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COMMISSION STAFF WORKING PAPER

Analysis of options beyond 20% GHG emission reductions: Member State results

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1. INTRODUCTION

The EU has put in place the Climate and Energy Package (hereafter referred to as the Package) to achieve its 2020 targets of reducing greenhouse gas (GHG) emissions to 20% below their 1990 levels and increasing the share of renewable energy to 20%. When proposing the Package in 2008, the European Commission estimated the economic, social and environmental impacts of meeting these two targets in order to support the decision making process in the EU institutions[1].

In May 2010, the Commission presented its *Analysis of options to move beyond 20% GHG emission reductions and assessing the risk of carbon leakage*[2] (hereafter referred to as the May 2010 Communication). This Communication explored the options for, and related costs and benefits of, moving towards a 30% reduction, which the EU had committed to do provided that other developed countries committed themselves to comparable emission reductions and that more advanced developing countries contributed adequately according to their responsibilities and respective capabilities. The purpose of this May 2010 Communication was not to decide to move to a 30% target: the conditions set were clearly not met. But it wanted to facilitate a more informed debate on the implications of the different levels of ambition.

It triggered a debate in the EU institutions on the EU's optimal strategy, not only in terms of the EU's offer and leverage in the international climate change negotiations, but also regarding how Europe's interests can be served best in a rapidly globalising world – a world characterised by the continued economic and physical vulnerability of conventional energy systems and accelerating innovation in energy and transport technologies.

In October 2010 the Council[3] invited the Commission to further elaborate options for moving to a 30% reduction and to conduct analyses on the consequences at Member State level. This Staff Working Document answers that request. Whereas the May 2010 analysis looked at the EU-level impacts, the purpose of this document is to provide more information on the effects projected at the Member State level. As in the May 2010 Communication, the focus is on the 2020 time horizon. The analysis also uses the same scenarios, in particular:

A **Baseline**, reflecting trends and policy measures implemented as of spring 2009. The **Baseline** projections estimate that EU GHG emissions would stay at 14% below 1990 levels in 2020, i.e. 6% short of the 20% reduction target;

A **Reference scenario**, reflecting full implementation of the Climate and Energy Package. The **Reference scenario** includes both the achievement in 2020 of the 20% renewable energy target and 20% GHG emissions reductions, compared to 1990 levels;

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1 SEC(2008) 85/3

2 COM(2010) 265 final

3 Council of the European Union, Environmental Council Conclusions, 14 October 2010 (14979/10)

A **30% Reduction Commitment scenario**[4], based on a 25% GHG reduction through domestic measures, with the remaining 5% reduction met through the use of international emission reduction credits.

The detailed results listed by Member State can be found in the Annex of this Staff Working document. It should be noted that the analysis and results presented do not include the impact of GHG emissions and removals from the land use, land-use change and forestry (LULUCF) sector. The potential impact of the LULUCF sector on GHG emissions will be analysed in the context of an assessment of the role of LULUCF in the EU' climate change commitments.

Scenarios must be considered with caution: they are a projection -not a forecast- whose results are partially dependent on assumptions such as GDP and fuel price developments, which are uncertain in nature, especially in today's difficult economic and budgetary circumstances. In this context, it is important to note that the EU GDP developments in these scenarios remain close to the latest DG ECFIN 2012 Ageing Report[5]. In addition, these scenarios also include the phase-out of nuclear energy in Germany.

2. COSTS AND BENEFITS OF THE CLIMATE AND ENERGY PACKAGE

The Package was expected to be a key driver for GHG emission reductions triggering innovation, and growth and job creation in the low carbon technology industries. However, since its adoption the ongoing economic crisis has dampened those hopes.

Firstly, the effect of the EU's climate change policies and measures in the period 2005-2008, together with higher energy prices, already resulted in faster emissions reductions than originally expected when the Package was proposed. Secondly, the economic and financial crisis that started in 2008 resulted in further significant emissions reductions and a build up of a large buffer of banked allowances and unused international emission reduction credits in the EU emissions trading system (ETS) – potentially representing the equivalent of 2.4 billion allowances by 2020. This surplus will have a depressing effect on the price of allowances in the ETS for years to come, even when taking into account the partial recovery in industrial production in the past two years and further projected economic growth to 2020. Many Member States are now also projecting they will overachieve their target in the sectors outside the ETS under the Effort Sharing Decision.[6]

Due in part to these factors, the 2020 GHG emission target is already within reach today. In 2010, EU-27 GHG emissions were 14% below the 1990 level[7].

Consequently the low-carbon transformation and innovation effect has been compromised. New but not yet fully commercial technologies, such as carbon capture

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4 This scenario was originally titled "30% with flexibility scenario" in the Staff Working Document accompanying the May 2010 Communication (SEC(2010) 650 final, Part 2)

5 European Commission, Directorate-General for Economic and Financial Affairs (2011)

6 Estimates for 2020 GHG emissions levels, COM(2011) 624 final, Report on the "Progress towards achieving the Kyoto Objectives".

7 Including CO_2 emissions from aviation.

and storage (CCS) are not progressing towards the market as anticipated or may require more direct support, just as budgetary constraints make this more difficult for governments to provide.

By depressing the carbon price, the fall in emissions in the ETS has paradoxically increased the risk of Europe getting locked into too high-carbon investments. This is particularly inopportune considering the size of the capital stock still to be replaced this decade. Carbon-intensive investments today would lead to higher mitigation costs after 2020, if increasing emissions reductions objectives are to be reached in order to stay in line with the internationally agreed objective of holding global warming below 2°C.

The natural consequence of recent developments, however, is that, as the May 2010 Communication showed, reaching the 20% GHG emissions reductions target and the 20% renewables target for 2020 has lower costs in absolute terms than originally foreseen: the costs for energy users in the year 2020 have fallen to an estimated €48 billion, or 0.3% of GDP, with further expansion of renewable energy accounting for a major part of this. This is not an estimate for any reduction in GDP. It rather represents an additional investment in the future, estimated at €34 billion annually over the period 2016-2020.

The present detailed analysis by Member State shows that cost effective implementation of the Package will cost considerably less than originally envisaged for **all** Member States. The cost reductions are greater in the lower income Member States. The analysis confirms that the measures foreseen in the Package, such as the re-distribution of auctioning revenues and the targets and flexibility foreseen in the Effort Sharing Decision, are instruments that contribute overall to a more equitable division of effort among Member States.

As costs have lowered for all Member States, the advantages for some Member States that benefit from these distributional elements are now expected to be less pronounced for three reasons. Firstly, lower carbon prices mean that there is significantly less auctioning revenue to be distributed between Member States (potential auctioning revenues in the year 2020 are estimated to total in the order of €21 billion). Secondly, revenues from potential transfers of national emissions allowances between Member States in the Effort Sharing Decision are expected to be significantly lower. Thirdly, governments are for the moment not planning to make use of the co-operation mechanisms to meet their renewable energy targets.

3. MOVING TO A 30% REDUCTION SCENARIO: COSTS AND BENEFITS

The fact that the 20% emissions reduction target is now less costly in monetary terms than was assumed in 2008, means that the 30% reduction scenario has become considerably less costly too. Achieving 25% out of 30% reductions domestically by 2020 is estimated now to cost around €70 billion. This figure of around €70 billion estimates the direct net impact on energy consumers but does not take into account the indirect economic benefits of accelerated technology innovations, increased energy security or reduced air pollution. Nevertheless, this reduction in absolute costs of the step-up to 30% reductions comes in the context of a crisis which has left businesses with much less capacity to find the finance needed to modernise in the short run, and great uncertainty over how long it will take to recover.

Cost savings

For the EU as a whole, moving to a 25% domestic reduction in 2020 would save an average of €20 billion in fuel costs each year over the period 2016-2020 compared to the Reference scenario. Of this, by 2020, €9 billion comes from reduced oil and gas imports. Furthermore, when compared to the Reference scenario with only 20% GHG reductions, air pollution control costs would be €2.7 billion lower and there would be additional EU-wide health benefits of €3.4-7.9 billion a year due to reduced mortality. The health benefits and air pollution control savings would be greatest in lower income Member States, and compensating significantly the higher costs they experience from stepping up to 30% GHG reductions.

Investment needs

As the Commission has shown in its Roadmap for moving to a competitive low carbon economy in 2050,[8] for a cost-efficient transition to a low carbon economy as a contribution to global efforts in line with the 2°C objective, that avoids carbon lock-in, domestic emissions reductions of the order of 40%, 60% and 80% below 1990 levels by 2030, 2040 and 2050 respectively should be considered as milestones. A 25% domestic reduction by 2020 is in line with this cost-efficient path.

Investments in energy efficiency can enhance competitiveness and support security of energy supply and sustainability. . As such, the EU Heads of State or Government have underlined the need to deliver on the 2020 20% energy efficiency target[9]. Furthermore if the 20% energy efficiency target were to be met through the full implementation of the Energy Efficiency plan, this would lead to outperform the current EU 20% GHG emissions reduction target and achieve 25% reduction by 2020. Quick adoption and implementation of the proposed Energy Efficiency Directive[10] could also help unlock benefits which have the potential to create two million jobs, as well as addressing climate change.

But achieving this would require additional upfront investments, which are currently more difficult to finance. .

Compared to the Reference scenario of a 20% GHG reduction, a 25% domestic GHG cut by 2020 would require additional investment in the energy system of €18 billion annually over the period 2016–2020. The biggest investments would be needed in the electricity grid, power plants and in energy efficiency, most notably in buildings and the transport sector[11]. These increased investments in energy-efficient low-carbon equipment would generate demand for high value-added products from manufacturing industries and reduce capital outflow to third countries outside Europe. This is particularly the case in

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8 COM(2011) 112 final.

9 European Council, 4 February 2011, Conclusions, (EUCO 2/1/11, Rev 1)

10 COM (2011) 370

11 Covering vehicles and alternative fuel infrastructure

the lower income Member States, where fuel savings by 2020 would be similar to the additional investment needed.

Auction revenues

If the 30% target in the ETS would be implemented by a reduction in auctioned allowances, it is estimated that overall auctioning revenues for Member States in the year 2020 would be up to €7 billion or around one-third higher than with the current 20% target, increasing auction revenues to around €28.5 billion. Member States opting for a temporary derogation from full auctioning for the power sector would obviously not only loose out on part of their auctioning revenues, but also partially forego increases in auctioning revenue resulting from a higher reduction target. As the Commission has repeatedly emphasised, most recently in the Annual Growth Survey 2012 in November 2011[12], smart recycling of both auctioning revenues and revenues from carbon pricing in the sectors outside the ETS could spur jobs and growth whilst at the same time combating climate change.

Risk of carbon leakage

The macro-economic analysis conducted for the *May 2010 Communication*[13] shows that the incremental impact of stepping up the EU effort to 30%, while the others remain at their low Copenhagen pledges in comparison to the current climate and energy package, on the output of the EU's energy intensive industry, even with increasing carbon prices due to the step up, would be limited as long as the existing special measures for energy-intensive industry stay in place. Stepping up to 30%, while the others remain at their low Copenhagen pledges, would entail extra estimated production losses of up to around 1%. The more that major trading partners implement their high-end pledges, the lower the risk of carbon leakage. As stated in the *May 2010 Communication*, the Commission continues to monitor the situation, including the competitiveness of EU industry *vis-à-vis* its main international competitors, particularly those which have not yet taken convincing action to combat climate change. Clearly, the best protection against the risk of carbon leakage would be effective global action.

4. MOVING TO A 30% REDUCTION SCENARIO: ENSURING EQUITABLE TREATMENT OF MEMBER STATES

As in the case of the current 20% emissions reduction target, a step-up to 30% would result in additional investment needs that are proportionally higher in the group of lower income Member States. Moving to a 30% target has an impact on the distribution of efforts between Member States, and would require decisions on mechanisms such as those adopted under the Package to ensure an equitable distribution of efforts between Members States. The underlying analysis suggests that there are mechanisms that have the potential to balance out these differences between Member States.

First, moving to a 30% target through reducing the number of allowances auctioned in the ETS can result overall in higher auctioning revenues, with carbon prices increasing

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12 COM(2011)815 final of 23.11.2011

13 SEC(2010) 650, Part 2.

more than the reduction in the amount of auctioned allowances. Due to the expected increase of the carbon price, the existing distribution key for auctioned allowances in the ETS Directive would already strengthen the redistributional effect in favour of lower income Member States. Furthermore, the analysis suggests that the more the higher income Member States were to contribute to set aside allowances, the more the lower income Member States would see auctioning revenues rise. In the extreme case where only higher income Member States contribute to a set-aside revenues for lower income Member States may rise by as much as 80% in 2020, without loss for the auctioning revenue for the higher income Member States.

