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Potentials and costs for mitigation of non-CO_2 greenhouse gas emissions in the European Union until 2030

Results

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1 Introduction

This report presents estimates of baseline emissions and mitigation cost curves for non-CO_2 greenhouse gases in the European Union (EU-27). It addresses the non-CO_2 greenhouse gases included in the Kyoto Protocol, i.e., methane (CH_4), nitrous oxide (N_2O), and the three groups of fluorinated gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6). This is an interim report produced for DG Climate Action by the International Institute for Applied Systems Analysis (IIASA) as a sub-contractor under Service project 07.030700/2009/545854/SER/C5 led by the National Technical University of Athens (NTUA). The results presented in this report draws on baseline emissions developed under the EC4MACS project[1].

This report complements a methodology report "Potentials and costs for mitigation of non-CO_2 greenhouse gases in the European Union - Methodology" (Höglund-Isaksson et al., 2010), which in a draft version was circulated together with draft baseline emissions to national experts for review on Sep, 18, 2009. Feedbacks from Member States or other experts on activity levels, emissions or methodology have been included in the current results.

Detailed information on activity data, emission factors, implementation of control technology, and control costs is available via the on-line version of the GAINS model at: http://gains.iiasa.ac.at/. See Box 1 for instructions how to extract data.

Box 1: How to extract data from the GAINS-online model

1. Go to http://gains.iiasa.ac.at/
2. Click on GAINS Online, and the "Europe" box.
3. Log in to the model (you need to register first if you are a new user).
4. Choose the tab of interest, e.g., "Activity Data" or "Emissions" for display of data.
5. Choose the pollutant (CH_4 , N_2O or FGAS) on the left menu bar.
6. Choose mode of data display in the left column, e.g., by sector.
7. A menu bar will appear to the right. Choose the scenario group name "**PRIMES_09**" and the scenario "**PRIMES_BL2009_14jan10**" .

The results presented here refer to the baseline emission scenario developed in December 2009. Energy sector activity data were retrieved from the PRIMES model developed by the National Technical University of Athens (Version received on Dec 23, 2009). Animal numbers and other agriculture activity data were retrieved from the CAPRI model developed by Bonn University (Version received on Dec 15, 2009).

The structure of the report is as follows: Section 2 describes the general GAINS methodology. Section 3 presents assumptions and results for estimating baseline non-CO_2 GHG emissions. Section 4 presents mitigation cost curves and Section 5 draws conclusions from the analysis.

[1] European Consortium for Modelling of Air Pollution and Climate Strategies (EC4MACS), LIFE06 ENV/AT/PREP/06 is a transnational collaboration project funded by the European Commission and led by IIASA.

2 Methodology

The methodology applied for estimating baseline non-CO_2 GHG emissions in EU-27 has been described in detail for each emission source sector in Höglund-Isaksson et al. (2010). The general features of the GAINS methodology for the various gases have been described in previous reports (Höglund-Isaksson et al., 2009; Höglund-Isaksson and Mechler, 2005; Winiwarter, 2005; Tohka, 2005). The overall framework, in which the GAINS model operates, has been described by Amann et al. (2008a) and the respective reports mentioned therein. This particular report builds on previous work on non-CO_2 GHGs using GAINS for the Climate & Energy Package in 2008 (see Amann et al., 2008b).

In brief, the methodology (i) adopts exogenous projections of future economic activities as a starting point, (ii) develops a corresponding baseline projection of greenhouse gas emissions, by primarily following the estimation approaches recommended in the IPCC (1997, 2006) guidelines complemented with information, e.g., on current control, derived from the national GHG inventories that have been reported by Member States to the UNFCCC, as well as through direct communication with Member State experts, (iii) estimates, with a bottom-up approach, for each economic sector in each country the potential emission reductions that could be achieved through application of available mitigation measures, and (iv) quantifies the associated costs that would emerge for these measures under the specific national conditions. The approach includes all anthropogenic sources of non-CO_2 GHG that are included in the emission reporting of Annex 1 countries to UNFCCC, except the sector Land Use, Land Use Change and Forestry (LULUCF).

The different steps in the estimation procedure used in this report for the baseline non-CO_2 greenhouse gases in EU-27 are illustrated in Figure 1. In a first step, projections on macro-economic development (GDP and population) in the EU Member States developed by the European Commission, DG Economic and Financial Affairs (DG-ECFIN 2009a,b) were used as starting points for all three models involved. PRIMES models for the European Commission[2] future energy production and consumption consistent with the economic development path and, for the purpose of non-CO_2 GHG, supplies relevant information to GAINS on, e.g., energy use, transport demand, energy-intensive industrial production (i.e., primary aluminium), and expected equilibrium carbon price levels in the European emission trading system (ETS). CAPRI models levels of future agricultural production in a consistent manner across Member States and supplies results to GAINS on e.g., animal numbers, fertilizer use, and milk yield. GAINS uses GDP and population data from DG ECFIN complemented by a more detailed disaggregation, on industrial value added provided by the PRIMES model and other sources, to produce projections for the amounts of solid waste and wastewater generated, as well as projections of industrial processes that are not estimated by the PRIMES model (e.g., adipic and nitric acid production and use of F-gases in different industrial processes).

In a second step, projections on activity data were used to estimate a first set of draft baseline emissions using GAINS data on country-specific emission factors and application of mitigation measures for the non-CO_2 GHG. GAINS follows the IPCC guidelines as closely as

[2] Capros, P., L. Mantzos et al. (2010): European Energy - Trends to 2030. European Commission (forthcoming).

permitted by available information. By applying the same methodology to all EU-27 countries, the model maintains methodological consistency across countries.

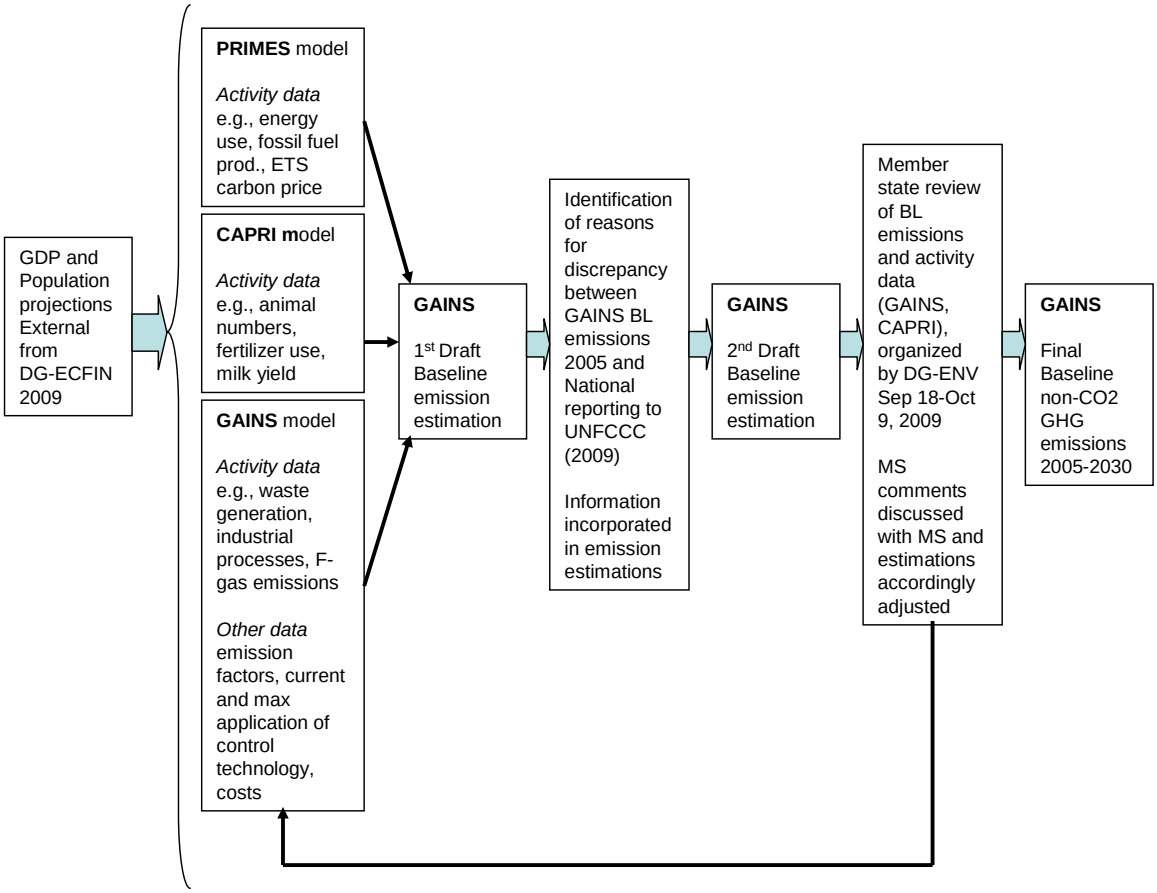

Figure 1: Work procedure for the 2009 estimation of baseline emissions of non-CO_2 greenhouse gases in EU-27 in the GAINS model.

In a third step, the first draft results for 2005 were compared to the 2005 emissions figures reported by countries to the UNFCCC in CRF tables and NIR reports (UNFCCC, 2009, version available in July 2009). For some emission sources, like CH_4 from enteric fermentation in livestock or coal mining, implied emission factors used in the national submissions to the UNFCCC are frequently based on empirical measurements in the Member States. These are likely to more accurately reflect country-specific circumstances than the default regional emission factors available from the IPCC guidelines. In these cases we have applied the CH_4 emission factors reported to UNFCCC rather than the IPCC default factors. For N_2O emissions from soils, most EU Member States follow the methodology described in the IPCC 1997 guidelines for calculating emissions[3]. The comparison for F-gas emission

[3] Exceptions are Germany and Poland, who in their 2009 submissions apply the revised IPCC methodology from 2006. As the two methodologies result in substantially different estimates, GAINS emission estimates are adjusted accordingly for these two countries.

sources is complicated by the high level of aggregation in the reporting of these emissions to UNFCCC and by the lack of information on underlying activity data. It was therefore only possible to explain the reasons for discrepancies in emission estimates in detail for CH_4 and N_2O emissions and not for the F-gases.

