 2030 and around 90% compared to 2005 in 2050 would be achieved in the ETS sectors, while non-ETS sectors would reduce their emissions by somewhat over 25% by 2030 and nearly 70% compared to 2005 in 2050.

(25) The highest reductions would occur in the power sector. Under similar economic incentives across sectors, it decarbonises fast through the penetration of a wide range of low carbon technologies (various renewable energy technologies, nuclear, CCS after 2020) and increased demand side efficiency, reaching usually well above 60% emission reductions by 2030. By 2050, decarbonisation of the power sector is practically complete.

(26) Above average contributions in the medium and long term can also be achieved by the residential and service sector. The key drivers for emissions reductions are significant reductions in required heating due to improved insulation, more use of (low carbon) electricity and renewables for building heating as well more energy efficient appliances.

(27) Industry decarbonises slightly less than the overall economy in the medium term, but in particular industry CCS allows for significant further reduction options, be it later (after 2030) than in the power sector.

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[1] Not including the specific scenario with measures that require less reductions from energy intensive industries.

(28) Transport and agriculture are the main sectors where no full decarbonisation in the longer term is achieved.

(29) In transport, the increasing trend of the last 20 years is reversed. In 2030 transport emissions (road, rail and inland navigation) are reduced below 1990 levels for most scenarios, with the effective technology scenario at reference fossil fuel prices achieving -5% and at low fossil fuel prices achieving -2%. But the largest part of reductions would be achieved between 2030 and 2050, reaching levels around -60% for transport[2].

(30) For agriculture the pattern is the inverse. Its reductions between now and 2030 are significant, but then further technical GHG reduction options are more limited. As in other sectors, there remains scope for further analysis concerning the impact of behavioural change on GHG mitigation options.

(31) Other non CO_2 emissions, such as methane from landfills and industrial N_2O emissions are also rapidly reduced until 2030, after which only limited further reductions are taking place. For the non-CO_2 emissions in the ETS these reductions occur already in the reference scenario, for the others sectors such as agriculture, waste and F-gases additional actions would be required beyond existing policies.

System costs: carbon prices, investment expenditure, and fossil fuel costs

(32) In all scenarios, carbon prices increase from around 50 to 60 € per tonne of $CO_{2\text{-eq:}}$ in 2030 to a range of € 100 to € 370 per ton of $CO_{2\text{-eq}}$ (150 € to 200 € for the effective technology scenarios) depending on the technological and fossil fuel parameters chosen.

(33) Notably, there is a clear inverse correlation between fossil fuel prices and carbon prices. Higher fossil fuel prices require lower carbon prices to decarbonise. This is a logical consequence of the fact that pricing in general, be it through the carbon price or through energy prices themselves is an important driver to reduce emissions due to its impact on energy demand and energy efficiency. The benefit of carbon pricing clearly is that it prices those inputs and processes more which are most carbon intensive and that revenues are recycled in the local economy, while with high energy prices this is not always the case, especially for the EU which is heavily reliant on fossil fuel imports.

(34) It is also concluded that delayed development & deployment of certain technologies (CCS, electrification), as well as delayed climate action (no extra action before 2030) leads eventually to significant higher carbon prices and overall higher costs and reduced fuel savings. This highlights the critical importance of :

- R&D and early deployment of low carbon technologies as a means to reduce overall costs and increase public acceptance for certain technologies.

- The need of continuing but gradual reductions over time, so as to avoid that late catch-up leads to large, sudden increases in carbon prices.

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2 NOx emissions from aviation and other indirect impacts of aviation on global warming potential are not included.

(35) The most important conclusion of all decarbonisation scenarios is the massive shift from fuel expenses (operating costs) to investment expenditure (capital expenditure). It is important to note from an economy-wide perspective that investments are to a large extent expenditures in the domestic economy, requiring increased added value and output from a wide range of manufacturing industries (automotive, power generation, industrial and grid equipment, energy–efficient building materials, construction sector etc), while fuel expenses are to a large extent flowing to third countries considering the EU's strong reliance of fossil fuel imports.

(36) In case of the effective technology scenarios, by 2040- 2050, annual investments on average are around € 550 billion higher than in reference case. Averaged out over the 40 year period, this increase in investment expenditure amounts to around € 270 billion annually, both in case of global and fragmented action.