The transfers related to the redistribution of auctioning rights to the lower income Member States would increase by €5.4 billion in 2020, without reducing the net value of revenues of higher income Member States. Such a differentiation could go a long way towards rebalancing relative costs and benefits. Before 2020, the use of the derogation permitting free allocation to the power sector (foreseen by Article 10(c) of the ETS Directive) would not reduce the distributional effect between countries but would reduce the revenue effect for governments.

Second, a higher ambition level would also require greater emission reduction efforts in the non-ETS sectors. The existing flexibility measures in the Effort Sharing Decision would assume a much more important role: demand for transfers of national emissions allocations would increase considerably – as would their value. This would give those Member States which are required to make less effort to achieve their non-ETS target, often lower income Member States, an additional incentive to implement carbon-efficient economic policies, and further over-achieve on their targets in the Effort Sharing Decision. Such over-achievement could then be transferred to another Member State in exchange for financial transfers.

The transfer mechanism in the Effort Sharing Decision could therefore encourage all Member States, including those that can more easily achieve their targets, to put in place smart policies, such as the reduction of fuel subsidies, efficiency improvements and the introduction of carbon pricing, thereby generating additional revenues which could be recycled to spur employment and innovation, for instance through reductions in labour costs, increased support for R,D&D of breakthrough technologies and necessary infrastructure such as carbon capture and storage projects, support to energy efficiency and renewable energy projects and funding of technical assistance for companies in need to reduce GHG emissions, and any support is limited to the amount necessary and does not unduly distort competition. This not only reduces GHG emissions but could also spur growth and job creation. For instance, estimates by the Commission put the EU wide potential for net employment increases by 2020, in the case of a step-up from recycling carbon pricing in the ETS and non ETS into lower labour costs, at up to 1.5 million extra jobs by 2020.

In conclusion, on the basis of the estimated impacts for each Member State, and taking into account the specific circumstances of each country, there seem to be potential mechanisms which, individually or in combination, could ensure an equitable distribution of costs and benefits between EU Member States if the political decision were taken to set a new GHG emission target for 2020 going beyond the current 20% reduction, taking into account the global context.

It is further worth recalling that the Commission's proposal for the Multiannual Financial Framework (MFF)[14] for the period 2014-2020 is fully aligned with the Europe 2020 strategy, whose headline targets include cutting GHG emissions by 20%, or 30% if the conditions are right. The Commission proposes increasing the share of the EU budget spent on furthering Europe's transition to a low carbon and climate-resilient society to at least 20%. This would take financial support for climate-related purposes to around €200 billion for the 2014-2020 period, making an important contribution to the EU's low carbon future.

Cohesion policy[15], can support increased regional investments in energy efficiency, renewables and alternative fuel infrastructures. In this respect, the Commission's proposal for the 2014-2020 cohesion policy[16] includes a mandatory concentration of European Regional Development Fund (ERDF) resources on energy efficiency and renewables, at a level of a minimum of 20% of the national ERDF resources for transition and more developed regions and a minimum of 6% for less developed regions. At the EU level, this equates to an estimate of about € 5.1 billion for more developed regions, € 4.7 billion for transition regions and € 7.3 billion for less developed regions, but Member States can choose to invest more in these sectors. In addition, climate-related programmes, such as on improved waste management, energy efficiency, sustainable transport or the deployment of renewables, can also be supported in the lower income Member States that are eligible for the Cohesion Fund. The proposed total Cohesion Fund budget for 2014-2020 is € 68.7 billion. It provides support to projects in Member States with a per capita gross national income of less than 90% of the Union average, which are those Member States that have more low-cost opportunities to reduce emissions, although with relatively higher resulting costs in relation to their GDP.

In this regard, it is worth noting that also other parts of the MFF will assist Member States in meeting greenhouse targets. Horizon 2020 will support research in transport, energy, advanced materials research and sustainable bio-economy, which will also improve EU competitiveness in these areas. The Connecting Europe Facility will make our energy system more energy secure and better prepared for a low carbon future. By focussing on transport modes that are less polluting and less carbon intensive, the Connecting Europe Facility will push our transport system to become more sustainable. The proposed reform of the Common Agricultural Policy, through the greening of direct payments and the inclusion of climate action as one of the objectives of the European Agricultural Fund for Rural Development, will further reduce greenhouse gas emissions from agriculture.

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14 COM(2011)500/I and II.

15 Cohesion policy related figures are expressed in 2011 prices.

16 COM(2011) 615.

5. ANNEXES

5.1. Scenarios analysed

The analysis is fully based on the scenarios and results of the *May 2010 Communication*[17]. This analysis mainly adds the Member State results of the step-up scenario towards a 30% GHG reduction commitment that achieves domestic GHG reductions in the EU of 25% by 2020 compared to 1990 in a cost effective manner.

The following three scenarios are analysed:

- The **Baseline** reflecting trends and already implemented policy measures as of spring 2009;
- The **Reference scenario** reflecting full implementation of the Climate and Energy Package;
- A 30% Reduction Commitment scenario[18] that represents a **25% domestic GHG reduction scenario** in 2020 in the EU. The remaining 5% is assumed to be met through the use of international emission reduction credits.

All scenarios estimate CO_2 and non-CO_2 GHG emissions from 2005 to 2030 alongside the related costs and investments at both the EU27 and Member State levels. They are based on macro projections of GDP and population and projections of international fuel prices which are exogenous to the models used[19].

The scenarios of the May 2010 Communication do not include emissions and removals in the LULUCF sector, neither the impact of increased penetration of renewables on this sector. It is clear that this issue of LULUCF in the EU requires further attention and examination. The Commission will revisit this issue in the context of an assessment on the role of LULUCF in the EU's climate change commitment. Furthermore the analysis did not take into account the potential of behavioural change, such as changes in consumption patterns and resulting waste management, beyond those triggered by pricing mechanisms.

The full consistency of the analysis with the May 2010 Communication implies, that certain recent developments are not reflected in the quantitative analysis. In this context, a number of observations can be made:

- The economic crisis has further evolved during the last year. However, a comparison of the scenario assumptions with the most recent available longer

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17 COM(2010) 265 final

18 This scenario was originally titled "30% with flexibility scenario" in the Staff Working Document accompanying the May 2010 Communication (SEC(2010) 650 final, Part 2).

19 For a detailed description of the assumptions and the results of the Baseline and Reference scenario, including on demographic and macroeconomic assumptions, see "EU energy trends to 2030 - UPDATE 2009".

term GDP projections from the DG ECFIN 2012 Ageing Report[20] shows that the differences are small. The scenarios use an EU GDP in 2020 of € 14963 bn in constant 2008 prices while the most recent Ageing Report projects € 14719 bn in 2010 prices. If any, this may imply a limited overestimate of the costs in this analysis.

- In March 2011, the Commission has published the Roadmap for moving to a competitive low carbon economy in 2050[21]. It was based on an extensive model–based scenario analysis. However, the reference scenario used for that analysis is basically an extension in time of the reference scenario used for this SWD.

- There were further developments on the intended use of nuclear energy in some Member States. However, it should be noted that with respect to the year 2020 the legal situation in Germany as covered in the scenarios presented here is very similar to the implemented policy today, i.e. a nearly completed phase out of nuclear energy.

Given that this is a modelling exercise, projections and results should be considered with caution. Results are not an exact prediction of future effects but are intended to inform policy makers on the potential nature of impacts of certain policy options. Especially for smaller Member States, where single investments can influence overall figures, the results are dependent upon specific assumptions and scenario developments.

The **Baseline** reflects current trends and implemented policy measures at EU and national levels as of spring 2009 to show the EU's progress in implementing the Package and other relevant measures. It results in domestic GHG emissions reductions of approximately 14% in 2020 compared to 1990, a level similar to the emission levels in 2010[22]. Consultations have been held with Member States concerning the main assumptions, implemented national policies and expected results.

The **Reference** scenario reflects the full implementation of the legally binding targets set out in the Package, i.e. the Member States' targets for GHG emissions reductions for sectors not included in the ETS (the so-called non-ETS emissions), as included in the Effort Sharing Decision[23], and the Member States' targets of 20% renewable energy use as included in the Renewable Energy Directive[24]. It also includes further EU legislation adopted between spring and end of 2009 to reflect eco-design implementation standards and the recast of the Directive on Energy Performance of Buildings.

The Package gives considerable freedom to Member States on how they can achieve their targets. The Reference scenario is based on general assumptions how these targets are achieved, it does not necessarily reflect specific national compliance strategies.

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20 European Commission, Directorate-General for Economic and Financial Affairs (2011)
21 COM(2011) 112 final
22 COM(2011) 624 final, Report on the "Progress towards achieving the Kyoto Objectives".
23 Decision No 406/2009/EC
24 Directive 2009/28/EC

All results (including for the Baseline) are consistent with the Member State level results presented in the report "EU energy trends to 2030 - update 2009"[25]. The results for the Reference scenario vary marginally from the Reference scenario results used in the Staff Working Document accompanying the *May 2010 Communication* that was adopted in May 2010.

For the achievement of the renewable energy target (including a renewable target for transport) trade is assumed only for those Member States that have indicated that they plan to make use of the so called co-operation mechanism[26] that allows for such transfers to achieve the renewable energy targets. National support measures are assumed to be of similar level in all renewable energy sectors within a country, provided that the transport specific target is met. On average a renewable energy incentive of around € 50 per MWh and a biofuel support of € 55 per MWh in 2020 are assumed, with considerable differences between countries.

For the cost effective achievement of the non-ETS targets as defined in the Effort Sharing Decision, the Reference scenario assumes the full use of the flexibility between Member States. Member States can partly comply with their national targets by transfers from other Member States that overachieve their targets domestically. Consequently, a uniform non-ETS carbon value of € 5 per tonne of CO_{2eq} is projected across the EU to achieve the necessary reductions in the non-ETS. This would make the non-ETS sectors across the EU compliant with the overall reduction commitment based on the national targets.

The Reference scenario results in domestic GHG emissions reductions of approximately 20% in 2020 compared to 1990 resulting in a large buffer of allowances and international emission reduction credits in the ETS into the period beyond 2012[27].

The **25% domestic GHG reduction scenario** achieves the additional reductions necessary cost effectively by using economic instruments (modelled as increasing carbon values in both the ETS and non-ETS) as the only additional driver beyond the policies assumed in the Reference scenario. Incentives for renewables, modelled through a renewable energy value, remain constant compared to the Reference scenario. This results in some additional renewable energy use, induced by the increasing carbon values and thus in a small overachievement of the Member States' renewables targets in 2020.

5.2. Impacts analysed

The scenario analysis at Member State level gives information on GHG emission levels, system costs, the required additional investments, fuel expenses or savings and the impacts on other air pollutants.

System costs include the estimate of costs related to the energy system, i.e. how much the rest of the economy has to pay in order to get the required services from energy, and the marginal cost curves for additional reduction of non-CO_2 emissions. System costs presented in this analysis exclude costs for buying auctioned ETS allowances. Costs

25 EU energy trends to 2030 - UPDATE 2009 (2010)

26 Following the provisions of Articles 6 to 8 of Directive 2009/28/EC

27 For a detailed analysis see SEC(2010) 650 final, part 2.

incurred by operators to buy allowances may be passed through to end-consumers, but at the same time auctioning revenues are recycled back into the economy by the government. Hence, from a macroeconomic perspective, auctioning costs do not represent a net direct additional cost to society.

System costs represent the costs to achieve the renewable energy, ETS and non-ETS targets. However, as the impact assessment for the Package pointed out[28], a cost effective achievement of these targets EU-wide can result in a distribution of the efforts among Member States with proportionally higher direct costs for Member States with lower GDP per capita, and hence the smallest capacity to invest in GHG mitigation and renewable energy.

The Climate Change and Energy Package, following the European Council in March 2007, explicitly recognised this and included a number of redistribution mechanisms through the targets per Member State it defined and the amount of allowances to auction in the ETS it foresaw per Member State.