Residual differences between CH_4 and N_2O emissions as estimated by GAINS and emissions reported by countries to the UNFCCC for the year 2005 are included in an emission category "Other". This category represents partly emissions from sources that are reported to UNFCCC but not explicitly distinguished in GAINS (e.g., CH_4 from thermal baths in Hungary, enteric fermentation emissions from rabbits in Italy, etc.) and partly result from differences in the applied calculation methodology. For each Member State, its magnitude is presented in the methodology report (Höglund-Isaksson et al., 2010) with a listing of the major reasons for the discrepancy between GAINS estimates and reported emissions. In absence of more detailed information, these residual emissions are held constant over the projection period.

After these adjustments, a second draft baseline was produced by the GAINS model. This revised baseline and the principal activity data generated by the CAPRI and GAINS models, were sent out to all EU-27 Member States as part of the review process organized by the European Commission, DG Environment. PRIMES activity data were reviewed in a separate process organized by DG Energy and Transport. In the review period (Sep 18 to Oct 9, 2009) comments were received from experts in Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Slovak Republic, Spain, and Sweden. All comments were discussed between country experts and IIASA (L. Höglund-Isaksson and W. Winiwarter) and CAPRI (Peter Witzke) modellers to assure that comments were appropriately integrated into the GAINS and CAPRI models. Country comments have been considered as long as they do not compromise international consistency in the GAINS calculations. E.g., some countries employ in their national reporting different assumptions about removal efficiencies of control measures. Unless there was clear evidence why removal efficiencies are different across countries, GAINS uses internationally coherent figures. Subsequently, a final set of baseline emissions was produced for each Member State.

Potentials and costs for mitigation of non-CO_2 GHG emissions were estimated using the optimization feature of the GAINS model. Mitigation costs were calculated for each control option assuming a discount rate of 10 percent to approximate market behaviour (and using Euros of 2005). Annual mitigation costs are calculated as the sum of annualized investment costs, wage costs, other operation and maintenance costs, and any cost-savings from, e.g., utilization of recovered CH_4 for energy purposes. Mitigation cost calculations by sector have been described in further detail by Höglund-Isaksson et al. (2010).

3 Baseline non-CO_2 emissions

3.1 Main drivers

Main drivers used in GAINS for the principal sources of non-CO_2 GHG emissions are listed in Table 1 together with references for the sources of data and information used.

Table 1: Principal sources for non-CO_2 GHG, drivers and data sources used in GAINS.

Emission source	Main drivers	Data source for drivers
Livestock	Animal numbers	Eurostat (2009) for 2005, projection trends from CAPRI model
	Nitrogen excretion rates of animals	UNECE-LRTAP, Ammonia Expert Group
	Milk yield	Eurostat (2009) for 2005, projection trends from CAPRI model
Soils	Fertilizer use	IFA (2009), EFMA (2009), FAO (2009) for 2005, projection trends from CAPRI model
	Nitrogen excretion rates of animals	UNECE-LRTAP, Ammonia Expert Group
	Crop residue to fields	UNFCCC (2009)
Municipal solid waste	GDP per capita	DG-ECFIN (2009)
	Population	DG-ECFIN (2009)
	Urbanization rate	UN (2006)
Industrial solid waste	Value added in respective manufacturing industry	PRIMES (2009)
Domestic wastewater	Population	DG-ECFIN (2009)
	Fraction of pop with centralized collection	UNFCCC (2009), UNstat (2009)
Industrial wastewater	Value added in respective manufacturing industry	PRIMES (2009)
Energy use	Energy consumption by fuel	PRIMES (2009)
Fossil fuel production	Amounts of coal mined	PRIMES (2009)
	Oil and gas produced	PRIMES (2009)
Natural gas transmission	Amounts of natural gas transported	UNFCCC (2009) and information from National experts
Transport	Energy use by vehicle type	PRIMES (2009)
	Vehicle numbers	Derived from PRIMES (2009) and information from national experts
Refrigeration and AC	HFC emissions affected by phasing out of CFCs following the Montreal protocol and demand increases	UNFCCC (2009), National expert comments and various other sources (see Tohka, 2005)
	Demand increases following growth in GDP or value added in respective manufactuirng industry	PRIMES (2009)
Nitric and adipic acid production	Amounts adipic and nitric acid produced	UNFCCC (2009) and information from National experts, projections based on PRIMES (2009)
Primary aluminium production	Amounts of primary Al produced	PRIMES (2009)

Projections of GDP and population are consistent with the economic outlook adopted by DG-ECFIN and used in the PRIMES model (version submitted to GAINS in December 2009). Development in GDP, population and industry value added are key drivers for the energy and agricultural projections, as well as for the future generation of solid waste and wastewater. As shown in Figure 2, GDP in EU-27 is expected to grow by 52 percent over the period 2005-2030. Population growth is expected to be moderate, on average 6 percent over the same period.

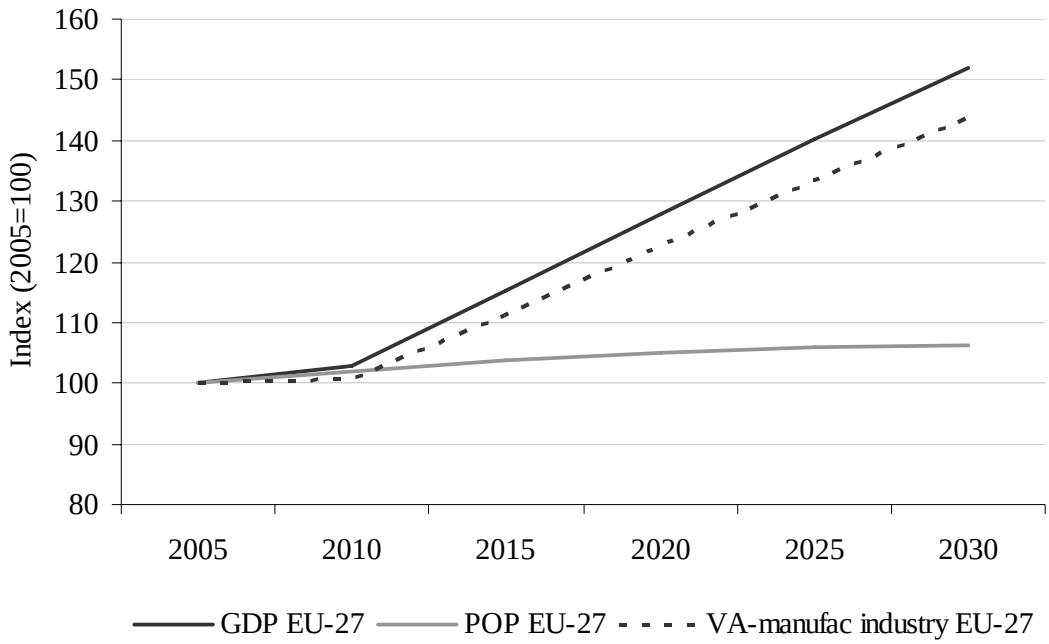

Figure 2: Assumed growth in GDP, industrial value added (VA) and population (POP) for the EU-27 in the period 2005-2030. Source: PRIMES (2009)

The main drivers of non-CO_2 GHGs from the agricultural sector are animal numbers and fertilizer use. Data for 2005 were taken from Eurostat (2009) for animal numbers and from IFA (2009), EFMA (2009) and FAO (2009) for fertilizer use. Projected future activity levels were obtained using trends estimated by the CAPRI model. Nitrogen excretion rates from animals were derived from national information that was collected by the Ammonia Expert Group under the UNECE Convention on Long Range Transboundary Air Pollution (UNECE-LRTAP). The amounts of nitrogen returned to fields in the form of crop residues were taken from UNFCCC (2009) for the year 2005 and assumed constant throughout the estimated period. Figure 3 shows the assumed development of the main drivers of agricultural non-CO_2 GHG emissions.

Main drivers for emissions from the energy sector are energy use by type of fuel and sector, production of fossil fuel and transportation of natural gas. Energy activity data and projections are taken from the 2009 energy baseline of the PRIMES model. The assumed developments of energy sector drivers in 2005-2030 are presented in Figure 4.

Industrial processes that are important drivers of non-CO_2 GHG emissions include adipic and nitric acid production (for N_2O) and primary aluminium production (for PFC). Amounts of adipic and nitric acid produced were taken from countries' reporting to UNFCCC (2009) for year 2005, complemented by information on major disruptions (e.g., close-downs or start-ups of installations) from national experts during the review process. Projections follow the expected growth in value added for the chemical industry as projected by the PRIMES model (2009). Projections of primary aluminium production were also taken from the PRIMES model.

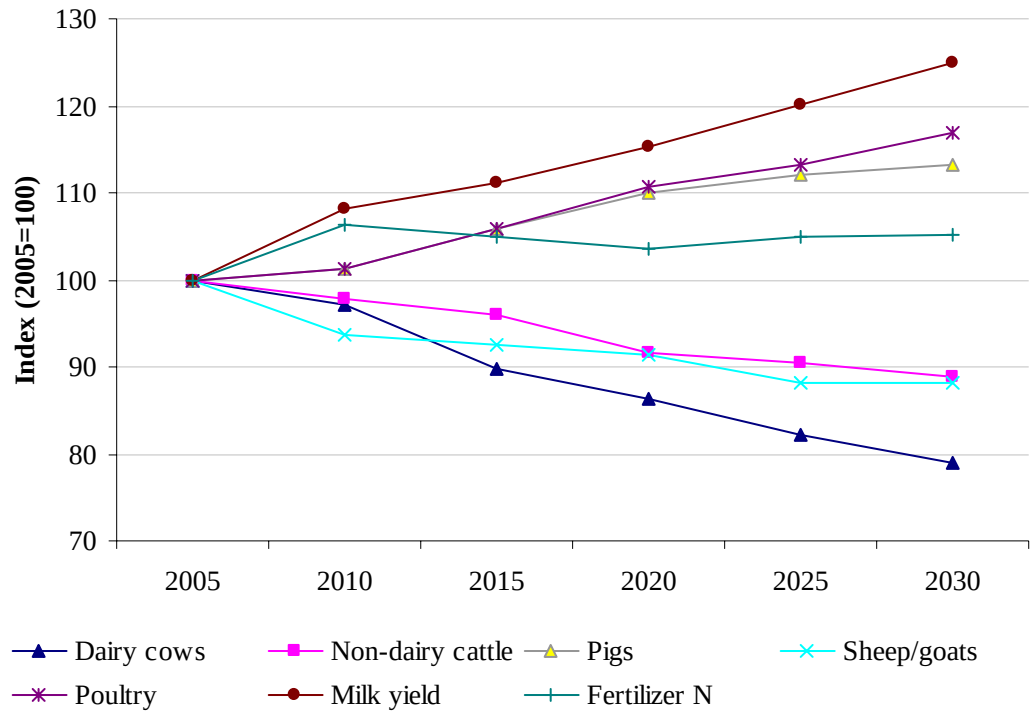

Figure 3: Development of drivers for emissions of non-CO_2 GHG from the agricultural sector for EU-27 in 2005-2030.

