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A roadmap for moving to a low carbon economy in 2050

{SEC(2010) xxx}

1. EUROPE'S KEY CHALLENGES

The EU provides its Member States with a long-term framework for dealing with the issue of sustainability and the cross-border effects of phenomena that cannot be dealt with at the national level alone. Climate change has long been recognised as one such long-term shaping factor where coherent EU action is needed, both inside the EU and internationally.

The Commission has recently proposed its Europe 2020 flagship initiative for a resource-efficient Europe[1] and within this framework it is now putting forward a series of long-term policy strategies in areas such as transport, energy and climate change. The aim of each of these strategies is to help public policy makers and the private sector plan for the future on the basis of well founded forecasts and projections of future developments that need to be taken into account in the coming years. This Communication sets out key elements that should shape the EU's climate action in order to help the EU become a low-carbon economy by 2050. The approach is based on the view that innovative solutions are required to mobilise investments in energy, transport, and information and communication technologies, and that more focus is needed on energy efficiency policies.

The Europe 2020 strategy for smart, sustainable and inclusive growth includes five targets that set out where the EU should be in 2020. One of them relates to climate and energy: Member States have committed themselves to reducing greenhouse gas emissions (GHG) by 20%, increasing the share of renewables in the EU's energy mix to 20%, and achieving a 20% energy efficiency improvement by 2020. The EU is currently on track to meet two of those targets, but will not meet its energy efficiency target unless further efforts are made[2].

In order to limit climate change to 2ºC, the European Council endorsed the EU objective of reducing greenhouse gas emissions by 80-95% by 2050 compared to 1990, as agreed in October 2009, in the context of necessary reductions according to the IPCC by developed countries as a group[3]. This is in line with the position of world leaders in the Copenhagen and the Cancun Agreements to limit climate change to 2º Celsius. The EU has made a commitment to deliver long-term low-carbon development strategies. Some Member States have already made steps in this direction, or are in the process of doing so, including setting emission reduction objectives for 2050 (e.g. United Kingdom, France, Germany, Hungary, Czech Republic, Finland and Denmark).

Together with the White Paper on Transport and the Energy Efficiency Action Plan, this Communication is a key deliverable under the Resource Efficiency Flagship. It presents a roadmap for action up to 2050 which would enable the EU to deliver greenhouse gas reductions in line with the 80 to 95% target agreed. The roadmap is based on a detailed modelling exercise[4]. It outlines milestones which would show whether the EU is on course for reaching its target, policy challenges, investments needs and opportunities in different sectors

[1] COM (2011) 21, see: http://ec.europa.eu/resource-efficient-europe
[2] Energy Efficiency Action Plan, COM 2011 XXX final
[3] Taking into account necessary efforts from developing countries, this will allow a global reduction of 50% in emissions by 2050.
[4] Explained in more detail in the accompanying impact assessment (SEC(2011)XX)

2. MILESTONES TO 2050

The transition towards a low-carbon economy means that the EU should prepare for reductions in its *domestic* emissions by 80% by 2050 compared to 1990[5]. The Commission has carried out an extensive modelling exercise of how this can be done, as explained in the box below.

This analysis has shown that domestic emission reductions of the order of 40% and 60% below 1990 levels could be achieved in a cost-effective way by 2030 and 2040, respectively. This is illustrated in Figure 1. Such a pathway would require an annual reduction compared to 1990 of approximately 1 percentage point in the first decade until 2020, 1.5 percentage points in the second until 2030, and 2 percentage points in the last two decades until 2050. The effort would become greater over time as a wider set of cost-effective technologies would become available.

Modelling approach for the 2050 roadmap

The results and findings presented in this Communication are based on a comprehensive global and EU modelling and scenario analysis on how the EU can shift towards a low-carbon economy by 2050 against the backdrop of continued population growth and rising global wealth and varying global trends in terms of climate action, energy and technological developments.