In order to take account of these redistribution mechanisms, "system costs including distributional impacts" are estimated. These are based on the "system costs" but include an estimate for the potential monetary transfers between Member States due to the use of flexible instruments to achieve the individual reduction targets and the different allocation of allowances to auction to Member States. Including these transfers can result in higher or lower system cost estimates.

Several mechanisms are at work when estimating system costs including distributional impacts:

- Operators in the ETS that have emissions higher than the amount of free allocation that they receive and operators in the electricity sector, that in principle do not receive any free allocation, will need to acquire allowances via auctioning, purchases on the secondary market or the use of international emission reduction credits. The amount of this acquisition can be higher or lower than the auctioning revenues received by governments, which will then increase or decrease the economic effort compared to system costs in that Member State.

- In the non-ETS sectors actual emissions in 2020 can be higher or lower than the target. For those Member States that have higher emissions in 2020 than the actual target for the non-ETS sectors, system costs underestimate the economic effort given that *by definition* systems costs does not take into account the additional expenses for acquiring emissions allocations from other Member States or international emission reduction credits for compliance purposes[29]. For those Member States with lower emissions in 2020 in the non-ETS sectors than the actual non-ETS target, system costs actually overestimate the economic effort for that Member State given that *by*

[28] See Section 4, Impact Assessment of the Climate and Energy Package (see table 2, SEC(2008) 85).

[29] Following the provisions of Articles 3 and 5 of Decision No 406/2009/EC

definition system costs do not account for the revenue from trading the "overachieved" emissions reductions of the non-ETS target[30].

- Similarly under the Renewable Energy Directive Member States can make use of the so called co-operation mechanism[31], which allows "trade" for compliance purposes from Member States that overachieve their targets domestically to countries that underachieve their targets domestically. But the Reference scenario assumes very limited use of trade between Member States[32], and thus the targets are largely met domestically. Thereby the "system costs including distributional impacts" do not adjust the system costs for any such trade.

Internal transfers within a Member State between operators in the ETS, private persons or the state are cost neutral from a societal point of view. Only transfers across borders have an impact on the estimate for the "system costs including distributional impacts".

For illustrative purposes results are also shown for a higher and a lower income group which are differentiated on the basis of the non-ETS targets under the Package. Member States with a 2020 non-ETS target that allowed for emissions increases compared to 2005 (BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT) are included in the group of lower income Member States[33]. Member States that received a 2020 non-ETS target that required emissions reductions compared to 2005 (AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK) are included in the group of higher income countries.

Furthermore, estimates for total energy-related investment and fuel expenses for the five year period 2016-2020 are given. Finally monetary estimates of the effects of changes in air pollution on mortality and air pollution control costs are estimated.

Section 6.2 gives more information on the definition of system costs (including how exactly the redistributional mechanisms are calculated), investments, fuel expenses and air the pollution cost estimates used in this analysis.

More detailed information, including impacts on the energy balance per Member State can be found in a background report from the National Technical University of Athens (NTUA)[34]. The focus of this analysis is on the year 2020, which is in line with the existing policy framework.

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30 The benefit can be translated through the selling of excess emission allocations to other Member States or the banking of those excess emission allocations.

31 Following the provisions of Articles 6 to 8 of Directive 2009/28/EC

32 It is only included in the scenario for those Member States that have indicated that they plan to make use of these so called co-operation mechanisms to achieve their renewable energy target.

33 This is identical to the group of Member States with a per capita gross national income (GNI) over the period 2007-2009 of less than 90% of the EU average. It is this group that is proposed to be eligible for the Cohesion Fund for the period 2013-2020, which can support also climate related programmes, such as on improved waste management, energy efficiency, sustainable transport or the deployment of renewables.

34 Capros et.al. (2012): Technical report accompanying the analysis of options to move beyond 20% GHG emission reductions in the EU by 2020: Member State results.

5.3. Emissions per Member State

At EU level, domestic Baseline GHG emissions projected for 2020 are 4764 Mt CO2 equivalent, which is equivalent to a reduction of 14% compared to 1990. Reaching 20% in the Reference scenario by implementing the renewables targets and the ETS and non-ETS targets in a cost effective way implies a further reduction of 7% compared to Baseline emissions in 2020. Stepping up to the 25% domestic GHG reduction scenario corresponds to a further 6% reduction compared to the Reference scenario emissions in 2020 and 13% compared to Baseline emissions in 2020.

Table 1: Total GHG emissions in 2020 across scenarios

		2020 Reduction		
	Baseline (million tonnes $CO_{2\text{-eq.}}$)	Reference compared to the Baseline	25% domestic GHG reduction scenario compared to Reference	25% domestic GHG reduction scenario compared to the Baseline
EU	4764	-7%	-6%	-13%
AT	92	-7%	-4%	-11%
BE	129	-7%	-6%	-12%
BG	68	-10%	-11%	-20%
CY	10	-6%	-3%	-9%
CZ	135	-4%	-5%	-9%
DK	56	-7%	-5%	-11%
EE	20	-12%	-6%	-17%
FI	65	-10%	-4%	-14%
FR	477	-9%	-6%	-14%
DE	885	-5%	-5%	-10%
EL	123	-8%	-10%	-17%
HU	76	-5%	-8%	-12%
IE	71	-8%	-5%	-12%
IT	530	-8%	-4%	-12%
LV	12	3%	-14%	-12%
LT	23	-7%	-4%	-10%
LU	15	-4%	-2%	-6%
MT	2	-5%	-6%	-10%
NL	196	-4%	-8%	-11%
PL	410	-9%	-5%	-13%
PT	72	-10%	-11%	-20%
RO	144	-8%	-6%	-14%
SK	53	-9%	-5%	-14%
SI	26	-12%	-6%	-18%
ES	446	-7%	-6%	-12%
SE	61	-10%	-3%	-13%
UK	568	-9%	-6%	-15%

Source: PRIMES, GAINS

In the non-ETS sectors, EU level emissions in 2020 compared to 2005 are projected to decrease by -3.6% in the Baseline and by -9.4% in the Reference scenario. A cost effective step-up to 25% domestic GHG emissions reductions compared to 1990 would lead to projected EU level reduction of -13% compared to 2005. Emissions at EU level are 6% lower in the Reference scenario when compared to the Baseline, and are 4% lower in the 25% domestic GHG reduction scenario compared to the Reference scenario. Most Member States reduce emissions in 2020 between the Reference scenario and the Baseline within a range of -4% and -8% and between the 25% domestic GHG reduction and the Reference scenarios within a range of -3% and -5%.

Table 2 non-ETS sector target and emissions 2020 compared to 2005 and across scenarios

	2020 non-ETS target vs 2005	2020 Reduction compared to 2005			2020 Reduction	
		Baseline	Reference	25% domestic GHG reduction	Reference compared to the Baseline	25% domestic GHG reduction compared to the Reference
EU	-10%	-4%	-9%	-13%	-6%	-4%
AT	-16%	-3%	-8%	-10%	-5%	-3%
BE	-15%	0%	-6%	-11%	-6%	-5%
BG	20%	-1%	-10%	-14%	-9%	-5%
CY	-5%	13%	4%	1%	-8%	-3%
CZ	9%	0%	-6%	-10%	-7%	-4%
DK	-20%	-7%	-12%	-15%	-5%	-4%
EE	11%	10%	-6%	-8%	-14%	-2%
FI	-16%	-10%	-18%	-20%	-8%	-3%
FR	-14%	-7%	-12%	-16%	-5%	-4%
DE	-14%	-11%	-16%	-19%	-6%	-4%
EL	-4%	-6%	-13%	-16%	-8%	-3%
HU	10%	2%	-3%	-8%	-5%	-5%
IE	-20%	5%	0%	-4%	-4%	-4%
IT	-13%	-3%	-8%	-11%	-6%	-3%
LV	17%	6%	3%	0%	-3%	-2%
LT	15%	4%	-1%	-4%	-5%	-3%
LU	-20%	4%	-2%	-3%	-5%	-2%
MT	5%	-13%	-18%	-20%	-6%	-3%
NL	-16%	-9%	-12%	-16%	-4%	-4%
PL	14%	18%	7%	2%	-9%	-5%
PT	1%	-11%	-17%	-19%	-7%	-3%
RO	19%	9%	-4%	-10%	-12%	-6%
SK	13%	17%	8%	3%	-8%	-4%
SI	4%	30%	20%	16%	-7%	-4%
ES	-10%	9%	5%	1%	-4%	-4%
SE	-17%	-8%	-12%	-14%	-4%	-2%
UK	-16%	-14%	-19%	-22%	-6%	-4%

Source: PRIMES, GAINS

Table 3 presents the reductions in the ETS at EU level. Domestic ETS sector emissions reduce by 11% compared to 2005 in the Baseline and by 19% in the Reference scenario. For more background information on the ETS in the Baseline and Reference scenario see the analysis in the Staff Working Document accompanying the *May 2010 Communication*. A 25% domestic GHG reduction scenario would lead to projected domestic reductions in ETS sectors of -26% compared to 2005.

Table 3 ETS sector emissions 2020 compared to 2005 and across scenarios

	2020 Reduction compared to 2005			2020 Reduction in the 25% domestic GHG reduction scenario compared to	
	Baseline	Reference	25% domestic GHG reduction	Baseline	Reference
EU	-11%	-19%[35]	-26%	-17%	-8%

Source: PRIMES, GAINS

5.4. System costs, including distributional impacts, per Member State

System costs excluding distributional impacts

Table 4 below gives the system costs per Member State of the Reference scenario and the 25% domestic GHG reduction scenario. It represents the step-up costs compared to the Baseline in 2020.

The system cost to achieve the Package domestically in the EU compared to the Baseline is equal to just below € 42 billion.

There is a small discrepancy between this estimate and the estimate presented in the Staff Working Document accompanying the *May 2010 Communication* of May 2010 which estimated the system cost of a step-up from the Baseline to the Reference scenario to be € 41 billion. This is due to rounding and the use in the *May 2010 Communication* of an "almost final" Reference scenario, whereas in this estimate the final Reference scenario is used[36]. Furthermore in the *May 2010 Communication* costs of the Reference scenario itself were estimated to be € 48 billion due to the inclusion in the cost estimate of additional energy efficiency measures since 2007 that were already included in the Baseline[37].

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35 The ETS includes aviation. The 2020 ETS target for aviation is not -21% compared to 2005. Overall the ETS target including aviation is thus is a bit less than -21% by 2005.

36 EU energy trends to 2030 - UPDATE 2009, September 2010. For the detailed results on non-CO2 emissions included see Höglund-Isaksson, L. et al. (2010): Potentials and costs for mitigation of non-CO2 GHG emissions in the European Union until 2030.

37 SEC(2010) 650 final ,Part 2, table 12

The additional costs beyond the Reference scenario of stepping up to a 25% domestic GHG reduction scenario are € 25 billion (excluding the air quality benefits). Total additional system costs from stepping up from the Baseline to a 25% domestic GHG reduction scenario are just below € 67 billion.

Table 4: 2020 System costs compared to the Baseline for the Reference and the 25% domestic GHG reduction scenarios

	Additional system cost (2020)			
	€ billion (2008 prices)		% 2020 GDP	
	Reference vs. Baseline	25% domestic GHG reduction vs. Baseline	Reference vs. Baseline	25% domestic GHG reduction vs. Baseline
EU	41.8	66.9	0.28%	0.45%
AT	1.0	1.6	0.32%	0.49%
BE	1.4	2.1	0.35%	0.51%
BG	0.4	0.6	1.12%	1.69%
CY	0.0	0.0	0.01%	0.09%
CZ	0.2	0.6	0.14%	0.35%
DK	0.3	0.4	0.10%	0.17%
EE	0.2	0.2	1.20%	1.01%
FI	0.8	0.9	0.36%	0.42%
FR	7.0	10.0	0.31%	0.44%
DE	8.3	14.7	0.29%	0.51%
EL	0.9	1.4	0.28%	0.46%
HU	0.2	0.6	0.18%	0.49%
IE	0.6	0.8	0.25%	0.35%
IT	2.4	5.7	0.14%	0.32%
LV	0.0	0.1	-0.02%	0.55%
LT	0.0	0.1	0.13%	0.24%
LU	0.2	0.2	0.38%	0.40%
MT	0.0	0.0	0.04%	0.24%
NL	0.9	2.3	0.14%	0.33%
PL	2.2	3.3	0.52%	0.76%
PT	0.8	1.3	0.41%	0.69%
RO	-0.3	0.0	-0.18%	0.01%
SK	0.4	0.6	0.54%	0.81%
SI	0.3	0.3	0.58%	0.68%
ES	4.0	6.0	0.29%	0.44%
SE	1.8	2.3	0.46%	0.56%
UK	7.7	11.0	0.31%	0.44%
Higher income group*			0.27%	0.43%
Lower income group**			0.35%	0.60%
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK ** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT				

Source: PRIMES, GAINS

On average additional system costs in the Reference scenario compared to the Baseline are around 0.3% of EU GDP by 2020. This is lower than the cost projections made for the Impact Assessment for the Package in 2008[38].