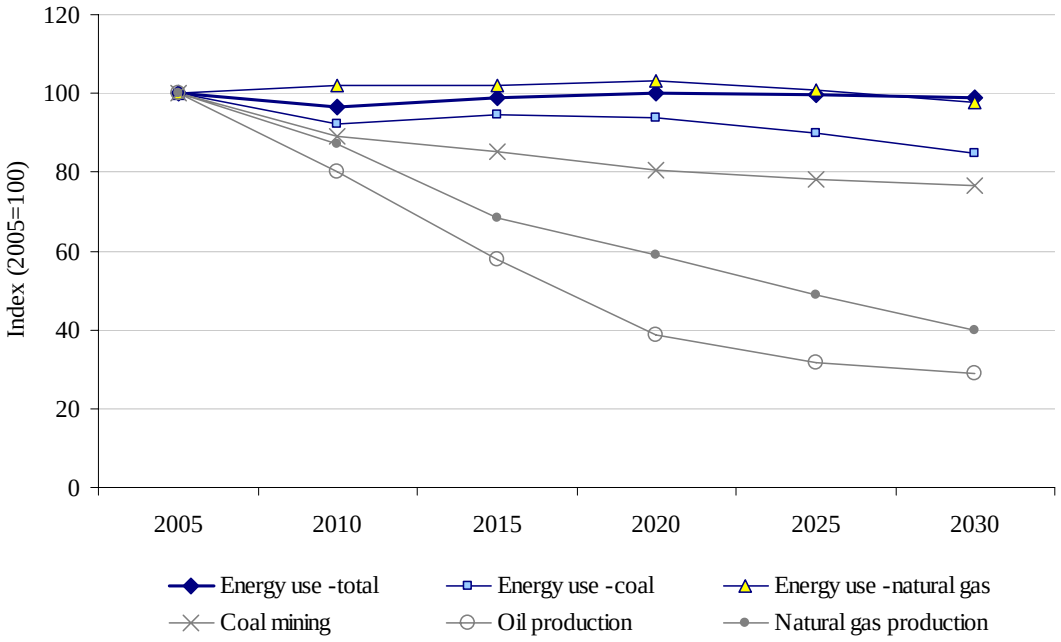

Figure 4: Development of main drivers for emissions of non-CO_2 GHG from the energy sector for EU-27 in 2005-2030.

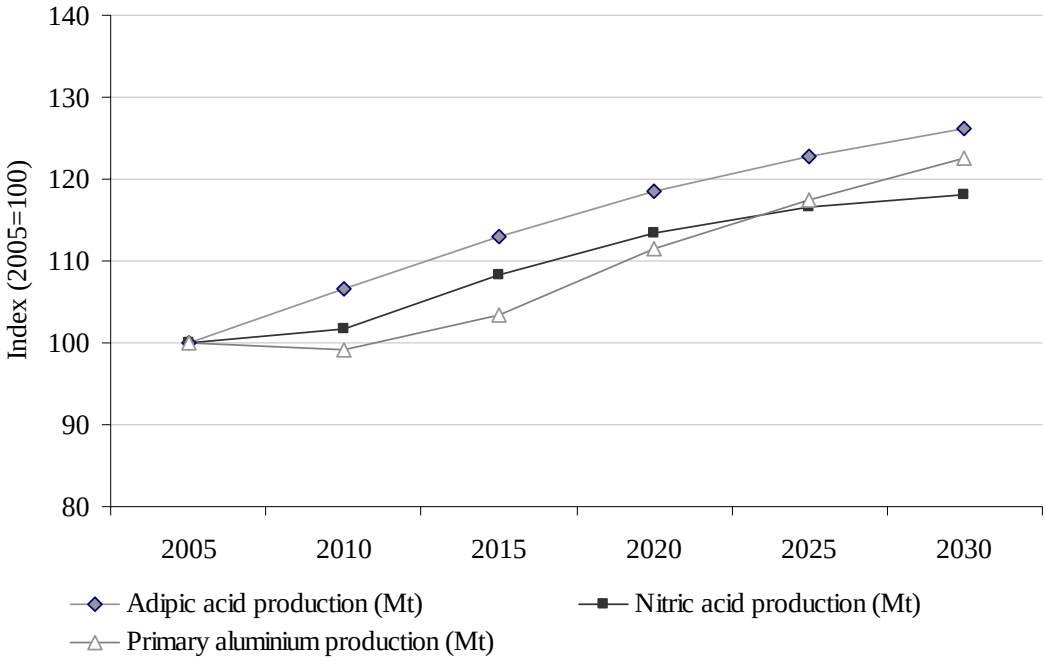

Figure 5: Development of main drivers for non-CO_2 GHG from industrial processes for EU-27 in 2005-2030.

3.2 Baseline emissions

3.2.1 Current legislation in baseline emissions

The baseline emission projection assumes implementation of mitigation measures according to the currently adopted EU and national legislations. The following legislation has been considered:

- Landfill Directive (1999/31/EC), the Waste Directive (2006/12/EC) and the Waste Management Framework Directive (2008/98/EC): All EU-27 countries are assumed to meet the required diversion of biodegradable waste away from landfills, i.e., 25 percent in 2006, 50 percent in 2009 and 65 percent in 2016 of the 1995 amounts land-filled. All landfill sites should by 2009 be equipped with gas recovery equipment. Countries with a heavy reliance on landfills have been granted a four years grace period for compliance (i.e., Greece, Ireland, Italy, Spain, Portugal, United Kingdom, Cyprus, Estonia, Hungary, Slovenia, Poland, and Slovakia). The EU waste hierarchy is followed to the extent that recycling and composting are preferred to incineration and deposition on landfills. Waste incineration is not assumed to increase above currently implemented levels, unless information from national experts suggests otherwise.
- Nitrate Directive (1991/676/EEC), Common Agricultural Policy (CAP) Reform (2006/144/EC), the CAP "Health Check" 2008 and the "Set aside" regulation (73/2009): Assumptions on agricultural policies in the activity projections produced by the CAPRI model comprise the effects of the "Health Check" of the CAP, the abolition of the "Set aside" and the milk quota regulations, as well as the impacts of

the Nitrate Directive. In addition, agricultural premiums are considered largely decoupled from production levels.

- F-gas Directive (2006/842/EC) and Motor Vehicles Directive (2006/40/EC): The F-gas Directive stipulates that by 2010 end-of-life recollection of refrigeration and air-conditioning equipment should be in place as well as adoption of good practice measures involving leakage control and improved components of refrigeration and air-conditioning equipment in use. From 2011, the use of HFC-134a in mobile air conditioners should be replaced by a cooling agent with a GWP of less than 150 in all new vehicles placed on the market. In addition, the F-gas Directive stipulates an increased use of alternative blowing agents for one-component foams, use of alternative propellants for aerosols, leakage control and end-of-life recollection and recycling of high-and mid voltage switches, SF_6 replaced by SO_2 in magnesium production and casting, and a ban of use of SF_6 in soundproof windows, sports equipment etc.
- Amended ETS Directive (2009/29/EC): The baseline scenario assumes adoption of mitigation technologies within the sectors included in the EU emissions trading system (ETS) to the extent that marginal mitigation costs are lower than the established carbon price in the market for emission permits. Non-CO_2 sector sources included in the ETS from 2013 are production of adipic and glyoxal/glyoxylic acid, nitric acid, and primary aluminium. Expected future carbon price levels in the ETS allowance market were taken from the new baseline results of the PRIMES model (December 2009)[4]. It is projected that these carbon prices imply use of catalytic reduction in nitric acid production (from 2015 onwards), catalytic reduction in adipic acid production (adopted voluntarily from 2000 onwards in all countries, except Italy where adoption starts from 2010 onwards), twin reduction system in adipic acid production (technology assumed readily available from 2020 onwards), and retrofitting of vertical stud Söderberg (VSS) technology in primary aluminium production (from 2015 onwards).
- Other relevant EU-wide legislation that has indirect effects on non-CO_2 GHGs, include regulations on transport-related emissions and the Biofuels Directive (2009/28/EC). Production of biofuels in EU-27 is assumed to develop as projected by PRIMES (see Amann et al., 2010).
- National legislation affecting emissions of non-CO_2 GHG includes complete bans on depositing biodegradable waste on landfills in Denmark, Germany and Sweden, and national legislation controlling emissions of nitrogen compounds (NO_X, NH_3) indirectly affecting non-CO_2 GHG emissions.

In addition, the voluntary agreement to reduce PFC emissions in the semiconductor industry by 10% by 2010 compared to 1995 is assumed to have contributed to considerable reductions by 2005 (ESIA, 2006). The effect of the control in place in 2005 is assumed to continue into the future, taking a conservative approach in line with the baseline philosophy.