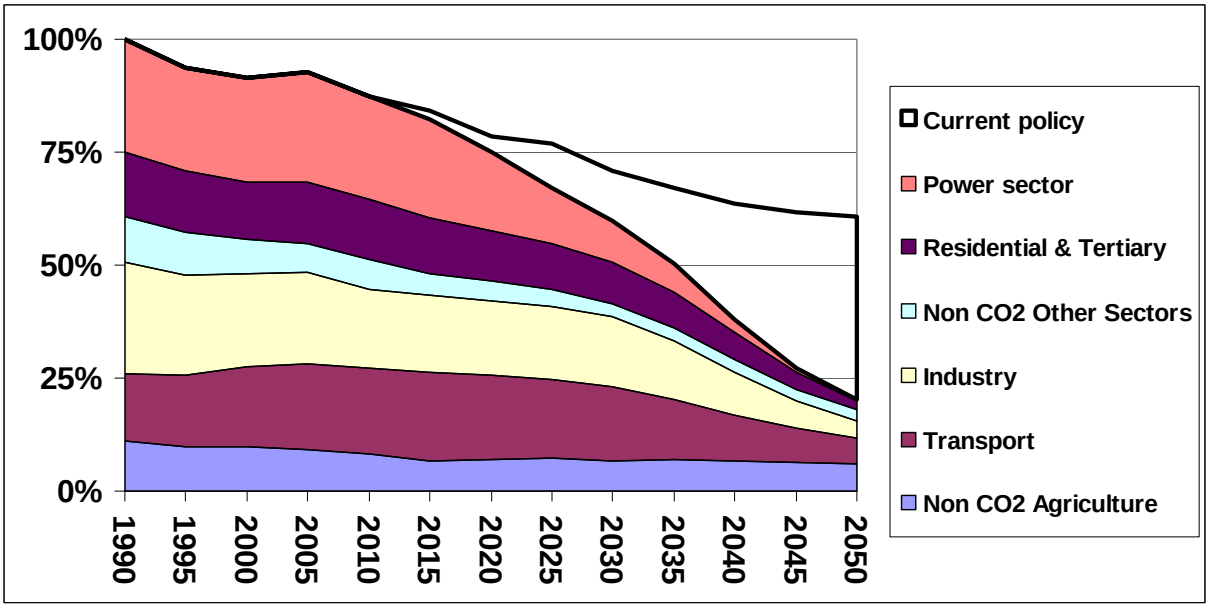
A set of global projections were used to look at global impacts of climate action, how it relates to the energy sector, agriculture and deforestation. Furthermore impacts on the EU's competitive sectors were projected to assess the risks of ambitious actions in the context of fragmented global action on climate.

Detailed EU projections were made within a wide set of potential future scenarios, focussing on the sensitivity to global energy price developments, levels of technological innovation and sectoral contribution, including from agriculture and other land uses. While there are always uncertainties relating to long term projections, results have been made more robust by developing a wide set of scenarios with different assumptions.

Figure 1 illustrates the pathway towards an 80% reduction by 2050. The emissions until 2010 show historic emissions in 5 year steps. The upper "reference" projection shows how greenhouse emissions would develop under current policies. A scenario consistent with an 80% domestic reduction then shows how overall and sectoral emissions evolve under stronger policy requirements, taking into account technological cost-effective options available over time.

[5] Domestic meaning real internal reductions of EU emissions and not offsetting through the carbon market

Figure 1: EU GHG emissions towards an 80% domestic reduction (100% =1990)



Emissions were estimated to be 16% below 1990 levels in 2009. If the EU Emissions Trading System legislation is fully implemented, and if the agreed 20% renewables target is achieved, the EU is on track to achieve a 20% domestic reduction in 2020 below 1990 levels, and 30% in 2030.