The highest costs related to the EU-wide cost effective achievement of the ETS and non-ETS targets and the domestic achievement of the renewables targets can be seen in some Member States with a lower income. But this is not the case for all lower income Member States.

To achieve the step-up to 25% GHG reductions domestically, system costs are projected to increase by 0.45% of GDP compared to the Baseline. This is the same share of GDP as projected in the Impact Assessment of the proposed Package to achieve the 20% target with access to international emission reduction credits.

The additional system costs compared to the Baseline and the Reference scenario for the cost effective achievement EU-wide of this step-up are largest in the lower income Member States, but this is again not the case for all lower income Member States, with some having lower additional costs than EU average.

System costs including distributional impacts

Table 5 below shows the additional costs of going to the Reference scenario from the Baseline, both for the "system costs" as well as the "system costs including distributional impacts", which include the effects of the redistribution mechanisms foreseen under the Package.

Total additional costs for the Reference scenario compared to the Baseline are slightly higher in case of "system costs including distributional impacts" because the targets as defined in the simplified methodology in Section 6.2.3 result in a slightly higher overall target for 2020 than the actual emissions reduction of 20% compared to 1990 in the Reference scenario as projected in the modelling set-up.

Flexibility instruments to achieve the targets and the redistribution mechanisms have a positive impact overall on the balancing of countries' system costs, as can be seen in the comparison of group impacts for higher and lower income Member States. But redistribution impacts do not have the same result as originally projected in the Impact Assessment for the proposed Package, with some Member States benefiting less from redistribution than initially projected. This can be for a number of reasons, for example:

– The economic crisis and higher oil prices impact the expected GDP growth differently for different Member States.

– Countries' emissions and energy consumption profiles diverge from the initial Impact Assessment, changing overall cost impacts and the effectiveness of the mechanisms for redistribution. For instance, countries that have projected emissions higher than

38 Projected costs increases compared to Baseline to achieve all targets domestically with no access to international emission reduction credits in the Impact Assessment of the Climate and Energy Package were around 0.6% of EU GDP by 2020 (see table 2, SEC(2008) 85).

their target in the non-ETS sectors have typically seen this gap reduced, thereby reducing costs.

– The final adopted Package has less auctioning than originally proposed by the Commission, thus reducing the distributional impact of the allocation of auctioning allowances. Furthermore, lower than expected carbon prices further decrease this distributional impact of the allocation of allowances to auction.

– The renewables targets can in principle also be achieved through transfers. The Impact Assessment of the proposed Package included this distributional mechanism in order to achieve the renewables target at least cost. But the analysis in this Staff Working Document does not assess the impact of any such transfers given that in reality only a very limited number of Member States have indicated that they see the need, and therefore plan, to make use of these so called co-operation mechanisms.

Table 5: Additional system costs and system costs including distributional impacts for the Reference scenario compared to the Baseline

	Reference vs Baseline (2020)			
	Additional system costs		Additional system costs including distributional impacts	
	€ billion (2008 prices)	% of 2020 GDP	€ billion (2008 prices)	% of 2020 GDP
EU	41.8	0.28%	42.1	0.28%
AT	1.0	0.32%	1.1	0.33%
BE	1.4	0.35%	1.4	0.35%
BG	0.4	1.12%	0.2	0.49%
CY	0.0	0.01%	0.0	0.04%
CZ	0.2	0.14%	0.0	0.03%
DK	0.3	0.10%	0.3	0.11%
EE	0.2	1.20%	0.2	1.07%
FI	0.8	0.36%	0.7	0.35%
FR	7.0	0.31%	6.5	0.29%
DE	8.3	0.29%	9.3	0.32%
EL	0.9	0.28%	0.8	0.27%
HU	0.2	0.18%	0.1	0.08%
IE	0.6	0.25%	0.8	0.32%
IT	2.4	0.14%	2.8	0.16%
LV	0.0	-0.02%	0.0	-0.18%
LT	0.0	0.13%	0.0	-0.07%
LU	0.2	0.38%	0.2	0.47%
MT	0.0	0.04%	0.0	-0.05%
NL	0.9	0.14%	1.2	0.18%
PL	2.2	0.52%	2.2	0.52%
PT	0.8	0.41%	0.5	0.27%
RO	-0.3	-0.18%	-0.9	-0.65%
SK	0.4	0.54%	0.3	0.41%
SI	0.3	0.58%	0.3	0.71%
ES	4.0	0.29%	4.6	0.34%

SE	1.8	0.46%	1.7	0.44%
UK	7.7	0.31%	7.6	0.30%
Higher income group*		0.27%	0.29%	
Lower income group**		0.35%	0.23%	
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK ** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT				

Source: Based on PRIMES

To assess the possible impact of reductions beyond the present 20% GHG reduction target including distributional impacts, a simplified 30% Reduction Commitment scenario is used. It assumes that the EU reduces its GHG emissions domestically as in the 25% domestic GHG reduction scenario and that international credits cover the remaining 5% gap to achieve a 30% reduction commitment.

The 2020 ETS target is set at 34% below 2005 and the overall non-ETS target is set at 16% below 2005 emissions, as suggested in the *May 2010 Communication*.

No differentiation per Member State is applied on the additional effort to go beyond the existing target of around 10% in the non-ETS sector. Individual targets for each MS are increased by about 6% for each Member State.

To implement the increase in ETS target in the simplified example, no reduction in free allocation is assumed compared to the amount attributed in the Reference scenario to operators in the ETS. Only the amount of allowances foreseen for auctioning is reduced compared to the Reference scenario. This is from a practical perspective the most straightforward method to increase scarcity in the ETS. Furthermore, to specifically address the distributional impacts, it is assumed that this reduction only affects the quantity of allowances that higher income Member States can auction.

This redistributional mechanism reduces the number of allowances available for auctioning from the higher income group by 38% compared to the Reference scenario. But overall impacts on auctioning revenue even for this group are not negative given that carbon prices increase from € 16.5 in the Reference scenario to € 30 per allowance in case of the step-up, an increase in value of 82%. The combined effect of lower auctioning quantities but at higher value for the higher income Member States is still a net increase in auctioning revenues of 13% compared to the Reference scenario.

At the same time, this redistribution mechanism would see the revenues from auctioning for Member States of the lower income group increase by 82% because they are still allowed to auction the same quantity of allowances as in the Reference scenario, but at considerably higher value.

For more detailed information on how the redistribution is estimated in the simplified example, see Section 6.2.4 below.

Table 6 gives the additional system costs compared to the Baseline of the step-up to 25% domestic GHG reductions and the system costs including distributional impact of the 30% Reduction Commitment scenario. Total EU-wide system costs increase to 0.50% of GDP. This is due to the assumed acquisition of international credits to meet the remaining 5% emission reduction target. Total costs to achieve a 30% target are estimated to be € 75 billion. If you include the costs of the additional energy efficiency measures in the Baseline itself (estimated a € 7 billion) total costs become € 82 billion (equal to the estimate of the *May 2010 Communication*).

Table 6: Additional system costs to achieve the 25% domestic GHG reduction scenario and system costs including distributional impacts for the 30% Reduction Commitment scenario

Additional system costs in 2020 vs Baseline				
	Additional system costs to achieve the 25% domestic GHG reduction scenario		Additional system costs including distributional impacts of the example of a 30% Reduction Commitment scenario *(25% domestic GHG reduction + acquisition of 5% international emission reduction credits)*	
	€ billion (2008 prices)	% of 2020 GDP	€ billion (2008 prices)	% of 2020 GDP
EU	67	0.45%	75	0.50%
AT	1.6	0.49%	1.9	0.59%
BE	2.1	0.51%	2.4	0.59%
BG	0.6	1.69%	0.0	0.09%
CY	0.0	0.09%	0.1	0.32%
CZ	0.6	0.35%	0.1	0.09%
DK	0.4	0.17%	0.7	0.25%
EE	0.2	1.01%	0.1	0.64%
FI	0.9	0.42%	1.1	0.51%
FR	10.0	0.44%	9.7	0.43%
DE	14.7	0.51%	19.1	0.66%
EL	1.4	0.46%	1.7	0.54%
HU	0.6	0.49%	0.3	0.24%
IE	0.8	0.35%	1.3	0.54%
IT	5.7	0.32%	7.9	0.44%
LV	0.1	0.55%	0.0	0.04%
LT	0.1	0.24%	0.0	-0.15%
LU	0.2	0.40%	0.3	0.62%
MT	0.0	0.24%	0.0	0.25%
NL	2.3	0.33%	3.1	0.45%
PL	3.3	0.76%	3.0	0.69%
PT	1.3	0.69%	0.7	0.37%
RO	0.0	0.01%	-1.3	-0.94%
SK	0.6	0.81%	0.4	0.53%
SI	0.3	0.68%	0.4	0.88%
ES	6.0	0.44%	8.2	0.60%
SE	2.3	0.56%	2.3	0.56%
UK	11.0	0.44%	12.1	0.48%
Higher income group*		0.43%	0.52%	
Lower income group**		0.60%	0.29%	
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK				

** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT

Source: Based on PRIMES

The cost effective outcome results in additional system costs which are largest in a number of lower income Member States. This picture changes considerably when taking into account the possible redistributional mechanisms in the 30% Reduction Commitment scenario as presented in Table 6. All Member States of the lower income group, with the exception of Malta and Slovenia, see their costs reduce, most of them substantially. This results for many lower income Member States in a significantly lower cost as a share of GDP than for the higher income Member States.

The allocation of allowances to auction between Member States is an important redistributional mechanism. As a basic principle, the Package proposed to base the allocation of auctioning allowances for sectors other than aviation on the 2005 share of ETS emissions. In addition, a further redistribution was foreseen that favours the lower income Member States. Table 7 below shows the monetary impact of such redistribution in case of the Reference scenario and the further increase in auctioning revenue in case of a step-up to 30% with the amount of auctioning being reduced only for those Member States in the higher income group.

The distribution as proposed in the Package results, in the Reference scenario, in € 1.5 billion extra revenues for the Member States in the lower income group. These would increase by an additional € 5.4 billion in the case of a step-up to the 30% GHG reduction target if it was only the Member States of the higher income group that contributed to the reduction of allowances for auctioning. At the same time, this group of higher income Member States will still see their total auctioning revenue increase by € 1.9 billion in case of such a step-up of the target.

These figures apply to 2020 and therefore do not account for any temporary derogation from full auctioning which can be used up to 2019 in accordance with Article 10(c) of the ETS Directive, as applications from 8 Member States are still being assessed by the Commission. Approved derogations would proportionally reduce the auction revenue of the Member States concerned.

Table 7: Auctioning revenues in the different scenarios in 2020, including distributional impact

Auctioning revenue (excluding aviation) in 2020			
(€ million, 2008 prices)	20% GHG reduction target		Example 30% Reduction Commitment scenario
	distribution of allowances for auctioning based on:		
	2005 share in ETS emissions	The share as proposed in the Package	A reduction only in Member States of the higher income group
EU	21203	21203	28524
AT	328	289	325
BE	545	527	592
BG[c]	381	571	1045
CY[c]	53	56	64
CZ[c]	822	959	1755

DK	297	262	296
EE[c]	130	186	340
FI	392	345	387
FR	1315	1162	1324
DE	4706	4148	4653
EL	699	717	803
HU[c]	256	308	563
IE	224	198	224
IT	2222	1997	2241
LV	28	55	101
LT[c]	64	111	204
LU	28	27	33
MT	20	21	39
NL	802	709	806
PL[c]	2012	2558	4682
PT	359	365	669
RO[c]	675	1023	1873
SK	245	314	575
SI	86	91	166
ES	1815	1801	2029
SE	194	188	213
UK	2504	2214	2521
Higher income group[a]	16125	14640	16511
Lower income group[b]	5078	6563	12012

[a] AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK
[b] BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT
[c] This value for 2020 does not take into account the reduced value of auctioning for those countries (BG, CY, CZ, EE, HU, LT, PL and RO) that have requested a temporal derogation applying Article 10(c) of the ETS Directive for a total amount of some 700 million allowances over the period 2013 to 2019.