[4] These ETS carbon prices are, in constant Euro of 2005: 13.6 Euro/t CO_2 in 2010, 18.7 Euro/t CO_2 in 2015, 23.4 Euro/t CO_2 in 2020, 30 Euro/ton CO_2 in 2025, and 36.6 Euro/ton CO_2 in 2030.

3.2.2 Baseline emission estimates

Estimated future baseline emissions of non-CO_2 GHG in EU-27 in the period 2005 to 2030 are presented in Table 2, by emission source. Without further control measures in addition to those that are already adopted in current legislation, total emissions are expected to fall by 13 percent until 2020 and by 14 percent until 2030, i.e., in 2030 a drop by 123 Mt CO_2eq, from 879 Mt CO_2eq to 755 Mt CO_2eq (differences due to rounding). Major reductions are expected from the full implementation of the EU Landfill Directive (corresponding to -69 Mt CO_2eq in 2030), mitigation measures in the adipic and nitric acid production (-44 Mt CO_2eq) with marginal costs below the expected permit price in the ETS system, and from a decline in coal mining (-12 Mt CO_2eq). Expected reductions in dairy cow and non-dairy cattle numbers due to productivity increases are expected to reduce CH_4 and N_2O emissions (-17 Mt CO_2eq), and the EU-wide replacement of HFC-134a in mobile air conditioners in all new vehicles from 2011 onwards is expected to reduce emissions (-6 Mt CO_2eq) despite an increase in demand for mobile air conditioning. Higher emissions of non-CO_2 GHG are expected from an increase in pig farming (+6 Mt CO_2eq), increase in demand for refrigeration coupled with the phase-out of CFCs in the industrial and commercial sectors (+20 Mt CO_2eq), and increased demand for stationary air conditioning (+6 Mt CO_2eq).

Baseline CH_4 emissions are expected to fall by 21 percent until 2020 and by 25 percent until 2030. Major reductions in methane emissions result from extended diversification of biodegradable waste away from landfills into different waste treatment options e.g., recycling, composting and anaerobic digestion, following the Landfill Directive. Methane emissions are also expected to fall due to a decline in coal mining in Europe and due to reductions in dairy and non-dairy cattle stocks.

Baseline emissions of N_2O are expected to fall by 8 percent until 2020 and by 9 percent until 2030. Major contributors to these reductions are implementation of catalytic reduction in nitric acid production and improved catalytic reduction in adipic acid production. Both options are expected to be adopted in the baseline as a result of including these sectors in the ETS system.

Baseline F-gas emissions in EU-27 are expected to increase by 10 percent until 2020 and by 25 percent until 2030. This is the result of a combined effect of increased demand for refrigeration and air conditioning, replacement of CFCs for HFCs following the Montreal Protocol, and mitigation in accordance with the F-gas Directive and the replacement of HFC-134a with alternative cooling agents in new vehicles from 2011 onwards.

Only about five percent of baseline non-CO_2 GHG emissions are included in the EU ETS system from 2013 onwards. These are N_2O emissions from nitric and adipic acid production and PFC emissions from primary aluminium production. Due to inclusion of these sectors in the ETS, emissions are expected to fall by 75 percent in 2020.

Baseline non-CO_2 GHG emissions in non-ETS sectors are expected to fall by 8 percent until 2020 and by 10 percent until 2030. Main contributors to reductions in non-ETS sectors are the waste sector, coal mining industry, and cattle herding. Agricultural emissions are expected to fall by a modest two percent, where emission reductions due to falling dairy and non-dairy cattle numbers are partly offset by an expected increase in pig numbers and in fertilizer use.

Baseline non-CO_2 GHG emission estimates by Member State are presented in Table 3. In absolute terms, largest reductions in non-CO_2 GHG emissions between 2005 and 2030 are

expected to take place in Germany (-25 Mt CO_2eq), the UK (-21 Mt CO_2eq), France (-14 Mt CO_2eq), and Italy (-14 Mt CO_2eq). Taken together, the expected reductions in these four countries make up more than 60 percent of the total expected reductions of 123 Mt CO_2eq in EU-27 over this period. In relative terms, highest declines in non-CO_2 GHG emissions are expected for Bulgaria, Germany, Greece, Hungary, Lithuania, Malta, Portugal, and the UK. In all of these countries expected emission reductions exceed 20 percent of the 2005 emission level.

Table 2: GAINS Baseline emissions of non-CO_2 GHG in EU-27 in 2005 and 2030, by source

Pollutant		Emission source	Baseline emissions (Mt CO_2eq)						Emission change	
			2005	2010	2015	2020	2025	2030	2005 to 2030	
Methane	CH4	Dairy cows	65.7	66.7	62.6	61.6	60.0	58.8	-7.0	-11%
	CH4	Non-dairy cattle	77.2	76.0	74.7	71.3	70.6	69.5	-7.7	-10%
	CH4	Pigs	32.7	34.0	35.8	37.3	37.9	38.2	5.5	17%
	CH4	Poultry	2.7	2.8	2.9	3.1	3.1	3.2	0.5	18%
	CH4	Other livestock	20.5	19.3	19.2	19.0	18.5	18.5	-2.0	-10%
	CH4	Rice cultivation	2.1	2.1	2.1	2.1	2.1	2.1	0.0	0%
	CH4	Agricultural waste burning	1.6	1.6	1.6	1.6	1.6	1.6	0.0	-1%
	CH4	Industrial solid waste	41.5	24.1	21.5	20.9	22.1	22.4	-19.0	-46%
	CH4	Municipal solid waste	72.6	40.7	31.8	29.6	25.8	22.3	-50.4	-69%
	CH4	Industrial wastewater	5.1	4.1	4.3	4.6	4.8	5.0	-0.1	-2%
	CH4	Domestic wastewater	11.9	10.9	11.4	11.4	11.4	11.4	-0.6	-5%
	CH4	Coal mining	30.7	26.0	24.2	21.4	19.3	18.3	-12.4	-40%
	CH4	Production of crude oil and natural gas	6.7	5.8	5.3	4.8	4.1	3.9	-2.8	-42%
	CH4	Long-distance gas transmission	23.5	23.8	23.6	23.4	22.9	22.1	-1.4	-6%
	CH4	Oil refinery	0.3	0.3	0.3	0.3	0.3	0.3	0.0	-10%
	CH4	Energy use in power plants	4.0	3.6	3.3	3.1	2.7	2.5	-1.5	-38%
	CH4	Energy use in industry sector	2.3	2.2	2.1	1.9	1.8	1.7	-0.7	-28%
	CH4	Energy use in domestic sector	8.7	7.3	6.7	5.9	5.3	4.8	-3.9	-45%
	CH4	Road transport	4.1	3.1	2.6	2.3	2.1	2.0	-2.0	-50%
	CH4	Air transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	42%
	CH4	Rail transport	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-91%
	CH4	Ship transport -large vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2%
	CH4	Ship transport -medium vessels	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6%
	CH4	Other transport	0.3	0.3	0.3	0.3	0.3	0.3	0.0	2%
	CH4	Other CH4 sources	7.6	7.6	7.6	7.6	7.6	7.6	0.0	0%
Nitrous oxide	N2O	Manure management	27.7	26.5	25.8	25.4	25.2	25.1	-2.7	-10%
	N2O	Soils	240.6	246.2	243.9	242.2	242.8	243.2	2.6	1%
	N2O	Domestic wastewater	15.5	15.8	16.1	16.2	16.4	16.4	1.0	6%
	N2O	Direct N2O use	8.5	8.7	8.8	9.0	9.0	9.1	0.6	7%
	N2O	Adipic acid production (ETS)	10.9	4.6	4.8	1.0	1.1	1.1	-9.8	-90%
	N2O	Nitric acid production (ETS)	44.5	29.9	9.8	10.2	10.5	10.7	-33.9	-76%
	N2O	Energy use in power plants	36.7	45.2	43.3	42.7	40.8	38.3	1.6	4%
	N2O	Energy use in industry sector	2.3	3.6	3.9	4.1	4.4	4.5	2.2	98%
	N2O	Energy use in domestic sector	3.3	3.2	3.2	3.2	3.2	3.1	-0.2	-5%
	N2O	Road transport	13.8	15.7	17.6	18.3	18.2	17.7	3.9	28%
	N2O	Air transport	0.3	0.3	0.3	0.3	0.3	0.3	0.1	35%
	N2O	Rail transport	0.1	0.1	0.1	0.1	0.1	0.0	-0.1	-86%
	N2O	Other transport	0.1	0.1	0.1	0.1	0.1	0.1	0.0	12%
	N2O	Other N2O sources	-19.3	-19.3	-19.3	-19.3	-19.3	-19.3	0.0	0%
F-gases	HFC	HCFC22 production	5.0	1.8	1.2	1.1	1.2	1.3	-3.7	-74%
	HFC	Refrigeration in industry	5.9	8.2	10.0	11.1	12.1	13.0	7.1	119%
	HFC	Refrigeration in commercial sector	21.0	22.5	26.1	28.5	31.3	34.2	13.2	63%
	HFC	Refrigeration in domestic sector	0.0	0.3	0.3	0.3	0.3	0.3	0.3	.
	HFC	Refrigeration in transport	2.2	1.4	1.6	1.6	1.6	1.6	-0.5	-25%
	HFC	Stationary air conditioning	5.0	6.5	8.0	9.0	10.0	10.9	5.9	117%
	HFC	Mobile air conditioning	6.4	6.9	8.3	0.6	0.6	0.6	-5.8	-91%
	HFC	Aerosols	7.8	8.0	8.8	9.7	10.6	11.5	3.8	49%
	HFC	Foams	4.4	4.9	5.0	5.2	5.2	5.2	0.8	19%
	HFC	Other HFC	0.6	1.8	1.8	1.8	1.8	1.8	1.2	207%
	PFC	Primary aluminium production (ETS)	3.4	3.3	3.3	3.5	3.6	3.8	0.4	12%
	PFC	Semiconductor industry	1.8	1.8	1.8	2.0	2.1	2.3	0.4	24%
	SF6	High and mid voltage switches	2.6	1.2	0.6	0.6	0.7	0.7	-1.9	-73%
	SF6	Magnesium production and casting	1.5	0.1	0.1	0.1	0.1	0.1	-1.4	-92%
	SF6	Soundproof windows	1.8	2.4	2.5	2.5	2.5	0.0	-1.8	-100%
	SF6	Other SF6	1.3	0.1	0.1	0.1	0.1	0.1	-1.2	-91%
	SF6	Other F-gas sources	1.1	1.3	1.3	1.3	1.3	1.3	0.2	19%
Sum CH_4			**422**	**362**	**344**	**334**	**324**	**316**	**-105**	**-25%**
Sum N_2O			**385**	**380**	**358**	**354**	**353**	**350**	**-35**	**-9%**
Sum F-gases			**72**	**73**	**81**	**79**	**85**	**89**	**17**	**24%**
Sum ETS			**59**	**38**	**18**	**15**	**15**	**15**	**-43**	**-74%**
Sum non-ETS			**820**	**778**	**765**	**751**	**747**	**740**	**-80**	**-10%**
Agriculture			**471**	**475**	**469**	**464**	**462**	**460**	**-11**	**-2%**
Energy			**137**	**141**	**137**	**132**	**126**	**120**	**-17**	**-12%**
Industrial processes (non-ETS sectors)			**11**	**5**	**4**	**4**	**4**	**4**	**-7**	**-60%**
Industrial processes (ETS sectors)			**59**	**38**	**18**	**15**	**15**	**15**	**-43**	**-74%**
Waste&wastewater			**147**	**95**	**85**	**83**	**80**	**77**	**-69**	**-47%**
AC&refrigeration			**40**	**46**	**54**	**51**	**56**	**61**	**20**	**49%**
Other			**14**	**16**	**17**	**18**	**19**	**17**	**4**	**26%**
Sum non-CO_2 GHG			**879**	**815**	**783**	**766**	**762**	**755**	**-123**	**-14%**