The analysis shows that the cost-efficient pathway to the necessary reduction in 2050 requires a 25% domestic reduction in 2020. It also shows, however, that the EU can produce this reduction if it delivers on its existing commitment to increase energy efficiency by 20% by 2020. The revised Energy Efficiency Plan proposed by the Commission alongside this Communication identifies the further measures which will be necessary to deliver the Energy Efficiency target, thus enabling that this cost-effective pathway is followed[6].

The analysis also demonstrates that moving away from this trajectory could lock in carbon intensive investments, resulting in higher carbon prices later on, and significantly higher overall costs over the entire period. In addition, R&D, demonstration and early deployment of technologies, such as various forms of renewable energy, carbon capture and storage, smart grids and hybrid and electric vehicle technology are of paramount importance to enable their cost-effective and large-scale penetration later on. Full implementation of the SET-Plan in the next 10 years, requiring an additional investment in R&D and demonstration of €50 billion over the next 10 years, is indispensable. Auctioning revenue and cohesion funds are financing options that Member States should exploit.

3. LOW-CARBON INNOVATION: A SECTORAL PERSPECTIVE

The Commission's analysis has also identified cost-efficient pathways for key sectors. This analysis looked at a range of scenarios, and although these varied in terms of assumptions, they produced largely convergent results on the extent of the reductions needed in each sector in 2030 and 2050. These are indicated by the ranges presented in Table 1. The key influences

[6] Energy Efficiency Action Plan, COM 2011 XXX final.

on results are the assumptions on the rate of technological progress and the fossil fuel price level.

Table 1: Sectoral reductions

GHG reductions compared to 1990	**2005**	**2030**	**2050**
Total	**-7%**	**-40 to -44%**	**-79 to -82%**
Sectors			
Power (CO_2)	-7%	-54 to -68%	-93 to -99%
Industry (CO_2)	-20%	-34 to -40%	-83 to -87%
Transport (incl. CO2 aviation, excl. maritime)	+30%	+20 to -9%	-54 to -67%
Surface Transport	*+25%*	*+8 to -17%*	*-61 to -74%*
Residential and services (CO_2)	-12%	-37 to -53%	-88 to-91%
Agriculture (Non-CO_2)	-20%	-36 to -37%	-42 to -49%
Other Non-CO_2 emissions	-30%	-72 to -73%	-70 to -78%

A secure and fully decarbonised power sector

Electricity plays a central role in the low-carbon economy. The analysis shows that it can almost totally eliminate CO_2 emissions by 2050, and offers the prospect of partially replacing fossil fuels in transport and heating. Although electricity will increasingly be used in these 2 sectors, electricity consumption overall will only increase in line with historic growth rates, thanks to continuous improvements in efficiency on the demand side.

The share of low-carbon technologies in the electricity mix (i.e. renewables, fossil fuels with carbon capture and storage, and nuclear) is estimated to increase from 45% today to around 60% in 2020, in particular through meeting the existing renewable energy target, to 75 - 80% in 2030, and nearly 100% in 2050. As a result, and without prejudging Member States' preferences for an energy mix which reflects their specific national circumstances, the EU electricity system could become more diverse and secure.

For this to happen, a wide range of technologies which is already available today, and which can reduce emissions at costs that are lower than in other sectors, need to be widely deployed. Other advanced technologies, such as photovoltaics, will continue to become cheaper and thus more competitive over time.

The EU Emissions Trading System (ETS) will need to be strengthened to drive a wide range of low carbon technologies into the market, so that the sector itself can adapt its investment and operational strategies to changing energy prices and technology. For the ETS to play this role, both a sufficiently strong carbon price signal and long term predictability are necessary. In this respect, it is important to note that the agreed linear reduction of the ETS cap[7] will not lead to the level of reductions projected for the power sector in 2030.

Given that the central role of electricity in the low carbon economy requires significant use of renewables, many of which are intermittent in nature, considerable investments in networks are required to ensure continuity of supply at all times[8]. Investment in smart grids is a key

[7] ETS Directive foresees a linear reduction of the cap of 1.74 percentage points per year. This reduction is legally enshrined in the ETS and continues after 2020.