Source: Based on PRIMES

Also in the non-ETS sector an important redistributional mechanism is applied in the form of differentiated targets. The step-up would increase the value of potential transfers for countries that can overshoot their target. In the Reference scenario Member States of the lower income group have a surplus of around 65 million tonnes $CO_{2\text{-eq.}}$ in 2020 (see Table 8). However, this only represents a low value in the Reference scenario due to the very low carbon price of € 5 per tonne $CO_{2\text{-eq.}}$. If they sell their surplus at a higher price, i.e. € 16.5, the projected carbon price in the ETS, then revenues would still be limited to around € 1 billion. With a step-up, the carbon price increases to € 30 per tonne CO2-eq and the value of the surplus, estimated at around 55 million tonnes CO2-eq. in 2020, also increases, resulting in a potential trading value of € 1.6 billion. Net demand from Member States of the higher income group also increases from 64 million tonnes CO2-eq. in the Reference scenario to 137 million tonnes CO2-eq. in the step-up scenario.

Table 8: Shortage or surplus per Member State in the non-ETS sectors

Shortage or surplus per Member State in the non-ETS sectors in 2020 Million tonnes $CO_{2\text{-eq.}}$

(negative means higher emissions than the target, positive means lower emissions than target)		
Million tonnes $CO_{2\text{-eq.}}$ *(negative means higher emissions than the target, positive means lower emissions than target)*	Reference scenario	30% Reduction Commitment scenario
EU	-0.6	-84.7
AT	-5.0	-7.4
BE	-6.4	-8.1
BG	7.7	7.1
CY	-0.4	-0.6
CZ	9.6	7.6
DK	-2.9	-4.0
EE	1.0	0.7
FI	0.6	-0.8
FR	-8.3	-18.8
DE	10.5	-6.0
EL	5.3	3.2
HU	6.4	5.6
IE	-9.4	-10.6
IT	-15.2	-27.5
LV	1.2	0.8
LT	2.0	1.6
LU	-1.9	-2.4
MT	0.3	0.2
NL	-4.1	-7.5
PL	10.8	8.2
PT	8.6	6.5
RO	16.5	15.6
SK	1.1	0.7
SI	-1.8	-2.0
ES	-34.2	-40.0
SE	-2.2	-4.4
UK	9.8	-2.6
Higher income group*	-64	-137
Lower income group**	65	55
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK ** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT		

Source: Based on PRIMES

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5.5. Investments per Member State

The Impact Assessment accompanying the Communication "A Roadmap for moving to a competitive low carbon economy in 2050" included estimates of the required average annual investments. Table 9 below shows similar data for the EU on average annual investment but only for the scenarios used in the Staff Working Document accompanying the *May 2010 Communication*. The time period in Table 9 is 5 years, from 2016 to 2020. This is the reported time period in PRIMES which is closest to 2020, the time focus of this analysis, and the one that has most overlap with the period of implementation of the next EU Multiannual Financial Framework, starting in 2014.

Average annual additional investment requirements over the 5 year period 2016-2020 for full implementation of the Package are estimated to be € 34 billion, whereas a step-up that achieves domestic reductions of 25% would require an annual additional investment of € 18 billion compared to the Reference scenario. Both are net additional investments, taking into account increased investments in low carbon technologies and reduced investments in more carbon-intensive technologies.

Table 9: EU Average annual total investments over the period 2016-2020 (energy related)

€ billion (2008 prices)	2016-20 Average annual Investment needs € billion (2008 prices)			2016-20 Average annual additional Investment needs	
	Baseline	Reference	25% domestic GHG reduction scenario	Reference vs Baseline	25% domestic GHG reduction scenario vs Baseline
EU	780	814	832	34	52

Source: PRIMES

Table 10 gives the total additional investments compared to the Baseline at Member State level. Additional investment expenditures expressed as a % of GDP are similar for the higher and lower income groups in the Reference scenario[39], but they become significantly higher for the lower income group in the step-up to a cost effective 25% domestic GHG reduction scenario.

Table 10: Average annual additional investments at Member State level over the period 2016-2020 (energy related)

	Additional investments over the period 2016-2020 vs Baseline			
	€ billion (2008 prices)		As a % of average GDP (using projected GDP in market prices)	
	Reference	25% domestic GHG reduction scenario	Reference	25% domestic GHG reduction scenario
EU	34	52	0.24%	0.37%

39 Note that the renewables target is assumed to be reached largely domestically, therefore not resulting per definition in lowest costs at the EU level.

AT	0.3	0.6	0.10%	0.19%
BE	0.8	1.2	0.21%	0.32%
BG	0.2	0.3	0.46%	0.99%
CY	0.1	0.1	0.24%	0.40%
CZ	0.4	0.7	0.26%	0.43%
DK	0.6	0.7	0.24%	0.27%
EE	0.1	0.1	0.58%	0.74%
FI	0.1	0.3	0.06%	0.13%
FR	3.8	6.0	0.18%	0.28%
DE	7.5	12.7	0.27%	0.46%
EL	1.0	1.4	0.34%	0.48%
HU	0.3	0.4	0.24%	0.34%
IE	1.0	1.3	0.47%	0.59%
IT	4.1	7.2	0.24%	0.42%
LV	0.1	0.2	0.80%	1.15%
LT	0.1	0.2	0.33%	0.75%
LU	0.1	0.1	0.14%	0.20%
MT	0.0	0.0	0.06%	0.38%
NL	1.0	2.4	0.15%	0.37%
PL	0.8	1.6	0.20%	0.41%
PT	0.9	1.5	0.50%	0.83%
RO	0.0	0.2	0.03%	0.18%
SK	0.2	0.4	0.31%	0.61%
SI	0.1	0.2	0.33%	0.44%
ES	3.7	5.4	0.30%	0.43%
SE	1.2	1.5	0.32%	0.40%
UK	5.0	5.2	0.21%	0.22%
Member States of the higher income group*			0.23%	0.35%
Member States of the lower income group**			0.27%	0.49%
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK ** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT				

Source: PRIMES

It should be noted that investment needs may be higher if the analysis takes longer time horizons into account. The analysis made for the *May 2010 Communication* stopped in 2030, but the analysis for Communication "A Roadmap for moving to a competitive low carbon economy in 2050" had a time horizon up to 2050. This longer time horizon, with the accompanying need for even higher reductions after 2030, results earlier in investments in electrification and a higher penetration of renewables. This subsequently leads to higher average annual additional investments before 2020.

5.6. Fuel expenses per Member State

The Impact Assessment accompanying the Communication "A Roadmap for moving to a competitive low carbon economy in 2050" included an estimate of average annual fuel expenses. Table 11 below shows similar data for the EU, but here for the 5 year period 2016 to 2020.

Average annual fuel expenses compared to the Baseline over the 5 year period 2016-2020 for full implementation of the Package are estimated at a bit more than 10 billion €, whereas stepping up action that would results in 25% domestic GHG reductions would see savings of € 31 billion.

Table 11: EU average annual fuel expenses over the period 2016-2020

€ billion (2008 prices)	2016-20 Average fuel expenses			2016-20 Average fuel expenses savings compared to the Baseline	
	Baseline	Reference	25% domestic GHG reduction scenario	Reference vs Baseline	25% domestic GHG reduction scenario
EU	1017.8	1007.1	986.4	-10.7	-31.3

Source: PRIMES

At Member State level, overall fuel expenditure savings compared to the Baseline, expressed as a share of GDP are highest in those Member States with lower income. This is already the case for the Reference scenario, and continues to be the case for the 25% domestic GHG reduction scenario (see Table 12).

Table 12: Average annual fuel expenses at Member State level over the period 2016-2020

	Fuel savings over the period 2016-2020 vs Baseline			
	€ billion (2008 prices)		as a % of average GDP (using projected GDP in market prices)	
	Reference	25% domestic GHG reduction scenario	Reference	25% domestic GHG reduction scenario
EU	-11	-31	-0.08%	-0.22%
AT	0.1	-0.4	0.05%	-0.12%
BE	-0.1	-0.8	-0.01%	-0.20%
BG	-0.1	-0.2	-0.30%	-0.57%
CY	0.0	-0.1	-0.18%	-0.40%
CZ	-0.1	-0.5	-0.10%	-0.35%
DK	-0.2	-0.6	-0.10%	-0.23%
EE	0.0	0.0	0.06%	-0.15%
FI	-0.4	-0.6	-0.19%	-0.31%
FR	-1.4	-3.5	-0.06%	-0.16%
DE	-2.7	-7.3	-0.10%	-0.26%
EL	-0.3	-0.8	-0.11%	-0.27%
HU	-0.2	-0.5	-0.17%	-0.42%
IE	-0.2	-0.5	-0.08%	-0.23%
IT	-2.1	-5.2	-0.12%	-0.31%
LV	-0.1	-0.2	-0.66%	-0.93%
LT	0.0	-0.1	-0.10%	-0.45%
LU	0.1	0.0	0.11%	-0.06%

MT	0.0	0.0	-0.09%	-0.31%
NL	-0.1	-1.2	-0.02%	-0.18%
PL	-0.4	-1.6	-0.09%	-0.39%
PT	-0.3	-0.6	-0.18%	-0.35%
RO	-0.6	-0.9	-0.46%	-0.70%
SK	0.1	-0.1	0.08%	-0.19%
SI	0.0	-0.1	0.06%	-0.15%
ES	-1.2	-2.8	-0.09%	-0.22%
SE	0.1	-0.4	0.01%	-0.10%
UK	-0.5	-2.4	-0.02%	-0.10%
Member States of the higher income group*			-0.07%	-0.20%
Member States of the lower income group**			-0.15%	-0.40%
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK ** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT				

Source: PRIMES

Savings are estimated to be even higher for action taken in a longer term context, i.e. the scenario for the 2050 Roadmap even if total GHG reductions in 2020 (25%) are the same in both cases. This is mainly due to higher fuel savings in transport in scenarios that take into account the long-term perspective.

5.7. Impacts on air pollution control costs and health benefits per Member State

Table 13 shows the estimates for air pollution control costs and health benefits for the Reference and the 25% domestic GHG reduction scenarios compared to the Baseline. A 25% domestic reduction would reduce air pollution control costs by €3.6 billion compared to the Baseline. In Reference air pollution control costs are projected to decrease by only €0.96 billion compared to the Baseline. The shift from the Baseline to the Reference scenario increases renewable energy use (i.e. biomass). This results in increased overall emissions of small particle matter (PM2.5) due to increases in emissions in some sectors (e.g. domestic heating using biomass), that do not apply the same level of end-of-pipe control technologies as larger combustion plants (see Table 15). In the 25% domestic GHG reduction scenario this impact is smaller and outweighed by the overall reduction in energy consumption and a fuel shifts away from solid fuels towards lower carbon energy sources. Consequently, health benefits are lower in the Reference compared to the Baseline, with projected reduced health benefit compared to baseline of €90 to 250 million. The 25% domestic GHG reduction scenario is expected to lead to positive (mortality) benefits for the EU as a whole and for the majority of Member States resulting in EU-wide health benefits of € 3.3 billion to € 7.6 billion.