Table 3: Baseline emissions of non-CO_2 GHG 2005-2030 by country

	BL 2005	**BL 2010**		**BL 2015**		**BL 2020**		**BL 2025**		**BL 2030**	
	Mt CO_2eq	Mt CO_2eq	Change to 2005	Mt CO_2eq	Change to 2005	Mt CO_2eq	Change to 2005	Mt CO_2eq	Change to 2005	Mt CO_2eq	Change to 2005
Austria	14.0	13.5	-4%	13.3	-5%	13.4	-5%	13.4	-5%	13.2	-6%
Belgium	18.3	18.8	3%	17.0	-7%	17.1	-6%	17.1	-6%	17.3	-5%
Bulgaria	16.8	15.8	-6%	13.9	-17%	13.5	-20%	13.3	-21%	13.4	-20%
Cyprus	1.7	1.6	-8%	1.7	-3%	1.6	-5%	1.8	4%	1.9	10%
Czech Rep.	19.7	19.0	-3%	17.7	-10%	16.9	-14%	16.6	-16%	16.5	-16%
Denmark	13.4	13.1	-2%	12.8	-4%	12.8	-4%	12.7	-5%	12.7	-5%
Estonia	2.8	2.5	-10%	2.5	-13%	2.5	-10%	2.5	-10%	2.5	-10%
Finland	12.3	12.1	-2%	10.7	-14%	10.6	-15%	10.3	-16%	10.2	-18%
France	134.7	129.3	-4%	123.2	-9%	119.7	-11%	120.3	-11%	120.2	-11%
Germany	116.2	107.0	-8%	102.3	-12%	97.9	-16%	96.0	-17%	91.3	-21%
Greece	23.5	18.7	-21%	18.5	-21%	18.7	-21%	18.7	-20%	18.8	-20%
Hungary	18.8	16.5	-12%	15.6	-17%	15.3	-18%	15.3	-18%	15.0	-20%
Ireland	22.6	22.0	-3%	22.0	-2%	21.8	-3%	22.3	-1%	22.2	-2%
Italy	83.5	73.7	-12%	72.2	-14%	71.2	-15%	70.6	-15%	69.8	-16%
Latvia	3.5	3.2	-9%	3.0	-13%	2.9	-17%	3.0	-14%	3.0	-15%
Lithuania	8.3	8.3	-1%	6.4	-23%	6.3	-25%	6.0	-28%	6.0	-28%
Luxembourg	1.1	1.1	0%	1.2	2%	1.1	1%	1.1	0%	1.1	0%
Malta	0.3	0.3	-13%	0.3	-14%	0.2	-24%	0.3	-18%	0.2	-22%
Netherlands	37.0	29.9	-19%	30.3	-18%	30.3	-18%	30.4	-18%	30.7	-17%
Poland	67.2	65.6	-2%	62.6	-7%	61.8	-8%	62.0	-8%	60.5	-10%
Portugal	19.7	16.0	-19%	16.0	-19%	15.6	-21%	15.8	-20%	15.7	-20%
Romania	43.9	40.9	-7%	39.1	-11%	37.8	-14%	36.2	-18%	36.8	-16%
Slovak Rep.	8.6	8.0	-7%	6.7	-22%	6.9	-21%	7.1	-18%	7.0	-19%
Slovenia	3.7	3.5	-5%	3.5	-4%	3.4	-7%	3.2	-13%	3.1	-15%
Spain	73.4	71.4	-3%	72.0	-2%	73.4	0%	73.7	0%	74.9	2%
Sweden	14.4	13.8	-4%	13.2	-8%	13.2	-8%	13.2	-8%	13.3	-7%
UK	99.1	89.9	-9%	85.3	-14%	80.2	-19%	79.4	-20%	78.1	-21%
EU-27	879	815	-7%	783	-11%	766	-13%	762	-13%	755	-14%

4 Potentials and costs for non-CO_2 GHG mitigation

Mitigation options for non-CO_2 GHG emissions that are considered in the GAINS model as technically feasible up to 2030 are described in detail in the methodology report (Höglund-Isaksson et al., 2010). For the baseline projection of activity data, full application of these measures in EU-27 would reduce non-CO_2 GHG emissions in non-ETS sectors by 40 and 41 percent, respectively in 2020 and 2030, below the 2005 emission level (Table 4 and Figure 6). About one fifth of the additional mitigation potential in non-ETS sectors would be available at marginal costs below 10 Euro/t CO_2eq. At a marginal cost below 30 Euro/t CO_2eq, the mitigation potential is 21 and 22 percent, respectively in 2020 and 2030, and expected to come at an annual total cost[5] of 519 and 540 million Euro, respectively (Table 4). The additional mitigation potentials in non-ETS sectors for individual Member States are presented in Table I in the Appendix. The most important mitigation options for non-ETS sectors below 30 Euro/t CO_2eq include reduction of N_2O emissions through combustion modification in fluidized bed combustion with coal as fuel (-26 Mt CO_2eq in 2030), reduced leakage of CH_4 from compressor stations in long-distance gas pipelines (-17 Mt CO_2eq in 2030), reduction of CH_4 emissions from manure through extended installation of farm-scale anaerobic digestion plants for pigs with liquid manure management (-17 Mt CO_2eq in 2030), and N_2O emission reductions through reduced application of fertilizers on agricultural lands and grasslands (-14 Mt CO_2eq in 2030). All mitigation potentials for EU-27 in 2030 are presented in Table III in the Appendix.

For the ETS sectors, extensive emission reductions of about 75 percent below the 2005 baseline are expected to be adopted already in the baseline (Table 5). This is because most mitigation options come at a lower marginal cost than the expected equilibrium carbon price in the ETS market. The additional mitigation options in the ETS sectors are two different technology conversions in primary aluminum production, estimated available at an average marginal cost of 60 and 87 Euro/t CO_2eq, respectively (Table II in Appendix). The additional mitigation potential from these options are very small, 2.2 Mt CO_2eq. Thus, 99 percent of the total additional mitigation potential for non-CO_2 GHGs in 2030 can be found in non-ETS sectors and only one percent in ETS sectors (Figure 6).

As shown in Figure 7, major reductions in CH_4 and N_2O emissions take place at a marginal cost below 30 Euro/t CO_2eq. Potentials for reducing F-gas emissions come primarily at a marginal cost exceeding 30 Euro/t CO_2eq.

Figure 8 illustrates the mitigation potentials in different sectors for increasing marginal mitigation cost levels in 2030. At marginal costs below 30 Euro/t CO_2eq the mitigation potentials is largest in the energy sector. Mitigation options in the agricultural sector come primarily at a cost exceeding 30 Euro/t CO_2eq and the same is true for extended reductions in F-gas emissions from cooling and refrigeration.

[5] Total annual cost is here calculated assuming that any negative costs resulting from adding up investment costs, A&M costs and cost-savings, e.g., in terms of recovered CH_4 utilized for energy purposes, are reflections of unaccounted costs and have been set to zero.