(37) The flip side of the investment increases is an equally large reduction of fuel costs. In the reference scenario, fuel costs still increases from around € 900 billion on average per annum in the period 2010-2020 to around € 1400 billion for the period 2040-2050. With reference energy prices, decarbonisation reduces fuel costs almost € 350 billion per annum in the period 2040-2050. With global action, the reduction in fuel costs compared to reference is of course even larger, with a bit more than € 600 billion saved per annum in the period 2040-2050, because of the combined effect of fossil fuel savings and lower prices for fossil fuels. Taken over the whole 40 year period, average fuel costs decreases per annum compared to reference are between € 175 billion (fragmented action – reference energy prices) and € 320 billion (global action – low fossil fuel prices) provided that electricity penetration in transport is not delayed.

(38) An oil shock or high fossil fuel prices would increase the required investment expenditure in the reference scenario by about € 100 billion per year; there is however no such impact in the decarbonisation scenarios. Fuel expenses are significantly lower in the decarbonisation scenarios combined with high fossil fuel prices than the reference case combined with high fossil fuel prices. In the high fossil fuel price scenario increases in investment expenditure for climate action are more than compensated for by the reduction in fuel costs.

(39) The rise in low carbon capital expenditure is a consistent feature across all sectors (power, industry, transport, and the built environment) but in absolute terms the largest investment increases are not taking place in power generation, grid infrastructure or industry, but in demand side technologies in the transport sector (most notably vehicles), and the built environment (energy-efficient building materials and components, heat pumps, appliances, etc). It is especially the business sectors providing those technologies and equipment that would benefit the most from decarbonisation.

(40) The size and composition of low-carbon capital expenditures in the coming decades raises important questions in policy terms how, even with strong carbon incentives, financing barriers, in particular for end-users of transport and buildings, can be overcome. Innovative finance and fiscal instruments will be required such as preferential loans, grants that pay back part of a low-energy investment and tax rebates, with the aim to unlock private investment in low carbon technologies. Also a larger share of regional funding within the EU budget would need to go to policy instruments that leverage private sector resources.

Energy resources, energy efficiency and energy security

(41) In the decarbonisation scenarios, the EU's energy resource efficiency would improve substantially bringing also energy security benefits linked in particular to lower fossil fuel use and imports. Total primary energy consumption would be reduced to 1650 Mtoe in 2030 and some 1300-1350 Mtoe in 2050; compared to more than 1800 Mtoe in 2005. More domestic energy resources would be used, in particular renewables, and total energy imports would more than halve compared to 2005 by 2050. Starting from 2025, this would lead to a complete reversal of the trend of fuel import dependency increases, reducing to less than 35% by 2050. The oil import bill would be halved or more compared to today by 2050, and reduced by around 80% compared to the reference case, the equivalent of € 400 billion or more.

(42) It is important to note that these levels of reduced primary energy consumption are mainly the result of technological changes on the demand side, and not from reduced energy services: first by more efficient buildings, heating systems and vehicles, reinforced later on by electrification in transport and heating, which combine very efficient demand side technologies (plug-in hybrids, electric vehicles, heat pumps) with a largely decarbonised power sector.

(43) Achieving the 20% energy savings target in 2020 enables the EU to reduce domestic emissions by 25% or more by 2020.

(44) Decarbonisation will significantly reduce fossil fuel security risks but large scale electrification combined with decentralised generation involves other challenges and opportunities. The 2050 Energy Roadmap will address these issues in more detail.

Power sector

(45) While final energy demand of all sectors decreases significantly, electricity consumption keeps on increasing until 2050. This is the result of two opposing trends:

- Increased efficiency improvements on the demand side
- Especially after 2025, an increasing demand from the heating and transport sector, triggered by the wide scale application of efficient demand side technologies (e.g. plug-in hybrids, electric vehicles, heat pumps).

However, the pace of the increase remains similar to historic trends of the last 20 years, despite the fact that over time a considerable part of the transport and heating sector is switching from oil and gas to electricity.

(46) On the supply side, the share of low carbon technologies in the electricity mix (renewables, fossil fuels + CCS, nuclear) is rapidly increasing from 45% today, around 60% in 2020 (as a result of the full implementation of the Climate and Energy Package), to 75 to 80% in 2030 and nearly 100% in 2050. As low carbon electricity technologies are characterised by higher capital expenditures and lower fuel costs, generation investment expenditures are high, as well as for grid expansion. As for other sectors, the key policy question is how to best enable these investments.

Transport

(47) Energy efficiency is one of the major contributors to the decarbonisation of transport. The analysis shows that up until 2025 and despite continuously increasing transport services, improved efficiency of vehicles is the main driver to reverse the trend of increasing GHG emissions and to bring back land based transport GHG emissions below 1990 levels in 2030. For passenger cars for instance, these efficiency improvements go beyond existing CO2&cars legislation after 2020, driven by a gradual hybridisation.