[8] See also Communication "Energy infrastructure priorties for 2020 and beyond – A blueprint for an integrated European energy network", COM (2010) 677 final

enabler for a low carbon electricity system, notably facilitating demand side efficiency, larger shares of distributed generation and enabling electrification of transport. For grid investments, benefits do not always accrue to the grid operator, but to society at large (with co-benefits for consumers, producers, and society at large: a more reliable network, energy security and reduced emissions). In this context, future work should consider how the policy framework can foster these investments at EU, national and local level.

The Commission will present a 2050 Energy Roadmap during 2011 which will examine and propose further developments in the EU energy market, infrastructure and policy framework.

Sustainable mobility through fuel efficiency, electrification and getting prices right

The White Paper on Transport provides a comprehensive set of measures to increase the sustainability of the transport system. Up until 2025, the main driver for reversing the trend of increasing greenhouse gas emissions in this sector is likely to remain improved fuel efficiency. Emissions from surface transport could in fact be brought back to below 1990 levels in 2030, in combination with measures such as pricing schemes to tackle congestion and air pollution, infrastructure charging, intelligent city planning and public transport whilst securing mobility. The drive for improved efficiency, fostered through the CO2 and cars legislation and smart taxation systems, should also advance the development of hybrid engine technologies and facilitate the gradual transition towards large scale penetration of plug-in hybrids and electric vehicles at a later stage.

The synergies with other sustainability objectives such as the reduction of oil dependence, the competitiveness of Europe's automotive industry as well as health benefits (improved air quality in cities) make a compelling case for the EU to step up its efforts to accelerate the development and early deployment of electrification of the transport system. In this respect, it is not surprising to see competitors such as US, Japan, Korea and China increasing their investments in battery technology and electric vehicles.

If electrification of the transport sector penetrates the market successfully, the analysis shows that the demand for biofuels could stay at levels not much higher than in 2020[9], and would be used mostly to power heavy duty vehicles and aviation. If this does not happen, biofuels would need to play a much greater role to achieve the same level of emissions reduction. This could lead to increased pressures on land use, bio-diversity, water management and the environment in general.

The built environment

The built environment provides low-cost and short-term opportunities to reduce emissions, first and foremost through the improvement of the energy performance of buildings. The Commission's analysis shows that emissions in this area could be reduced by around 90% by 2050, a larger than average contribution over the long term. This process has already started, with many Member States implementing stricter energy performance standards for buildings. On 4 February 2011 the European Council decided that from 2012 onwards all Member States should include energy efficiency standards taking account of the EU headline target in public procurement for relevant public buildings and services.

[9] In 2020, the EU has a target of 10% renewables target in the transport sector

This effort will need to be strengthened significantly over time. Today, new buildings should be designed as intelligent low or zero-energy buildings. The extra cost of this will be recovered through fuel savings. A greater challenge, however, is the refurbishment of the existing building stock, and in particular how to finance the necessary investments. The analysis projects that in the next decade we will already need to increase investments in energy saving building components and equipment by up to 200 billion euro. Several Member States have already implemented smart financing schemes, such as preferential interest rates for leveraging private sector investments in the most efficient building solutions.

As in the transport sector, if we succeed in shifting energy consumption towards low-carbon electricity (notably heat pumps) and renewable energy (e.g. solar heating), biogas, biomass, also provided through district heating systems), this will help to protect consumers against rising fossil fuel prices and bring significant health benefits.

Industrial sectors, including energy intensive industries

The Commission's analysis shows that emissions in the industrial sector could be reduced by 83 to 87% in 2050. The application of more advanced and efficient industrial processes and equipment, as well as abatement technologies for non-CO2 emissions (e.g. nitrous oxide and methane) could make a major contribution by allowing the energy intensive sectors to reduce emissions by half or more. As solutions are sector-specific, the Commission sees a need to develop specific roadmaps in cooperation with the sectors concerned.