Table 4: Reduction potentials and costs for non-CO_2 GHGs in non-ETS sectors in 2020 and 2030, EU-27 aggregated

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative) million €/year
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	
EU-27 2005	**Baseline**	**819745**									
EU-27 2020	**Baseline**	**751365**	**-8%**		**463520**	**132329**	**3810**	**82747**	**51092**	**17867**	
	10	660523	-19%	-90841	-21096	-52592	0	-13284	-1511	-2358	242
	20	649902	-21%	-101463	-30153	-54158	0	-13284	-1511	-2358	375
	30	644540	-21%	-106825	-32376	-54193	-1823	-14498	-1576	-2358	519
	40	632611	-23%	-118754	-44117	-54382	-1823	-14498	-1576	-2358	946
	50	620373	-24%	-130991	-46588	-56001	-1823	-14498	-9724	-2358	1470
	70	615475	-25%	-135890	-47769	-57410	-1823	-14498	-12032	-2358	1775
	100	564564	-31%	-186801	-77511	-59003	-1823	-14498	-31607	-2358	5925
	200	547769	-33%	-203596	-90766	-61795	-1927	-15075	-31674	-2358	8409
	Max	494048	-40%	-257317	-115884	-65892	-1927	-23503	-39762	-10348	26779
EU-27 2030	**Baseline**	**739889**	**-10%**		**460216**	**119899**	**4398**	**77455**	**60516**	**17405**	
	10	652802	-20%	-87087	-21175	-47275	0	-13902	-1616	-3119	234
	20	642304	-22%	-97586	-30375	-48574	0	-13902	-1616	-3119	366
	30	635910	-22%	-103979	-32533	-48595	-2107	-15275	-2351	-3119	540
	40	623822	-24%	-116068	-44455	-48761	-2107	-15275	-2351	-3119	973
	50	610282	-26%	-129608	-46880	-50377	-2107	-15275	-11849	-3119	1548
	70	604074	-26%	-135815	-48042	-51724	-2107	-15275	-15548	-3119	1929
	100	549536	-33%	-190354	-77834	-52956	-2107	-15275	-39062	-3119	6384
	200	533083	-35%	-206807	-91113	-55180	-2220	-15336	-39839	-3119	8816
	Max	480353	-41%	-259536	-116147	-57908	-2220	-22488	-49568	-11204	26587

Table 5: Reduction potentials and costs for non-CO_2 GHGs in ETS sectors in 2020 and 2030, EU-27 aggregated

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO2 GHG emissions in ETS sectors (cumulative)	Total cost (cumu-lative) million €/year
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	
EU-27 2005	**Baseline**	**58793**			
EU-27 2020	**Baseline**	**14708**	**-75%**		
	50	14708	-75%	0	0
	70	13267	-77%	-1440	86
	100	12655	-78%	-2053	140
EU-27 2030	**Baseline**	**15498**	**-74%**		
	50	15498	-74%	0	0
	70	13953	-76%	-1544	92
	100	13280	-77%	-2217	151

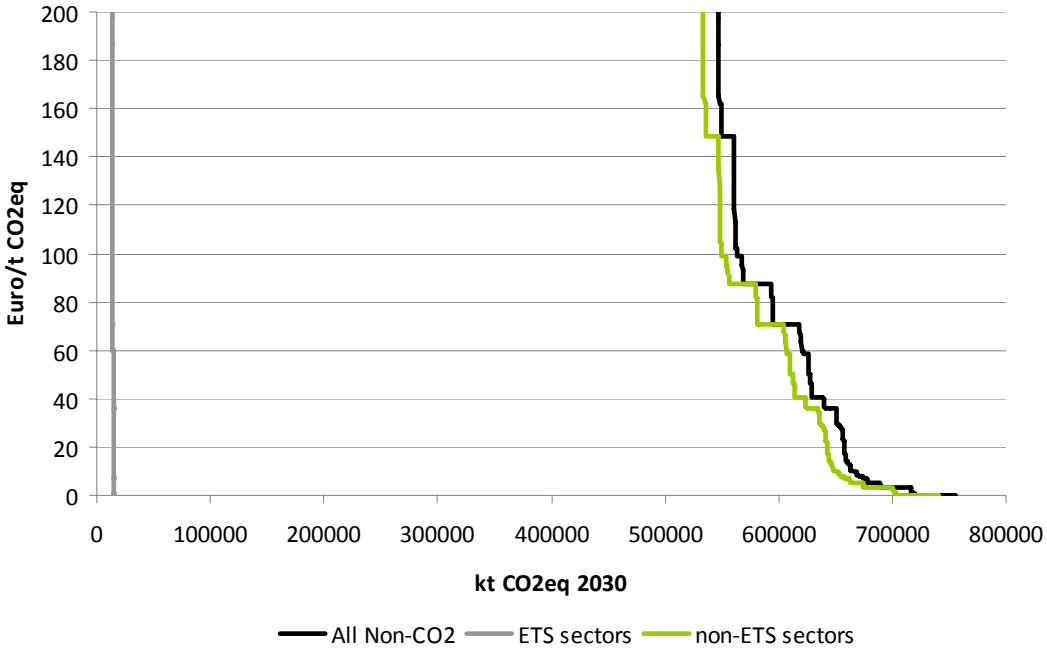

Figure 6: Marginal mitigation cost curve for non-CO_2 GHG in EU-27 2030, in total and split by ETS and non-ETS sectors.

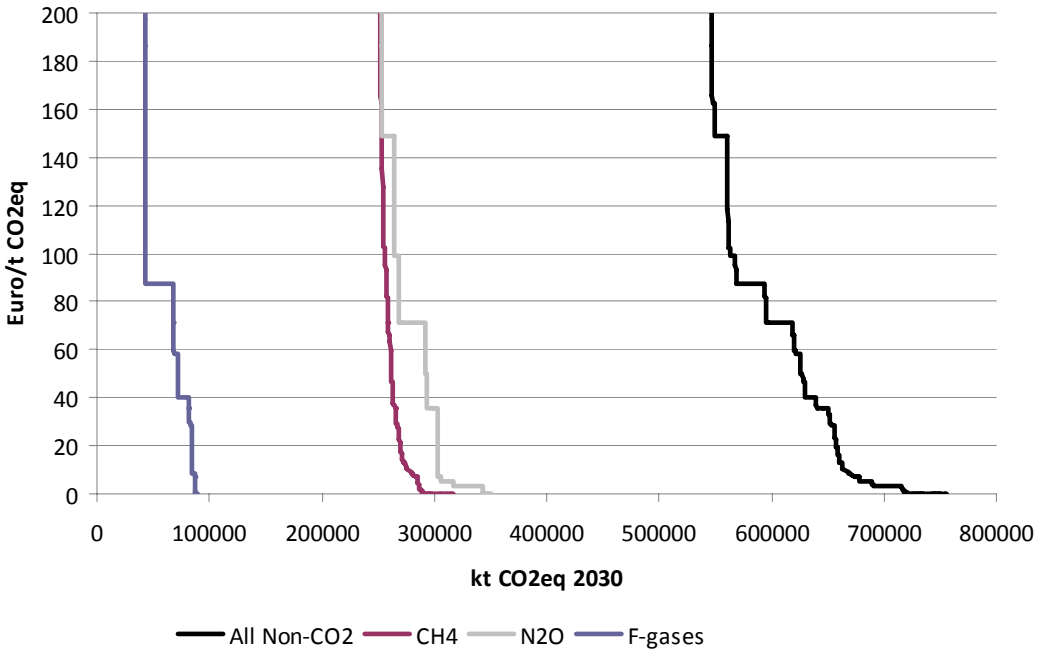

Figure 7: Marginal mitigation cost curve for non-CO_2 GHG in EU-27 2030, in total and split by greenhouse gas.

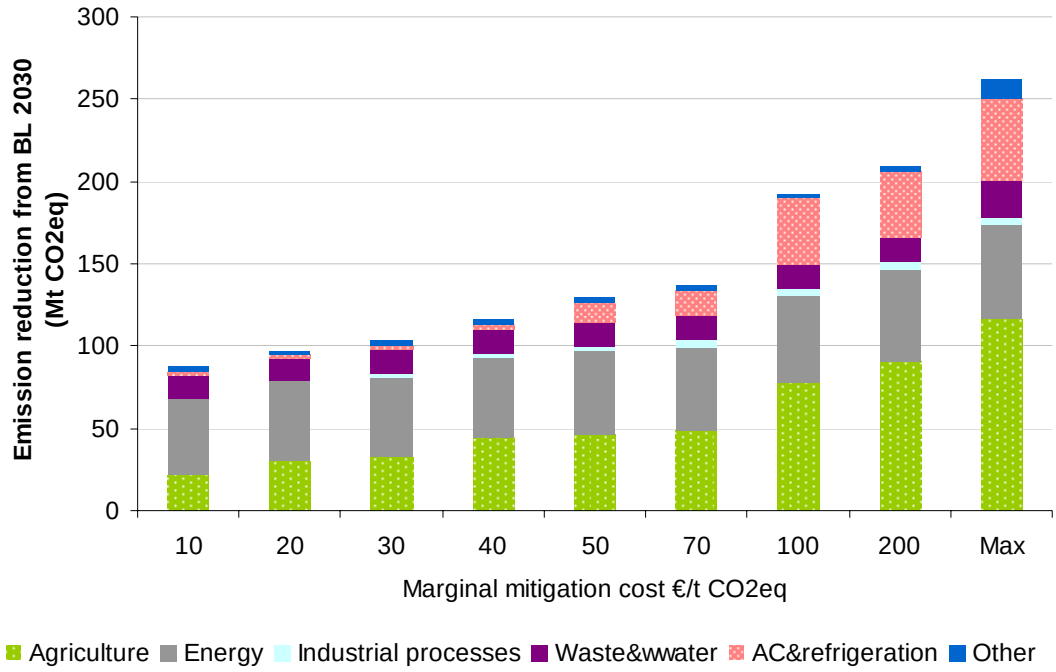

Figure 8: EU-27 mitigation potential for non-CO_2 GHGs (ETS and non-ETS sectors) in 2030 by sector and increasing marginal cost.

5 Conclusions

This report presents estimates of baseline emissions of non-CO_2 greenhouse gases (GHGs) in the EU-27, the available potential for further mitigation, and associated costs. The study employs the GAINS model for estimating baseline emissions, mitigation potentials and costs, and the projections of baseline activity data of the PRIMES energy and CAPRI agricultural models.

Baseline emissions have been estimated in an iterative, step-wise procedure. First, a set of initial emission estimates for 2005 were compared to emissions reported by countries to the UNFCCC. By scrutinizing the reasons behind differences in GAINS estimates and reported emissions, it was possible to substantially improve the GAINS estimates. Second, a review process was organized by the European Commission, DG Environment, during which Member States were given the opportunity to comment on a set of draft emission estimates and projections on important drivers. Comments and subsequent discussions with Member State experts made it possible to incorporate a lot of country-specific information that is not documented in other international sources. Any remaining differences between GAINS and national estimates for non-CO_2 GHG can primarily be referred to the requirement that GAINS and its collaborating models CAPRI and PRIMES need to maintain international consistency in order to enable comparability of mitigation potentials and costs.