Table 13 Changes in air pollution control costs and mortality-related health impacts

€ million / year (2008 prices)	2020 Impact vs Baseline			
	Reference		25% domestic GHG reduction scenario	
	Air pollution control costs (-) cost reduction	Health (mortality) impacts	Air pollution control costs (-) cost reduction	Health (mortality) benefits
		(-) improved health benefit		(-) improved health benefit

	(+) cost increase	(+) reduced health benefit		(+) cost increase	(+) reduced health benefit	
		Low estimate	High Estimate		Low Estimate	High Estimate
EU	-964	90	250	-3648	-3335	-7641
AT	-13	-13	-29	-28	-72	-165
BE	-49	12	28	-117	-100	-230
BG	-73	5	12	-186	-54	-122
CY	-3	1	2	-5	1	2
CZ	-7	10	25	-77	-104	-238
DK	-18	6	14	-42	-28	-63
EE	-15	12	29	-33	1	3
FI	11	-7	-17	-10	-19	-43
FR	739	69	162	660	-155	-354
DE	-418	-150	-338	-890	-929	-2134
EL	-73	22	53	-230	-37	-83
HU	-6	11	27	-87	-94	-213
IE	-12	-8	-19	-36	-19	-45
IT	-241	-70	-155	-392	-467	-1067
LV	11	3	7	-8	-8	-19
LT	-3	3	8	-8	-19	-44
LU	-6	1	2	-11	1	2
MT	-1	1	1	-4	1	1
NL	21	-10	-22	-128	-178	-410
PL	-246	161	376	-538	-281	-643
PT	-33	10	24	-138	-26	-58
RO	-24	59	139	-128	-102	-231
SK	-41	-7	-15	-51	-54	-122
SI	-38	-9	-20	-62	-21	-48
ES	-223	-15	-32	-447	-136	-308
SE	-44	6	13	-69	-17	-39
UK	-159	-10	-21	-583	-420	-969

Source: GAINS

When the benefits of lower mortality and lower air pollution control costs in Table 13 are combined, the largest savings made are in the lower income Member States. Comparing these savings to the system costs as presented in Section 5.4 poses methodological difficulties. Both analyses apply different cost concepts. For instance health benefits in Table 13 are based on the 'value of statistical life year and statistical life lost' which is not applied when assessing energy system costs. They use also different interest rates. The energy system cost estimates apply private interest rates (see Section 6.2.1) whereas the estimate for air pollution control costs uses a lower interest rate (see Section 6.2.6). Therefore the results in the table below should be interpreted with care, but they confirm the positive impact of reduced health impacts and air pollution control costs in lower income Member States.

Table 14 Sum of additional system cost and savings due to changes in air pollution control costs and mortality-related health impacts

Comparing costs and benefits in 2020 25% domestic GHG reduction scenario vs. Baseline						
	Additional System costs		Additional System costs reduced by the low estimate savings from reduced air pollution		Additional System costs reduced by the high estimate savings from reduced air pollution	
	€ billion	% of 2020 GDP	€ billion	% of 2020 GDP	€ billion	% of 2020 GDP
EU	66.9	0.45%	59.9	0.40%	55.6	0.37%
AT	1.6	0.49%	1.5	0.46%	1.4	0.43%
BE	2.1	0.51%	1.9	0.46%	1.8	0.43%
BG	0.6	1.69%	0.4	1.03%	0.3	0.84%
CY	0.0	0.09%	0.0	0.08%	0.0	0.08%
CZ	0.6	0.35%	0.4	0.24%	0.3	0.16%
DK	0.4	0.17%	0.4	0.14%	0.3	0.12%
EE	0.2	1.01%	0.1	0.81%	0.1	0.82%
FI	0.9	0.42%	0.9	0.40%	0.8	0.39%
FR	10.0	0.44%	10.5	0.46%	10.3	0.45%
DE	14.7	0.51%	12.9	0.45%	11.7	0.41%
EL	1.4	0.46%	1.1	0.37%	1.1	0.35%
HU	0.6	0.49%	0.4	0.34%	0.3	0.25%
IE	0.8	0.35%	0.8	0.33%	0.7	0.32%
IT	5.7	0.32%	4.8	0.27%	4.2	0.24%
LV	0.1	0.55%	0.1	0.46%	0.1	0.40%
LT	0.1	0.24%	0.0	0.15%	0.0	0.08%
LU	0.2	0.40%	0.2	0.38%	0.2	0.38%
MT	0.0	0.24%	0.0	0.20%	0.0	0.20%
NL	2.3	0.33%	2.0	0.29%	1.7	0.26%
PL	3.3	0.76%	2.4	0.57%	2.1	0.49%
PT	1.3	0.69%	1.1	0.60%	1.1	0.58%
RO	0.0	0.01%	-0.2	-0.15%	-0.3	-0.24%
SK	0.6	0.81%	0.5	0.67%	0.5	0.58%
SI	0.3	0.68%	0.2	0.50%	0.2	0.44%
ES	6.0	0.44%	5.4	0.40%	5.2	0.38%
SE	2.3	0.56%	2.2	0.54%	2.1	0.53%
UK	11.0	0.44%	10.0	0.40%	9.4	0.38%
Member States of the higher income group*		0.43%	0.40%		0.37%	

Member States of the lower income group**	0.60%	0.44%	0.36%
* AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK ** BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT			

Source: Based on PRIMES and GAINS

Table 15 shows that in the Reference scenario PM2.5 emissions are higher than the Baseline for 20 Member States. At the EU level PM2.5 emissions are also higher. This relates to the increase in renewable energy (i.e. biomass) in the Reference scenario. In the step-up case to 25% domestic GHG reductions, the outcome is more mixed at Member State level, with a total reduction compared to the Reference scenario but an increase compared to the Baseline. Higher PM2.5 concentrations in the atmosphere have negative effects on mortality. Note also that other pollutants (SO_2 and NOx) also contribute indirectly to the formation of concentrations of small particles in the atmosphere.

Table 15 PM2.5 emissions

2020 PM2.5 emissions (kilotonnes per year)	Baseline	Reference	25% domestic GHG reduction scenario
EU	1059	1110	1083
AT	13	14	13
BE	20	21	21
BG	33	34	33
CY	1	1	1
CZ	25	27	26
DK	19	20	19
EE	7	8	8
FI	21	22	22
FR	207	215	213
DE	83	85	84
EL	33	35	34
HU	22	24	23
IE	8	8	7
IT	81	84	82
LV	15	15	15
LT	10	11	11
LU	2	2	2
MT	0	0	0
NL	16	16	16
PL	96	110	103
PT	62	64	63
RO	106	112	109
SK	10	11	10
SI	6	6	6
ES	90	92	90
SE	19	20	19

UK	53	54	52

Source: GAINS

Whereas PM2.5 emissions on average do not decrease, other pollutants (SO_2 and NOx) that contribute indirectly to the formation of concentrations of small particles in the atmosphere do decrease in the Reference and the 25% domestic GHG reduction scenarios compared to the Baseline. From the Baseline to the Reference scenario SO_2 emissions reduce by 105 kilotonnes in the EU. In the 25% domestic GHG reduction scenario SO_2 emission go down compared to the Baseline by 304 kilotonnes in the EU. All Member State see their SO_2 emissions decrease or stabilise in both the Reference and the 25% domestic GHG reduction scenarios.

NO_X emissions decrease for all Member States from the Baseline to the Reference scenario. At EU level, NO2 emissions decrease by 326 kilotonnes. When going from the Baseline to a 25% domestic GHG reduction scenario emissions go further down by 505 kilotonnes.

Changes in emissions of PM2.5 and other pollutants (SO_2 and NOx) determine the concentrations of PM2.5 in the atmosphere, and hence the resulting mortality impacts. Table 16 represents the resulting impact on million-life-years-lost for the Baseline, the Reference and the 25% domestic GHG reduction scenario due to PM2.5 concentrations in the atmosphere.

Table 16 Million life years lost due to PM2.5 concentrations

2020 Million life years lost*	Baseline	Reference	25% domestic GHG reduction scenario
EU	111.05	111.28	108.20
AT	1.68	1.67	1.62
BE	3.78	3.79	3.69
BG	1.64	1.65	1.60
CY	0.14	0.14	0.14
CZ	2.61	2.63	2.52
DK	1.06	1.07	1.04
EE	0.21	0.22	0.21
FI	0.56	0.55	0.54
FR	12.35	12.42	12.22
DE	23.24	23.13	22.42
EL	2.59	2.62	2.56
HU	2.87	2.89	2.80
IE	0.41	0.40	0.39
IT	13.69	13.65	13.30
LV	0.47	0.47	0.46
LT	0.64	0.64	0.62
LU	0.12	0.12	0.12
MT	0.09	0.09	0.09
NL	5.50	5.49	5.34
PL	10.10	10.26	9.86

PT	2.11	2.12	2.09
RO	5.47	5.53	5.39
SK	1.26	1.26	1.22
SI	0.47	0.46	0.45
ES	6.18	6.18	6.07
SE	0.99	1.00	0.98
UK	10.82	10.81	10.44

Source: GAINS

On top of the changes in mortality due to the changes in concentrations of small particles, mortality is also affected by increases in ground-level ozone concentrations. These are produced by chemical interactions and emissions which contain NO_X and Volatile Organic Compounds (VOC). Increases in ground-level ozone concentrations increase premature mortality.

In both the Reference and the 25% domestic GHG reduction scenarios, changes in NO_X and Volatile Organic Compound emissions compared to the Baseline result in the lowering of ground-level ozone concentrations. Consequently the number of premature death is lower in the Reference and the 25% domestic GHG reduction scenarios, when compared to the Baseline. Table 17 shows the projected result for each Member State.

Table 17 Premature deaths from ozone (cases/year)

	Baseline	Reference	25% domestic GHG reduction scenario
EU	17153	17108	16954
AT	280	278	275
BE	337	337	335
BG	366	363	357
CY	26	26	26
CZ	368	365	358
DK	150	150	149
EE	18	18	18
FI	46	46	46
FR	1847	1851	1838
DE	2962	2957	2930
EL	502	499	493
HU	511	507	499
IE	79	79	79
IT	3334	3320	3292
LV	42	42	42
LT	62	62	61
LU	22	22	22
MT	19	19	19
NL	333	333	331
PL	1010	1004	988
PT	447	445	441
RO	793	790	780

SK	164	162	158
SI	73	72	71
ES	1538	1531	1520
SE	159	159	158
UK	1665	1668	1665

Source: GAINS

6. APPENDICES

6.1. Description of the economic modelling tools used

The analysis is based on model-based scenarios using the PRIMES energy system model for CO_2 emissions and the GAINS emissions model for non-CO_2 emissions, supported by the CAPRI agricultural model for projecting trends on animal numbers and fertiliser use.

The PRIMES model projects CO_2 emissions and the GAINS model projects non-CO_2 emissions. A split between ETS and non-ETS emissions is performed by estimating ETS emissions based on the results of both models. In order to ensure comparability over time, the split between ETS and non-ETS emissions assumes for all time periods the scope of the ETS from 2013 onwards, i.e. including the current ETS scope, aviation, additional industrial process emissions and non-CO2 process emissions.

For energy-related emissions, PRIMES is calibrated to Eurostat energy data. For aviation, emissions included are those covered in PRIMES, i.e. emissions from fuels sold in the EU. For the other industrial sectors with process CO_2 emissions, 2005 emissions have been estimated based on UNFCCC data.

Non-CO2 process emissions covered under the ETS are captured as a separate category in the GAINS model, and for 2005 are calibrated to UNFCCC data.

PRIMES:

The PRIMES model simulates the response of energy consumers and the energy supply systems to different pathways of economic development and exogenous constraints and drivers. It is a modelling system that simulates a market equilibrium solution in the European Union and its Member States. The model determines the equilibrium by finding the prices of each energy form such that the quantity producers find best to supply matches the quantity consumers wish to use. The equilibrium is forward looking and includes dynamic relationships for capital accumulation and technology vintages. The model is behavioural, formulating agents' decisions according to microeconomic theory, but it also represents in an explicit and detailed way the available energy demand and supply technologies and pollution abatement technologies. The system reflects considerations about market competition economics, industry structure, energy /environmental policies and regulation. These are conceived so as to influence the market behaviour of energy system agents. The modular structure of PRIMES reflects a distribution of decision making among agents that decide individually about their supply, demand, combined supply and demand, and prices. Then the market integrating part of PRIMES simulates market clearing. For further information see

http://www.e3mlab.ntua.gr/e3mlab/index.php?option=com_content&view=article&id=58%3Amanual-for-primes-model&catid=35%3Aprimes&Itemid=80&lang=en

GAINS:

The GAINS model explores cost-effective multi-pollutant emission control strategies that meet environmental objectives on air quality impacts (on human health and ecosystems) and GHG. It is an integrated assessment model that brings together information on the sources and impacts of air pollutant and GHG emissions and their interactions. GAINS brings together data on economic development, the structure, control potential and costs of emission sources, the formation and dispersion of pollutants in the atmosphere and an assessment of environmental impacts of pollution. For further information on the GAINS Europe model which has been used for this analysis, as well as access to background data, see http://gains.iiasa.ac.at/gains/EU/index.login?logout=1.