In addition to the application of more advanced industrial processes and equipment, carbon capture and storage would also need to be deployed on a broad scale after 2035, notably to capture industrial process emissions (e.g. in the cement and steel sector). This would entail an annual investment of more than € 10 billion. In a world of global climate action, this would not raise competitiveness concerns. But if the EU's main competitors would not engage in a similar manner, the EU would need to consider how to address the risks for carbon leakage.

As the EU develops its climate policy framework, there will be a need to continue to monitor and analyse the effects of these measures on the competitiveness of energy-intensive industries in relation to efforts by third countries, and to consider appropriate measures where necessary. The Commission's analysis confirms earlier findings that the current measures provide adequate safe-guards in the current context[10].

Raising land use productivity sustainably

The Commission's analysis shows that by 2050 the agriculture sector can reduce emissions by between 42 and 49% compared to 1990. The sector has already achieved a significant reduction, and more reductions are feasible in the next two decades. European agricultural policies should focus on a number of promising options such as further efficiency gains, more efficient fertiliser use, bio-gasification, improved manure management, better fodder and improved livestock productivity.

Improved agricultural and forestry practices can increase the sector's function to sequester carbon, and preserve stored carbon in soils and forests. This can be achieved for instance through targeted measures to maintain grasslands, restore wetlands and peat lands, low or zero

[10] COM (2010) 265 final

tillage, reduce erosion and allow for the development of forests. Agricultural and forestry are also providing the resources for bio-energy, and this contribution is bound to increase further.

After 2030, reductions in the agricultural sector slow down, in part because of increased agricultural production, linked to the growing global population. However, it is important to note that, by 2050, it represents a third of total EU emissions, tripling its share compared to today. Its importance in terms of climate policy is therefore bound to increase: if it does not achieve the projected emissions, other sectors would need to reduce even more, which would come at a high cost.

The analysis also considers implications for the agricultural and forestry sector in a global perspective. In 2050, the world will have to feed 9 billion people. At the same time, tropical forests will have to be preserved as an essential component of effectively tackling climate change. In addition, mitigation efforts are expected to increase demand for bio-energy on top of existing and increasing demand for feed for animals, timber and paper production. In order to cope with these increased land use requirements, sustainable increases in productivity in the agricultural and forest sector need to continue, not the least in developing countries. If not, food prices are projected to increase significantly.

This also underscores the need to consider all land uses in a holistic manner, and the importance to include Land Use, Land Use Change and Forestry (LULUCF) in the EU climate policy. In addition, products such as timber and paper should be increasingly reused and recycled as a means to reduce pressure on land use. Reversing existing global trends by reducing food waste and re-orienting consumption towards less carbon intensive food could also contribute.

4. INVESTING IN A LOW CARBON FUTURE

A major increase in capital investments

Various forms of renewable energy, smart grids, passive housing, carbon capture and storage, advanced industrial processes and electrification of transport (including smart grids and energy storage technologies) are key components which are starting to form the backbone of low carbon energy and transport systems after 2020. This will require a major and sustained investment: on average over the coming 40 years, the increase in investment expenditure is calculated to amount to around € 270 billion annually. This represents an additional investment of around 1.5% of EU GDP per annum on top of the overall current investment representing 19% of GDP. It would simply take us back to the investment levels before the economic crisis. Investments today will determine the future competitiveness of economies. In this context, it is interesting to take note of the much larger shares of GDP allocated to investments in China (48%), India (35%), and Korea (26%) in 2009, showing emerging economies' strength in rapidly modernising their economy.

Unlocking the investment potential of the private sector and citizens presents a major challenge. While most of this extra investment will be paid back over time through lower energy bills and increased productivity, markets tend to discount future benefits, and disregard long term risks. A key question is therefore how policy can create the framework conditions for such investments to happen, including through new financing models.