Based on the most recent projections of population and economic development, baseline emissions of non-CO_2 GHGs are estimated to decline by 13 percent between 2005 and 2020, whereof the reduction in non-ETS sectors is estimated at eight percent and in ETS sectors at 75 percent. The latter reduction is a result of including adipic and nitric acid production in the EU-ETS system. The reduction in non-ETS sectors is primarily a consequence of full implementation of the EU Landfill Directive, a decline in the number of dairy cows and non-dairy cattle following productivity increases, and a decline in coal mining. Additional mitigation measures below 30 Euro/t CO_2eq in 2020 are only found available in the non-ETS sectors. These account for a total reduction of 107 Mt CO_2eq or 21 percent below emissions from these sectors in 2005 and are expected at a total annual cost of 519 million Euro for EU-27. The most important low-cost options include reduced leakage of CH_4 from compressor stations in long-distance gas pipelines, reduced emissions of N_2O through modifications in fluidized bed combustion when burning coal, reduced N_2O emissions from soils due to reduced fertilizer application, and reduced CH_4 emissions from manure handling through extended use of farm-scale anaerobic digesters for pigs with liquid manure management.

When focussing on the changes between 2005 and 2030 (instead of 2020), baseline emissions of non-CO_2 GHGs are estimated to decline by 14 percent. Again, primary reasons are the full implementation of the EU Landfill Directive, mitigation measures in the adipic and nitric acid production, the declining number of dairy cows and non-dairy cattle following productivity increases in agriculture, and a decline in coal mining. The analysis suggests that non-CO_2 GHG emissions from non-ETS sectors by 2030 can be reduced by up to 41 percent below the 2005 level through full application of currently available technical mitigation measures. The respective mitigation options and sectors dominating the mitigation potential in different countries are highly country-specific and depend on a combination of factors, such as the relative importance of different sectors to overall emissions and the combination of fuel types used. At an aggregate EU-27 level, the additional technical mitigation potential is highest in

the agricultural sector. However, most of the measures that could be implemented at low costs are available in the energy sector. Reducing non-CO_2 GHG emissions in non-ETS sectors in 2030 by 25 percent from the 2005 emission level, is expected to be attainable at a marginal cost not exceeding 50 Euro/t CO_2eq or a total annual cost of 1.5 billion Euro.

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Appendix

Table I: Reduction potentials and costs for non-CO_2 GHGs in non-ETS sectors, by country

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduction relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumulative)
				Total	whereof Agriculture	whereof Energy	whereof Industry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Austria 2005	**Baseline**	**13746**									
Austria 2020	**Baseline**	**13141**	**-4%**								
	10	11890	-14%	-1252	-308	-629	0	-272	-42	0	2
	20	11886	-14%	-1255	-308	-632	0	-272	-42	0	2
	30	11852	-14%	-1290	-308	-632	-5	-300	-44	0	3
	40	11683	-15%	-1459	-478	-632	-5	-300	-44	0	9
	50	11500	-16%	-1641	-478	-632	-5	-300	-227	0	17
	70	11451	-17%	-1690	-478	-632	-5	-300	-275	0	20
	100	10579	-23%	-2562	-960	-632	-5	-300	-666	0	89
	200	10541	-23%	-2600	-996	-632	-5	-300	-667	0	93
	Max	9801	-29%	-3341	-1337	-704	-5	-373	-786	-136	355
Austria 2030	**Baseline**	**12976**	**-6%**								
	10	11666	-15%	-1310	-316	-577	0	-304	-45	-68	3
	20	11663	-15%	-1313	-316	-580	0	-304	-45	-68	3
	30	11607	-16%	-1368	-316	-580	-6	-336	-62	-68	4
	40	11430	-17%	-1546	-494	-580	-6	-336	-62	-68	11
	50	11216	-18%	-1760	-494	-580	-6	-336	-276	-68	19
	70	11139	-19%	-1836	-494	-580	-6	-336	-353	-68	24
	100	10186	-26%	-2790	-987	-580	-6	-336	-812	-68	100
	200	10138	-26%	-2838	-1024	-580	-6	-336	-824	-68	106
	Max	9414	-32%	-3562	-1380	-616	-6	-388	-964	-207	359
Belgium 2005	**Baseline**	**15219**									
Belgium 2020	**Baseline**	**15884**	**4%**								
	10	15003	-1%	-881	-347	-201	0	-230	-72	-31	2
	20	14174	-7%	-1710	-1164	-214	0	-230	-72	-31	14
	30	14093	-7%	-1792	-1164	-214	-4	-305	-74	-31	16
	40	13875	-9%	-2009	-1382	-214	-4	-305	-74	-31	24
	50	13666	-10%	-2218	-1382	-214	-4	-305	-282	-31	32
	70	13609	-11%	-2275	-1382	-214	-4	-305	-340	-31	36
	100	12627	-17%	-3257	-1904	-214	-4	-305	-799	-31	113
	200	12534	-18%	-3350	-1996	-214	-4	-305	-801	-31	123
	Max	11452	-25%	-4432	-2521	-335	-4	-423	-942	-207	555
Belgium 2030	**Baseline**	**16066**	**6%**								
	10	15086	-1%	-980	-348	-249	0	-258	-75	-50	2
	20	14231	-6%	-1835	-1191	-261	0	-258	-75	-50	14
	30	14112	-7%	-1954	-1191	-261	-4	-354	-94	-50	18
	40	13895	-9%	-2171	-1408	-261	-4	-354	-94	-50	25
	50	13655	-10%	-2411	-1408	-261	-4	-354	-334	-50	35
	70	13564	-11%	-2502	-1408	-261	-4	-354	-426	-50	41
	100	12493	-18%	-3573	-1928	-261	-4	-354	-976	-50	126
	200	12342	-19%	-3724	-2066	-261	-4	-354	-989	-50	147
	Max	11315	-26%	-4751	-2542	-337	-4	-480	-1156	-233	573
Bulgaria 2005	**Baseline**	**15881**									
Bulgaria 2020	**Baseline**	**13327**	**-16%**								
	10	11571	-27%	-1756	-194	-1144	0	-333	-16	-69	4
	20	10891	-31%	-2436	-234	-1783	0	-333	-16	-69	12
	30	10878	-32%	-2449	-244	-1786	0	-333	-17	-69	13
	40	10708	-33%	-2619	-414	-1786	0	-333	-17	-69	19
	50	10579	-33%	-2748	-414	-1871	0	-333	-61	-69	24
	70	10570	-33%	-2757	-419	-1871	0	-333	-65	-69	25
	100	10180	-36%	-3147	-780	-1871	0	-333	-94	-69	53
	200	10180	-36%	-3147	-780	-1871	0	-333	-94	-69	53
	Max	9295	-41%	-4032	-1069	-1950	0	-728	-103	-181	339
Bulgaria 2030	**Baseline**	**13216**	**-17%**								
	10	11499	-28%	-1717	-214	-1008	0	-411	-17	-67	3
	20	10998	-31%	-2218	-265	-1458	0	-411	-17	-67	9
	30	10980	-31%	-2236	-274	-1462	0	-411	-21	-67	10
	40	10794	-32%	-2422	-460	-1462	0	-411	-21	-67	17
	50	10646	-33%	-2570	-460	-1553	0	-411	-78	-67	23
	70	10634	-33%	-2582	-465	-1553	0	-411	-84	-67	24
	100	10192	-36%	-3024	-869	-1553	0	-411	-123	-67	56
	200	10191	-36%	-3025	-869	-1553	0	-411	-124	-67	56
	Max	9320	-41%	-3896	-1193	-1639	0	-757	-135	-172	327

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Cyprus 2005	**Baseline**	**1720**									
Cyprus 2020	**Baseline**	**1633**	**-5%**								
	10	1362	-21%	-271	-64	0	0	-191	-10	-7	0
	20	1325	-23%	-308	-101	0	0	-191	-10	-7	1
	30	1325	-23%	-308	-101	0	0	-191	-10	-7	1
	40	1308	-24%	-325	-118	0	0	-191	-10	-7	1
	50	1292	-25%	-341	-118	-12	0	-191	-14	-7	2
	70	1289	-25%	-344	-118	-12	0	-191	-17	-7	2
	100	1224	-29%	-409	-163	-12	0	-191	-36	-7	7
	200	1222	-29%	-411	-165	-12	0	-191	-36	-7	8
	Max	1145	-33%	-489	-199	-24	0	-202	-42	-21	35
Cyprus 2030	**Baseline**	**1892**	**10%**								
	10	1541	-10%	-351	-72	0	0	-263	-10	-7	0
	20	1495	-13%	-397	-118	0	0	-263	-10	-7	1
	30	1495	-13%	-398	-118	0	0	-263	-10	-7	1
	40	1475	-14%	-417	-137	0	0	-263	-10	-7	2
	50	1455	-15%	-438	-137	-15	0	-263	-16	-7	3
	70	1450	-16%	-442	-137	-15	0	-263	-21	-7	3
	100	1370	-20%	-523	-190	-15	0	-263	-49	-7	9
	200	1367	-21%	-526	-192	-15	0	-263	-50	-7	9
	Max	1280	-26%	-612	-232	-28	0	-271	-58	-23	40
Czech R. 2005	**Baseline**	**18726**									
Czech R. 2020	**Baseline**	**16656**	**-11%**								
	10	13783	-26%	-2873	-364	-2067	0	-367	-25	-50	8
	20	13777	-26%	-2879	-364	-2073	0	-367	-25	-50	8
	30	13716	-27%	-2940	-403	-2073	-21	-367	-26	-50	9
	40	13168	-30%	-3487	-790	-2234	-21	-367	-26	-50	29
	50	13108	-30%	-3547	-790	-2234	-21	-367	-86	-50	32
	70	11684	-38%	-4972	-790	-3643	-21	-367	-101	-50	127
	100	10815	-42%	-5840	-1530	-3643	-21	-367	-229	-50	191
	200	10757	-43%	-5899	-1530	-3701	-21	-367	-229	-50	202
	Max	9777	-48%	-6879	-2124	-3756	-21	-497	-267	-214	561
Czech R. 2030	**Baseline**	**16263**	**-13%**								
	10	13711	-27%	-2551	-385	-1851	0	-235	-26	-55	7
	20	13705	-27%	-2557	-385	-1857	0	-235	-26	-55	7
	30	13639	-27%	-2623	-421	-1857	-24	-235	-31	-55	9
	40	13109	-30%	-3153	-807	-2000	-24	-235	-31	-55	28
	50	13040	-30%	-3223	-807	-2000	-24	-235	-100	-55	31
	70	11669	-38%	-4594	-807	-3347	-24	-235	-125	-55	123
	100	10735	-43%	-5527	-1585	-3347	-24	-235	-281	-55	192
	200	10677	-43%	-5586	-1585	-3401	-24	-235	-285	-55	203
	Max	9591	-49%	-6671	-2213	-3453	-24	-434	-330	-217	594
Denmark 2005	**Baseline**	**13384**									
Denmark 2020	**Baseline**	**12818**	**-4%**								
	10	11537	-14%	-1281	-471	-425	0	-339	-25	-21	3
	20	11534	-14%	-1284	-471	-428	0	-339	-25	-21	4
	30	11036	-18%	-1782	-944	-434	-18	-339	-26	-21	17
	40	10724	-20%	-2093	-1228	-462	-18	-339	-26	-21	28
	50	10631	-21%	-2186	-1228	-462	-18	-339	-119	-21	32
	70	10592	-21%	-2225	-1228	-462	-18	-339	-158	-21	34
	100	9599	-28%	-3219	-1908	-462	-18	-339	-470	-21	110
	200	9440	-29%	-3378	-2066	-462	-18	-339	-471	-21	130
	Max	8586	-36%	-4231	-2696	-462	-18	-380	-567	-109	399
Denmark 2030	**Baseline**	**12707**	**-5%**								
	10	11440	-15%	-1267	-468	-380	0	-358	-27	-34	3
	20	11437	-15%	-1269	-468	-383	0	-358	-27	-34	3
	30	10920	-18%	-1787	-952	-386	-21	-358	-35	-34	18
	40	10610	-21%	-2097	-1241	-408	-21	-358	-35	-34	29
	50	10501	-22%	-2206	-1241	-408	-21	-358	-144	-34	33
	70	10439	-22%	-2267	-1241	-408	-21	-358	-205	-34	37
	100	9376	-30%	-3330	-1933	-408	-21	-358	-576	-34	118
	200	9223	-31%	-3483	-2077	-408	-21	-358	-585	-34	137
	Max	8345	-38%	-4362	-2707	-408	-21	-403	-698	-124	411