CAPRI:

CAPRI models the response of the European agricultural system to a range of policy interventions. It is a comparative static equilibrium global agricultural sector model with focus on EU27 and Norway. Its supply module consists of separate, regional, non-linear programming models which cover about 250 regions (NUTS 2 level) or even up to six farm types for each region (in total 1000 farm-regional models). Its market module is a spatial, global multi-commodity model for agricultural products, 40 product, and 40 countries in 18 trade blocks. For further information see http://www.capri-model.org/.

6.2. Definition of system costs, investments and fuel expenses

6.2.1. Definition of system costs excluding distributional impacts

The analysis uses the results of the PRIMES model to estimate costs related to the energy system and CO_2 abatement, and the GAINS model to estimate marginal cost curves for additional reduction of non-CO_2 emissions. Both costs taken together are referred to in the following as the system costs.

The PRIMES model calculates the total cost of energy, measuring how much the rest of the economy has to pay in order to get the required services from energy. The cost covers all types of costs incurred in energy demand and supply sectors for all energy purposes, including annuities for energy equipment investments made based on the weighted average cost of capital applying private interest rates, related operating and maintenance costs, costs related to thermal integrity improvements of buildings and the rational use of energy, fuel, electricity and steam costs, relevant costs related to ETS allowances, energy taxes and subsidies and household utility losses due to changed energy services compared to the Baseline. As such, any changes in system costs cannot be interpreted as a direct loss to GDP.

System costs in this analysis exclude costs for buying auctioned ETS allowances. Costs incurred by operators to buy allowances may be passed through to end-consumers, but at the same time auctioning revenues are recycled back into the economy by the government. Hence, under that assumption and from a macroeconomic perspective, auctioning costs do not represent a net direct additional cost to society. System costs represent in the Reference scenario the costs to achieve the ETS and non-ETS targets cost effectively from an EU-wide perspective and the renewable energy targets domestically, but they do not include any transfers necessary to achieve compliance.

Decarbonisation via price signals has two effects: substitutions towards lower carbon emitting options and efficiency gains resulting in lower demand for energy. Usually, the costs involve lower variable and fuel costs because of energy savings, and higher investment and unit capital costs because of shifts towards more advanced, capital intensive, technologies[40]. As the model simulates market behaviour, capital and variable costs are assessed from the perspective of different market actors. According to microeconomic theory, the reduction of energy-consuming activities (e.g. switch lights off, heat less, move less, etc) corresponds to lower benefits/utility for the consumer. Therefore costs associated to loss of utility (disutility) compared to the Baseline are estimated and included in the system costs analysis. The scope of the energy system costs is hence significantly more comprehensive as compared to the mere marginal abatement costs. For a more detailed description of what constitutes energy system costs, see background report from NTUA[41].

Consistent with the analysis presented for the *May 2010 Communication*, additional system costs are estimated in several steps.

- Cost beyond the system costs in the Baseline associated with the full implementation of the Package, i.e. additional system costs in the Reference scenario.

- Cost beyond the system costs in the Baseline associated with the achievement of a 25% domestic GHG reduction scenario in 2020 and additional costs to achieve a 30% reduction commitment through the use of international emission reduction credits equal to an amount of 5% of the EU's 1990 GHG emission levels.

To maintain consistency and comparability with Member State Baselines, the estimated incremental cost compared to the Baseline at Member State level, does not include the costs for additional energy efficiency measures since 2007 that are included in the 2009 Baseline. At EU level, these were estimated at a total cost of € 7 billion and were included in total cost estimates presented in the Staff Working Document for the *May 2010 Communication*. For more background information see Section 3.4 of the Staff Working Document for the *May 2010 Communication*[42].

6.2.2. Definition of system costs including distributional impacts

To calculate the system costs including distributional impact, net transfers between Member States are added to the system costs.

Internal transfers within a Member State between operators in the ETS, private persons or the State are not added because they are seen as cost neutral from a full societal point of view. Only transfers across borders have an impact on the estimate for the "system costs including distributional impacts".

To calculate the "system costs including distributional impacts", system costs of a Member State are increased by the following:

40 Total capital costs can be lower, as lower activity implies lower needs for energy equipment; this effect may offset the effect of the unit capital cost.

41 See Capros et al. (2012).

42 SEC(2010) 650 final, Part 2

- any acquisitions of allowances or international emission reduction credits by operators in the ETS due to higher emissions than the amount of free allocation they receive (if any).

- any acquisitions of excess emission allocations or international emission reduction credits by Member States themselves to compensate for any shortfall in the non-ETS target, including any payments made to other Member States for buying the right to use unused international emission reduction credits from these Member States.

To calculate the "system costs including distributional impacts", system costs of a Member State are decreased by the following:

- any selling of allowances by operators in the ETS due to lower emissions than the amount of free allocation they received;

- any revenue for governments from the sale of allowances through auctioning;

- any selling of excess emission allocations by Member States themselves that overachieve their target in the non-ETS;

- any compensation received for the selling of unused international emission reduction credits to other Member States.

The achievement in the Reference scenario of the 20% renewables target and the 10% renewable target in transport assumes very limited use of trade between Member States[43]. As such it is assumed that these targets are largely met domestically and thereby the system costs do not need to be adjusted to determine the "system costs including distributional impacts' related to renewable energy.

PRIMES - GAINS reports the split between ETS and non-ETS taking into account the extended scope of the ETS as of 2013, also for emissions in 2005. Any ETS or Non-ETS target or allocation that is estimated in Sections 6.2.3 and 6.2.4 and that uses a 2005 emission estimate from PRIMES – GAINS is based on an estimate for 2005 that includes the impact of the extended scope as of 2013.

6.2.3. Assumptions applied to assess the distributional impacts of the Climate and Energy Package

The Reference scenario achieves the targets of the Climate and Energy Package internally. But to estimate the distributional impacts of the Package a number of simplifications need to be made, for instance, on how much free allocation there is in total, on how much free allocation each Member State's industries and aviation sectors receive, on what the share of total auctioning revenues is per Member State both for the aviation sector and other ETS sectors. The following gives an overview of the assumptions applied in the analysis of the Reference scenario to estimate the distributional impacts of the Package:

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[43] It is only included in the scenario for those Member States that have indicated that they plan to make use of these so called co-operation mechanisms to achieve their renewable energy target.

ETS targets for sectors other than the aviation sector:

Targets are calculated by applying a 21% reduction compared to 2005 emissions of those sectors. In PRIMES - GAINS the sectors and gases included in the ETS as of 2013 other than aviation have a total of 2291 million tonnes $CO_{2\text{-eq.}}$ emissions in 2005. Applying a target of -21% by 2020 translates into a target for the ETS other than aviation in 2020 equal to 1810 million allowances.

Target ETS aviation:

The target for the aviation sector is calculated using the CO_2 emission level represented in the PRIMES model for aviation for the year 2005, and applying a target of -5%. Aviation has 147 million tonnes CO_2 emissions in 2005 in PRIMES, which translates into a target available for aviation in 2020 equal to 140 million allowances.

ETS operators in the electricity sector:

All CO_2 emissions from power generation as reported in the PRIMES results in the Reference scenario in 2020 are assumed to result in the acquisition of allowances through auctioning, trade between operators or the acquisition of international emission reduction credits. The price level for allowances and international emission reduction credits is assumed to be identical to the carbon price for the ETS as reported by PRIMES for the Reference scenario. To calculate system costs including distributional impacts in 2020 the expenses for this acquisition by the electricity sector is simply added to the system costs.

Transitional free allocation for the modernisation of electricity generation, as potentially allowed for a number of Member States that choose to do so[44], does not affect the system costs including distributional impacts, as presented in this analysis, given that it represents a mere transfer within a Member State. It would anyway not apply for 2020 as it in principle will be phased out by 2020.

ETS operators other than the electricity sector and aviation:

The target for ETS sectors other than the aviation sector in the Reference scenario in 2020 equals 1810 million allowances. Of this a maximum amount will be available for free allocation to sectors other than the electricity sector and aviation. To estimate this amount a simplified method is used applying the share of non-electricity sector emissions in 2005 as reported by PRIMES - GAINS. In 2005 ETS sectors other than aviation are assumed to have emitted 2291 million tonnes $CO_{2\text{-eq}}$ emissions in PRIMES - GAINS, of which the electricity sector had a share of 58.7% and the other sectors 41.3%. Thus the maximum amount of free allocation for those other sectors than the electricity sector and aviation is assumed to be 41.3% of 1810 million allowances or 748 million allowances.

Furthermore the simplified method applied in this analysis assumes that only 73% of the maximum amount available for free allocation will indeed be used for free allocation to the ETS sectors other than the electricity sector and aviation This translates into 546

[44] Following the provisions of Article 10c of the ETS Directive 2003/87/EC as amended by Directive 2009/29/EC

million allowances that are allocated for free and 202 million allowances that are auctioned.

This analysis does not make any judgement on the amount that will be eventually be freely allocated when implementing the Commission Decision determining transitional Union-wide rules for the harmonised free allocation of emission allowances[45].

For the distribution of the free allocation to the sectors other than the electricity and aviation sectors another simplified method is again applied, applying the share per Member State of 2005 emissions of these sectors as reported in PRIMES - GAINS. This results in a share per Member State as represented in Table 18 below. It should be noted that this is, of course, a rough approximation given that the Directive does not provide for a fixed share of free allocation per Member State. The eventual amounts of free allocation will depend on Member States national implementing measures regarding free allocation.

If emissions for these sectors in a Member State are higher than the available free allocation for those sectors in that country, then these sectors are assumed to acquire allowances through auctioning, trade or the acquisition of international emission reduction credits. The price level for allowances and international emission reduction credits is assumed to be identical to the carbon price for the ETS as reported by PRIMES for the Reference scenario.

To calculate system costs including distributional impacts in 2020, the expense of this acquisition by those sectors for emissions in excess of the free allocation is simply added to the system costs for that Member State. If emissions in a Member State for those sectors are lower than the available free allocation for those sectors in a Member State, then the value of this surplus is subtracted from the system costs to estimate the system costs including distributional impacts.

Table 18: Share free allocation for operators in the ETS other than the electricity sector and aviation

Share free allocation ETS sectors other than the electricity sector and aviation			
EU	100%	IT	11.1%
AT	2.2%	LV	0.2%
BE	3.9%	LT	0.7%
BG	1.6%	LU	0.2%
CY	0.1%	MT	0.0%
CZ	2.5%	NL	4.8%
DK	0.8%	PL	7.3%
EE	0.2%	PT	1.6%
FI	1.9%	RO	4.6%
FR	9.8%	SK	2.1%
DE	20.8%	SI	0.3%
EL	1.9%	ES	8.3%

45 Commission Decision of 27 April 2011 determining transitional Union-wide rules for harmonised free allocation of emission allowances pursuant to Article 10a of Directive 2003/87/EC of the European Parliament and of the Council (2011/278/EU)

HU	1.4%	SE	1.8%
IE	0.8%	UK	9.1%

Source: Based on PRIMES - GAINS

ETS operators in the aviation sector:

Aviation operators in the ETS receive a significant amount of free allocation of allowances in 2020. In total it is assumed that 85% of the target foreseen for aviation is freely allocated to aviation operators in the ETS. Given that the target for aviation is assumed to be equal to 140 million allowances in 2020, the number of free allocation is assumed to be 119 million allowances.

The share of the total amount of free allocation to aviation operators of a Member State in 2020 is assumed to be determined by the share of that Member State in the total EU CO_2 emissions from aviation as reported in PRIMES - GAINS for the year 2010 in the Baseline. This results in a share per Member State as represented in Table 19 below.

If emissions for the aviation sector in a Member State are higher than the available free allocation for aviation in that country, then it is assumed that the aviation sector acquires allowances through auctioning, trade or the acquisition of international emission reduction credits. The price level for allowances and international emission reduction credits is assumed to be identical to the carbon price for the ETS as reported by PRIMES for the Reference scenario.

To calculate system costs including distributional impacts in 2020 the expense of this acquisition by the aviation sector for emissions in excess of the free allocation is simply added to the system costs for that Member State.