Smart policies are part of the answer. With the Climate and Energy package, the EU already has in place a range of key instruments it can build on. In its May 2010 Communication[11], the Commission has already indicated that excess allowances from phase 2, which are estimated to amount to 500 to 800 million allowances, would increase the total amount of allowances available in phase 3, compared to what was envisaged during the review of the ETS. Setting aside an equivalent number of allowances during the period 2013-2020 in phase 3 would restore the originally foreseen overall allowances budget for the next decade. This would restore the reward for low carbon investments, preparing the sector for the innovations needed in a 2030 perspective.

Additional public private financing mechanisms are indispensable in order to overcome initial financing risks and cash flow barriers. Public finance through innovative financing mechanisms, such as revolving funds, preferential interest rates, risk sharing facilities and blending mechanisms can mobilise and steer the required private finance. In this way, limited public finance can leverage a multitude of private sector investments.

Increasing domestic investments provide a major opportunity for increased productivity, added value and output from a wide range of EU manufacturing industries (e.g. automotive, power generation, industrial and grid equipment, energy–efficient building materials, and the construction sector), which are key industries for the creation of future growth and jobs. .

Beyond the reductions in greenhouse gas emissions, which are the key benefits of the shift to the low carbon economy, this transition will bring a number of other essential benefits.

Reducing Europe's energy bill and its dependency on energy imports

Taken over the whole 40 year period, it is estimated that energy efficiency and the switch to domestically produced low carbon energy sources will reduce the EU's average fuel costs by between € 175 billion and € 320 billion per year. The actual cost saving depends on the extent to which action on climate change is undertaken. The highest fuel savings will be achieved if the rest of the world also steps up its efforts to save energy and reduce greenhouse gas emissions as this will lead to a reduction in global fossil fuel prices. If the rest of the world does not do so, however, a major benefit of EU action would be to protect the economy against high energy prices. The analysis, as well as the IEA World Energy Outlook 2010, clearly demonstrates that fossil fuel prices are indeed projected to be significantly higher in case of limited global action.

In 2050, the EU's total primary energy consumption could therefore be almost 40% below 2005 levels. More domestic energy resources would be used, in particular renewables. Imports of oil and gas would decline by half compared to today, reducing the negative impacts of potential oil and gas price shocks significantly. Without action the oil and gas import bill would instead double compared to today, a difference of € 400 billion or more by 2050, the equivalent of 3% of today's GDP.

New jobs

Investing early in the low carbon economy will create new jobs both in the short and the medium term. Renewable energy has a strong track record in job creation. In just 5 years, the

[11] COM(2010) 265 final

renewable industry increased its work force from 230.000 to 550.000. Also for the construction sector low carbon investment offers large job opportunities. With some 15 million employees in the EU, it was particularly hard hit by the economic crisis. Its recovery could get a significant boost through a major effort to accelerate the renovation and building of energy efficient houses. The Energy Efficiency Action Plan confirms the large job creation potential from promoting investments in more efficient equipment.

In the longer term, the creation and preservation of jobs will depend on the EU's ability to lead in terms of the development of new low carbon technologies through increased R&D and entrepreneurship, as well as favourable economic framework conditions for investments. In this context, the Commission has repeatedly emphasized the positive employment benefits of using revenues from the auctioning of ETS allowances and CO_2 taxation to reduce of labour costs, with the potential to increase total employment by up to 1.5 million jobs by 2020.

As industry takes advantage of the economic opportunities provided by the low carbon economy, the need to ensure a skilled work force, especially in the construction sectors, technical professions, engineering and research, becomes more pressing. This will require targeted vocational training of the existing work force towards green job opportunities.