(48) While hybridisation is important from the perspective of increased efficiency up until 2025, it is from a technological perspective also an essential step to enable the move towards electro-mobility (electric propulsion vehicles) after 2025. For passenger cars, this is a key technology that enables very strong reductions in the transport sector post 2030. For aviation, and to lesser extent heavy duty vehicles, biofuels would play a more important role, mostly after 2030.

(49) For aviation biofuels become an important GHG reduction technology in the period after 2030. For road transport the largest increase in biofuels used is in the period up to 2020 to achieve the 20% overall renewables target and the specific 10% renewables target for transport. After 2020 up to 2050 the absolute increase would continue but remain lower than in the period 2005 – 2020, if electro mobility penetrates the market successfully. However, if this is not the case, biofuels would need to become more important to achieve the same level of reductions. Such increases in biofuels could lead to increased pressures on land use, including emissions from land use, biodiversity, water management and the environment in general, at least assuming that land-based biofuels would be used.

(50) There is only a small impact in all scenarios analysed on total transport demand. This is in part due to the modelling framework that focuses on GHG reductions, and does not include specific transport policies to enable a more efficient transport system, modal shift and to reduce different kinds of externalities, such as congestion and air pollution, that can lead to additional co-benefits in terms of emission reductions. These aspects will be dealt with in more detail in the impact assessment of the White Paper on Transport.

(51) A comparison between different scenarios shows there is a clear correlation between GHG reductions in the transport sector and in the power sector. If the transport sector reduces GHG emissions more through electro-mobility, electricity use is increased, which would have an impact on electricity emissions. So, even if the transport sector is not included in the ETS, it would over time increasingly influence developments in the EU ETS.

The built environment

(52) Heating & cooling (two third) and water heating & cooking (more than 20%) are the most important energy consumers in this sector, with the remaining largely lightning and electrical appliances.

(53) The key trends observed are similar to those in the transport sector. First, overall energy demand is reduced: efficiency, in particular the energy performance of

buildings, is improved with passive house technology becoming mainstream, and much improved energy performance of existing buildings through refurbishments. This entails quite substantial investments, which can be recuperated over time by reduced energy bills. A key policy question is how initial financing barriers can be overcome.

(54) As in the transport sector, there is an important shift in terms of the fuels used, from oil, gas and coal towards electricity and renewable fuels. Efficient heat pumps play an important role by allowing to increase end-use efficiency as well as to decrease the carbon intensity of fuels by using geothermal energy and electricity. In addition, biogas, biomass and solar heating are replacing to a significant extent fossil fuels.

Industry

(55) The cost-effective contribution of energy intensive industries in the Effective Technology scenario would increase to around 35% emission reductions in 2030 and between 85 and 90% in 2050. These potentials are a combination of further energy intensity decreases, and the application of CCS for the remaining energy intensive industrial CO_2 emissions (e.g. process emissions in for instance steel and cement) from 2035 onwards.

(56) In the context of fragmented action with the EU reducing emissions significantly more than other countries, certain industries will benefit from additional investments in a wide range of low carbon technologies and improved competitiveness due to first mover advantages.

(57) But also the impact of a more ambitious climate policy on energy intensive industries was assessed. The results of previous macro-economic modelling was revisited and refined up to 2030. It confirmed that the impact on the production levels of energy intensive industries were limited and that free allocation protects energy intensive industry in the ETS, even if the EU would implement more ambitious targets in a world where other regions have more limited ambition.

(58) However, for energy intensive industries, the described reduction potentials after 2035 requires large scale introduction of CCS, which is a technology that has no other real benefits than reduced GHG emissions and which brings both extra investment as well as higher operating costs.

(59) An alternative scenario is therefore analysed where energy intensive industries would be subject to lower emission reduction requirements, where industry emissions stay closer to the reference scenario results, reaching not a reduction of -86% by 2050 but around -50%, in particular because CCS would not become a mainstream technology for process related emissions. In such a scenario, energy-intensive industries would not need to bear the extra costs related to CCS deployment, which would otherwise rise to more than € 10 billion annually in the last decade.

Agriculture and other non CO2 emissions

(60) From 1990 until 2005, non CO_2 emissions were reduced by a quarter, considerably faster than CO_2 emissions. Today, agricultural emissions (N_2O and methane) make up more than half of non CO_2 emissions.

(61) Non CO_2 emissions other than agriculture are projected to decrease significantly, especially before 2030. The main reasons are the N_2O reductions in industrial sectors covered by the ETS, reduction of methane emissions due to the full implementation of the Landfill Directive, reduction of HFCs[3], and the reduction of methane releases in mining, energy and industrial sectors.