Table 19: Share free allocation for aviation operators in the ETS

Share free allocation aviation operators in the period 2013 - 2020			
EU	100%	IT	8.2%
AT	1.5%	LV	0.2%
BE	2.6%	LT	0.1%
BG	0.5%	LU	0.8%
CY	0.7%	MT	0.2%
CZ	0.7%	NL	7.1%
DK	1.9%	PL	1.0%
EE	0.1%	PT	1.9%
FI	1.1%	RO	0.4%
FR	12.7%	SK	0.1%
DE	16.8%	SI	0.1%
EL	2.5%	ES	10.9%
HU	0.5%	SE	1.7%
IE	1.9%	UK	24.1%

Source: Based on PRIMES

Revenues from auctioning in the ETS to Member States:

The revenue from auctioning for Member States is deducted from the system costs to get to the system costs including distributional impacts. There are only two forms of auctioning assumed, the auctioning in the sectors other than aviation and the auctioning for the aviation sector.

For the sectors other than aviation the distribution to Member States is expressed as a share of the total auctioning rights to that sector. This share is determined following the distributional rules as defined in the ETS directive[46]. For an overview of the shares per Member State used for this analysis see Table 20 below. This is not yet the final redistribution but based on preliminary estimates using data from the Community Independent Transaction Log. Furthermore, shares are rounded for representational matters to the first digit after the comma.

The total amount to be auctioned to these sectors is equal to the target for these sectors minus the amount of free allocation, i.e. 1810 - 546 million allowances or 1264 million allowances for auctioning in 2020.

Table 20: Share auctioning revenue for Member States from auctioning to sectors in the ETS other than aviation

Share auctioning revenue from auctioning in sectors other than aviation in the period 2013 – 2020			
EU	100%	IT	9.4%
AT	1.4%	LV	0.3%
BE	2.5%	LT	0.5%
BG	2.7%	LU	0.1%
CY	0.3%	MT	0.1%
CZ	4.6%	NL	3.3%
DK	1.2%	PL	12.2%
EE	0.9%	PT	1.7%
FI	1.6%	RO	4.9%
FR	5.4%	SK	1.5%
DE	19.6%	SI	0.4%
EL	3.4%	ES	8.5%
HU	1.5%	SE	0.9%
IE	0.9%	UK	10.2%

For the auctioning to the aviation sector, the distribution to Member States is expressed as a share per Member State of the total auctioning rights for the aviation sector. This share is determined using that Member State's share of the EU CO_2 emissions from aviation as reported in PRIMES - GAINS for the year 2010. This results in a share per Member State which is the same as the one used to determine the share of free allocation that aviation operators of a Member State receive out of the total amount of free allocation available for the aviation sector. These shares are represented in Table 19 above. The total amount to be auctioned to the aviation sector is equal to the target for

46 Following the provisions of Article 10 of the ETS Directive 2003/87/EC as amended by Directive 2009/29/EC

this sector minus the amount of free allocation, i.e. 140- 119 million allowances or 21 million allowances for auctioning in 2020.

Revenue and costs of transfers due to the non-ETS targets:

Non-ETS targets are defined by applying the emission limits expressed in percentages in the Annex of the non-ETS Decision[47] on the 2005 emissions in the non-ETS as reported by PRIMES - GAINS. It should be noted that due to scope differences in the PRIMES – GAINS model set-up, this is not necessarily identical with emissions reported under UNFCCC. This results in a total target equal to 2439 million $CO_{2\text{-eq.}}$ by 2020 for the non-ETS, whereas emissions in 2005 are reported as equal to 2691 million $CO_{2\text{-eq.}}$.

The system costs in the Reference scenario represents the cost effective achievement of the non-ETS target EU wide through the application of an equal carbon price across non-ETS sectors (note that the renewable energy targets are met domestically which might not result in a EU wide cost effective outcome).

This means that Member States over- and underachieve their non-ETS targets.

Those Member States that underachieve their target are assumed to acquire excess emission allocations from Member States that overachieve their target or international emission reduction credits. The price level for this acquisition from other Member States is assumed to be identical to the carbon price for the ETS as reported by PRIMES for the Reference scenario. This is also the assumed acquisition cost for international emission reduction credits. Member States that underachieve their target are assumed to first acquire excess emission allocation from other Member States before acquiring international emission reduction credits. The cost for these acquisitions is added to the system costs to determine the system costs including distributional impacts for these Member States.

It should be noted that this price assumption for trade between Member States in the non-ETS puts a higher price for the transfer of excess emission allocation in the non-ETS compared to the projected carbon value in the non-ETS in the Reference scenario (i.e. ETS price projection of 16.5 € compared to a non-ETS carbon value projection of 5 €). This is due to incorporating the assumption that Member States are unlikely to sell non-ETS excess emission allocations at prices seen as well below the price level for international emission reduction credits as paid for by the ETS sectors and, furthermore, takes account that many of these excess emission allocations are due to reductions that are achieved through renewables incentives that also have a cost, which is not translated in a carbon price but which Member States might want to see compensated when selling any excess emission allocations.

Furthermore some Member States will need to acquire international emission reduction credits beyond the limit of annual use of credits by each Member State as defined in the non-ETS Decision[48]. They can do so by acquiring any unused quantity from other Member States. It is assumed that any need to use international emission reduction credits beyond 3% of the 2005 non-ETS emissions as reported by PRIMES - GAINS is

47 Following the provisions of Article 3 and Annex II of Decision No 406/2009/EC

48 Following the provisions of Article 5 of Decision No 406/2009/EC

met through the acquisition of the right to use these international emission reduction credits from those countries that overachieve their non-ETS target. These countries only get a limited compensation for selling this unused part, set at 3 € per international emission reduction credit. It is assumed that this 3 € compensation is included in the cost for international emission reduction credits without increasing the cost of international emission reduction credits for those who need to acquire the international emission reduction credits.

The revenue from the selling of any excess allocation emissions by those Member States that overachieve their non-ETS target is subtracted from the system costs to determine the system costs including distributional impacts for these Member States. Similarly any transfer for selling the right to use unused international emission reduction credits (set at 3 €) is also subtracted from the system costs to determine the system costs including distributional impacts for these Member States.

6.2.4. Assumptions applied to assess the distributional impacts of the 30% Reduction Commitment scenario

The **25% domestic GHG reduction scenario** achieves a 25% domestic GHG reduction. But to assess a 30% commitment scenario, targets need to be defined for a 30% target whereby it is assumed that international credits are used to achieve the 5% of reduction target beyond the **25% domestic GHG reduction scenario**.

The following gives an overview of the assumptions applied to estimate the redistributional impacts of a 30% target:

<u>Target for the ETS sectors:</u>

The Staff Working Document for the May 2010 Communication[49] suggests in case of a 30% reduction target to increase the 2020 ETS target (including aviation) to 34% below 2005 emissions instead of the 21% below 2005 emissions (excluding aviation)[50].

The ETS emissions in 2005 as represented in PRIMES – GAINS are equal to 2438 million tonnes $CO_{2\text{-equi.}}$. Applying a 34% target on this emission level results in an ETS target in 2020 equal to 1609 million allowances.

The total target in the Reference scenario for all sectors of the ETS was equal to 1950 million allowances or around 20% lower than 2005 emissions (see also Section 6.2.3 above). Therefore, going from the Reference scenario to a 30% with flexibility scenario sees a decrease in the number of allowances available in 2020 equal to 341 million allowances.

<u>ETS operators in the electricity sector:</u>

The same approach is applied as for the Reference scenario. No free allocation is assumed to the operators in this sector (see Section 6.2.3 above).

49 COM(2010) 265

50 SEC(2010) 650, Part 2, Section 5.2

ETS operators other than the electricity sector and aviation:

The amount of free allocation, both for the operators other than the electricity sector as well as the aviation sector is assumed to remain identical to the amount as foreseen for the Reference scenario (see Section 6.2.3).

Revenues from auctioning in the ETS to Member States:

In the Reference scenario the total amount of allowances that is foreseen for auctioning in 2020 from the target allocated to the sectors other than aviation is 1264 million allowances. For the aviation sector this is 21 million allowances. In total 1285 million allowances are auctioned in 2020 in the Reference scenario

In this 30% Reduction Commitment scenario, this amount is assumed to decrease by the total reduction of allowances in 2020 for the ETS sectors, i.e. a reduction of 341 million allowances to 944 million allowances.

It is assumed that in the 30% Reduction Commitment scenario none of Member States of the lower income group (BG, RO, LV, LT, PL, SK, EE, HU, CZ, MT, SI, PT) see a reduction in the amount of allowances they can auction compared to the Reference scenario, including the auctioning foreseen for the aviation sector.

It is assumed that all the other Member States of the higher income group (AT, BE, CY, DK, FI, FR, DE, EL, IE, IT, LU, NL, ES, SE, UK), see exactly the same % decrease in the amount of allowances they can auction compared to the Reference scenario, including the auctioning foreseen for the aviation sector. This % reduction of allowances to auction equals to 38% compared to the Reference case.

For more background about the choice of country groupings, see Section 5.2 above.

Revenue and costs of transfers due to the non-ETS targets

The Staff Working Document for the May 2010 Communication[51] suggests in case of a 30% reduction target to increase the 2020 non-ETS sectors to 16% below 2005 emissions In 2005 emissions are reported as equal to 2691 million $CO2_{-equi.}$. A target of 16% below this level results in an emission allocation in the non-ETS of 2261 million $CO2_{-equi.}$ or an increase of target compared to the Reference scenario reported in PRIMES – GAINS of around 6.5% of 2005 emissions.

To determine the non-ETS targets for individual Member States, the emission targets expressed in percentages in the annex of non-ETS Decision[52] are increased by this additional 6.5% reduction for every Member State. This would for instance mean that the Bulgarian target would become +13.5% compared to 2005 in case of a 30% reduction target and the targets of Ireland, Luxembourg and Denmark would become -26.5% The resulting increased emission limit, expressed in a percentage, is applied on the 2005 emissions in the non-ETS per Member State as reported by PRIMES - GAINS.

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51 COM(2010) 265

52 Following the provisions of Article 3 and Annex II of Decision No 406/2009/EC

For the rest the same simplified methods are used as described in Section 6.2.3.

6.2.5. *Definition of investments and fuel expenses*

Estimates for total energy-related investment and fuel expenses per period are provided. This information is relevant to determine the corresponding finance needs over time and the short-term benefits regarding impacts on fuel expenditure. For comparison, system costs include the annual depreciation spreading the total cost of investment over the entire lifetime of the investment, decreasing fuel expenditures and immaterial impacts of disutility costs.

For most energy-related equipment the calculation of total and additional investment expenditures is straightforward using the PRIMES results. It uses the same data basis as is used to calculate capital costs associated with investments. Fuel costs expenses relate to costs paid for fuels by all sectors, including the fuel costs included in electricity costs.

Investments are given for full 5 year periods in the PRIMES model, e.g. from 2016 to 2020. The results for both investments and fuel expenses as presented in Sections 5.5 and 5.6 of this analysis focus therefore on this period, i.e. from 2016 to 2020, given that it is the period reported in PRIMES which is closest to the year 2020 which is used as the main Reference for comparison. At the same time, the period 2016 to 2020 in large part overlaps with the period of actual implementation for the next EU Multiannual Financial Framework, starting in 2014.

6.2.6. *Definition of impacts on air pollution*

The analysis as presented in the Staff Working Document of the *May 2010 Communication* also included an estimate of the impacts on air pollution, air pollution control costs and health impacts.

Reductions in GHG emissions have an impact on other air pollutant emissions because of the reduction in energy production and consumption and a shift in the energy mix towards more low carbon energy sources. To analyse the impact on air pollution of reducing GHG emissions the GAINS model was used, permitting a broad estimation of the changes in on air pollution impacts.

Furthermore, impacts on air pollution control costs were estimated. To calculate these air pollution control costs a 4% interest rate on capital for investments was assumed.

The GAINS model was also used to calculate the physical impacts on premature mortality due to fine particles and ground level ozone using dose-response functions that link concentrations of air pollutants to physical impacts.[53] Using population projections these can be translated into total physical impacts per Member State. 2010 population data was used as a proxy for 2020. Using these physical impacts monetary benefits were estimated using the valuation parameters that were also used for the Thematic Strategy on Air Pollution[54].

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[53] See Mechler et al. (2002).

[54] Values used for a statistical life lost were €980.000 to 2 million € respectively €52.000 to €120.000 per life year lost (in 2005 prices).

In addtion to mortality, there is also an impact on morbidity (sickness). Also damage to materials, crops and sensitive ecosystems (due to acidification, excess nitrogen deposition and ground level ozone) can be inflicted. However, these further impacts were neither estimated nor valued in monetary terms.

This analysis uses the same scenarios that were used to estimate the air pollution impacts for the Staff Working Document of the *May 2010 Communication.*

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