Improving air quality and health

Air pollution would be significantly reduced as a result of action to reduce greenhouse gas emissions. Electrification of transport, and the expansion of public transport, could drastically improve air quality in Europe's cities. 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 up to €17 billion per year in 2030, and up to €38 billion in 2050. Moreover, public health would be improved, with a reduction in health care costs and damage to ecosystems, crops, materials and buildings.

5. THE INTERNATIONAL DIMENSION

The EU with only little more than 10% of global emissions will not be able to tackle climate change on its own. Nonetheless, by formulating and implementing ambitious domestic climate change policies for more than a decade, the EU has brought many other countries on board. The situation today is fundamentally different than at the end of 2008 when the EU unilaterally adopted its Climate and Energy Package. At COP15 in Copenhagen, world leaders agreed that global average temperature should not rise more than 2°C. In 2010, more than 80 countries have pledged domestic targets under the Copenhagen Accord and the Cancun agreements.

This concrete action, sometimes more ambitious than what countries would be ready to commit to internationally, is driven to a significant extent also by other domestic agendas: to accelerate innovation, increase energy security and competitiveness in key growth sectors and reduce air pollution. Quite a number of Europe's key partners from around the world, like China, Brazil and Korea, are addressing these issues, first through stimulus programmes, and now more and more through concrete action plans to promote the 'green economy'. Standstill is not an option for the EU, as it would mean losing ground in major manufacturing sectors. In the coming years, implementing these pledges will be a key step in globalising climate change

policies. The EU should use this opportunity to strengthen its cooperation with its international partners.

However, swift implementation of the pledges made since Copenhagen would only achieve part of the reductions needed. A recent report by UNEP estimated that their full implementation would reach 60% of the required emission reductions until 2020. If no firm global action is taken against climate change, temperatures might increase by more than 2°C already by 2050, and more than 4ºC by 2100. In order to avoid this scenario, science indicates that by 2050 global greenhouse gas emissions need to be reduced by at least 50% compared to 1990. With the preparation of this roadmap to accomplish deep emission cuts of 80% - 95% by 2050, the EU is taking a new initiative to stimulate international negotiations in the run-up to Durban. In this way, the roadmap is an integral part of a wider strategy to deliver on the objective to keep global average temperature increase below 2 degrees Celsius compared to pre-industrial levels.

6. CONCLUSIONS

The Commission's detailed analysis of cost-effective ways of reducing greenhouse gases by 2050 has produced a number of important findings.

In order to be in line with the 80 to 95% overall objective by 2050, the roadmap indicates that a cost effective and gradual transition would require a 40% domestic reduction of greenhouse gas emissions compared to 1990 as a milestone for 2030, and 80% for 2050. Building on what has already been achieved the EU needs to start working now on appropriate strategies to move in this direction.

Second, the analysis also confirms that current progress with existing policies will achieve the goal of a 20% GHG reduction by 2020. If the revised Energy Efficiency Plan is fully and effectively implemented so that we meet the 20% energy efficiency objective this would enable the EU to reduce domestic emissions by 25%, which would be in line with the cost-effective trajectory presented in this Communication. In the international negotiations, the EU offer to take on a 30% reduction target if the conditions are right, remains on the table and is not affected by this Communication.

Third, the roadmap gives ranges for emissions reductions for 2030 and 2050 for key sectors.

The Commission intends to use the roadmap as a basis for developing sector specific policy initiatives. It has already done so with the White Paper on Transport and the revised Energy Efficiency Plan which are adopted alongside this Communication. The Commission will initiate the appropriate sectoral dialogues. Later this year, the Commission will present a 2050 Energy Roadmap. As part of the development of the next Multi-Annual Financial Framework, it will also examine how EU funding can support instruments that are necessary to promote the transition to a low carbon economy. The Commission will continue to ensure that the EU ETS remains a central instrument to drive low carbon investments.

The Commission invites the other European institutions, Member States and stakeholders to take this roadmap into account in the further development of EU and national policies for achieving the low-carbon economy by 2050.