(62) With additional actions agricultural emissions can continue to decrease up until 2030, this trends slows down after 2030. With emissions levels at around 330 Mio ton in 2050, a third below emission levels in 2005, agriculture represents around a third of the remaining total EU emissions in 2050, tripling in share from 2005. This points to the important role of agriculture in achieving decarbonisation. If emissions would not continue to decrease by a third by 2050 compared to 2005, other sectors would need to do even more.

(63) At the same time, as global food demand grows, and food patterns change towards more carbon intensive diets, the analysis clearly shows there are limits to the reduction of agricultural emissions. A potentially important element that is not included in the quantitative assessment is the possible impacts of behavioural changes that would reverse current trends towards less carbon intensive food patterns. In the long term, a transition to a more healthy diet could reduce methane and nitrous oxides emissions substantially, and have positive impacts on land use requirements.

Land use, land use change and forestry

(64) Energy from biomass will be a significant component of the increase in renewable energy projected over the coming decades. In the reference case bio-energy production more or less doubles between 2010 and 2050. In the decarbonisation case the production of bio-energy more than triples on the same period. Increased bio-energy supply mainly comes from increased biofuel production from agricultural crops, increased use of agricultural residues, woody biomass and waste materials.

(65) The increases in bio-energy demand will have effects on the manner that land is used in the EU, which are to a certain extent competing with other uses, such as food and feed production, paper and timber production. Furthermore, the production itself could have an impact on the EU's GHG emissions by changing (1) the required inputs in agriculture that could increase emissions (e.g. increased fertiliser use in agriculture), (2) land use leading to net increased greenhouse gas emissions (e.g. changes in deforestation or afforestation rates or conversion of grassland into cropland) and (3) forest management practices and thus altering emissions and absorptions of managed forests (e.g. change in harvesting cycles).

(66) In Europe, land use, land use change and forestry leads to a net sequestration of carbon, in particular in forests. Over time, this net sink is projected to decrease significantly, because of maturing forests, and increased harvesting for bio-energy, paper production and timber. Reducing the increase in virgin wood demand over time, for instance through recycling of organic waste, paper and wood products, would reduce this lowering of the net sink function over time.

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3 F-gas Regulation and Directive of mobile air conditioning systems in vehicles.

(67) Uncertainties are large, and interrelations between the energy, forestry and agricultural sector complex, also on a global scale. EU demand for bio-energy will partly be met through imports, which would lead to lower impacts in the EU, but potentially more in third countries. It is clear that this issue requires further attention and examination. Productivity increases in agriculture would be very important to ensure that these increases in bio-energy can be delivered without too negative impacts on other end uses of forestry or agriculture products. Finally also the impact on biodiversity of changes in management practices will require further attention.

Employment impacts

(68) In terms of employment, the underlying structural changes are expected to have no or a slightly positive impact on the overall employment level (at least in the long run), but significant shifts in employment among or within sectors are expected, provided adequate labour market policies are implemented. The development of policies will matter to ensure overall effects are positive and ensure shifts in employment to sectors and occupations that are innovative and with high growth potential. The analysis has shown that increased investment in capital-intensive goods (power generation equipment, renewable energy, transport equipment, buildings and building components) would require increased output of a wide range of manufacturing sectors, as well as in the construction sector.

(69) Changing the energy system, the transport and the housing sector, which are main sources of GHG emissions, will raise demand for new skills and competences. This is particularly significant in the energy sector as a result of major investments and expansion in renewable and energy management subsectors. The main need is to revise and upgrade the skills of existing workers. But reskilling is not only limited to sectors that see growth decrease or increase but also in sectors that are indirectly involved such as the banking sector.

(70) Furthermore pricing policies can allow for smart recycling of revenues, with employment benefiting most from reductions in labour costs. The introduction of pricing policies such as auctioning for sectors not exposed to international competition or taxation in the Non ETS, together with a reduction in labour costs through recycling can result in net job growth of 0.7% compared to reference, or an increase with a bit more than 1.5 million jobs by 2020.

Co-benefits in terms of air quality

(71) Overall, air quality benefits are observed. Average air pollution levels would be more than 65% lower in 2030 compared to 2005. In 2030, annual costs of controlling traditional air pollutants could be more than € 10 billion lower; and in 2050 even close to € 50 billion could be saved every year. These developments would also reduce mortality, with benefits estimated at around € 7 to 17 billion per year in 2030, and € 17 and 38 billion in 2050. Moreover, public health would be improved, with a reduction in health care costs as well as reduced damage to ecosystems, crops, materials and buildings.

(72)