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduction relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumulative)
				Total	whereof Agriculture	whereof Energy	whereof Industry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Estonia 2005	**Baseline**	**2830**									
Estonia 2020	**Baseline**	**2548**	**-10%**								
	10	1743	-38%	-805	-48	-646	0	-93	-2	-15	1
	30	1731	-39%	-817	-60	-646	0	-93	-2	-15	2
	40	1699	-40%	-849	-93	-646	0	-93	-2	-15	3
	50	1624	-43%	-924	-104	-671	0	-93	-41	-15	6
	70	1613	-43%	-936	-104	-671	0	-93	-52	-15	7
	100	1442	-49%	-1107	-183	-671	0	-93	-144	-15	20
	200	1437	-49%	-1112	-187	-671	0	-93	-144	-15	21
	Max	1243	-56%	-1305	-255	-695	0	-172	-148	-36	79
Estonia 2030	**Baseline**	**2550**	**-10%**								
	10	1769	-38%	-781	-48	-620	0	-95	-2	-16	1
	30	1755	-38%	-795	-59	-620	0	-95	-4	-16	2
	40	1723	-39%	-827	-92	-620	0	-95	-4	-16	3
	50	1644	-42%	-906	-105	-646	0	-95	-43	-16	6
	70	1625	-43%	-925	-105	-646	0	-95	-62	-16	7
	100	1427	-50%	-1123	-184	-646	0	-95	-182	-16	24
	200	1423	-50%	-1127	-188	-646	0	-95	-182	-16	24
	Max	1231	-57%	-1319	-255	-671	0	-171	-187	-35	80
Finland 2005	**Baseline**	**11313**									
Finland 2020	**Baseline**	**10342**	**-9%**								
	10	8601	-24%	-1741	-205	-1269	0	-237	-13	-16	5
	20	8597	-24%	-1744	-205	-1273	0	-237	-13	-16	5
	30	8563	-24%	-1779	-205	-1273	-28	-242	-14	-16	6
	40	8423	-26%	-1918	-345	-1273	-28	-242	-14	-16	11
	50	8322	-26%	-2020	-345	-1273	-28	-242	-116	-16	15
	70	8281	-27%	-2060	-345	-1273	-28	-242	-157	-16	18
	100	7573	-33%	-2769	-725	-1273	-28	-242	-484	-16	74
	200	7280	-36%	-3062	-1018	-1273	-28	-242	-485	-16	118
	Max	6668	-41%	-3674	-1297	-1305	-28	-373	-569	-101	344
Finland 2030	**Baseline**	**9955**	**-12%**								
	10	8315	-27%	-1641	-193	-1162	0	-245	-15	-26	5
	20	8311	-27%	-1644	-193	-1165	0	-245	-15	-26	5
	30	8262	-27%	-1694	-193	-1165	-32	-251	-26	-26	6
	40	8127	-28%	-1828	-327	-1165	-32	-251	-26	-26	11
	50	8014	-29%	-1941	-327	-1165	-32	-251	-140	-26	16
	70	7949	-30%	-2006	-327	-1165	-32	-251	-204	-26	20
	100	7195	-36%	-2761	-692	-1165	-32	-251	-594	-26	80
	200	6895	-39%	-3061	-985	-1165	-32	-251	-602	-26	125
	Max	6359	-44%	-3596	-1255	-1182	-32	-317	-699	-112	314
France 2005	**Baseline**	**127664**									
France 2020	**Baseline**	**117544**	**-8%**								
	10	109226	-14%	-8318	-6324	-76	0	-1556	-187	-175	39
	20	109197	-14%	-8347	-6324	-105	0	-1556	-187	-175	40
	30	108417	-15%	-9127	-6324	-105	-596	-1733	-195	-175	62
	40	106095	-17%	-11450	-8646	-105	-596	-1733	-195	-175	145
	50	105131	-18%	-12413	-8646	-105	-596	-1733	-1159	-175	184
	70	103846	-19%	-13698	-9588	-105	-596	-1733	-1502	-175	264
	100	95303	-25%	-22242	-15082	-105	-596	-1733	-4551	-175	921
	200	95128	-25%	-22416	-15250	-105	-596	-1733	-4558	-175	951
	Max	87738	-31%	-29806	-20273	-165	-596	-2199	-5379	-1195	3229
France 2030	**Baseline**	**117929**	**-8%**								
	10	109358	-14%	-8571	-6340	-41	0	-1700	-207	-284	41
	20	109330	-14%	-8599	-6340	-69	0	-1700	-207	-284	41
	30	108327	-15%	-9601	-6340	-69	-708	-1904	-298	-284	70
	40	106045	-17%	-11884	-8623	-69	-708	-1904	-298	-284	152
	50	104900	-18%	-13029	-8623	-69	-708	-1904	-1443	-284	198
	70	103404	-19%	-14525	-9569	-69	-708	-1904	-1991	-284	290
	100	94344	-26%	-23584	-14968	-69	-708	-1904	-5653	-284	994
	200	94104	-26%	-23825	-15130	-69	-708	-1904	-5731	-284	1033
	Max	86684	-32%	-31245	-20076	-97	-708	-2317	-6707	-1341	3291

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Germany 2005	**Baseline**	**103055**									
Germany 2020	**Baseline**	**94938**	**-8%**								
	10	79439	-23%	-15499	-1918	-12194	0	-1036	-268	-83	40
	20	79398	-23%	-15540	-1918	-12235	0	-1036	-268	-83	41
	30	78669	-24%	-16269	-1918	-12235	-713	-1036	-284	-83	62
	40	77367	-25%	-17571	-3221	-12235	-713	-1036	-284	-83	109
	50	73646	-29%	-21292	-4571	-12445	-713	-1036	-2445	-83	272
	70	73137	-29%	-21801	-4571	-12445	-713	-1036	-2954	-83	302
	100	65037	-37%	-29901	-8176	-12445	-713	-1036	-7448	-83	1049
	200	60174	-42%	-34764	-12924	-12445	-816	-1036	-7460	-83	1768
	Max	53489	-48%	-41449	-16200	-13110	-816	-1054	-8919	-1350	4269
Germany 2030	**Baseline**	**88407**	**-14%**								
	10	73934	-28%	-14474	-1813	-11207	0	-1019	-296	-139	39
	20	73898	-28%	-14509	-1813	-11242	0	-1019	-296	-139	40
	30	72953	-29%	-15454	-1813	-11242	-777	-1019	-464	-139	67
	40	71525	-31%	-16882	-3241	-11242	-777	-1019	-464	-139	119
	50	67641	-34%	-20767	-4534	-11479	-777	-1019	-2819	-139	288
	70	66884	-35%	-21523	-4534	-11479	-777	-1019	-3575	-139	332
	100	58480	-43%	-29927	-7930	-11479	-777	-1019	-8584	-139	1104
	200	53495	-48%	-34913	-12678	-11479	-890	-1019	-8709	-139	1842
	Max	47212	-54%	-41195	-15748	-11812	-890	-1040	-10321	-1385	4217
Greece 2005	**Baseline**	**22995**									
Greece 2020	**Baseline**	**18494**	**-20%**								
	10	16182	-30%	-2312	-376	-1448	0	-348	-30	-109	7
	20	15623	-32%	-2871	-439	-1945	0	-348	-30	-109	18
	30	15579	-32%	-2915	-439	-1945	-31	-361	-31	-109	19
	40	15316	-33%	-3178	-702	-1945	-31	-361	-31	-109	28
	50	15259	-34%	-3234	-702	-1945	-31	-361	-87	-109	30
	70	15229	-34%	-3265	-702	-1945	-31	-361	-118	-109	32
	100	14409	-37%	-4085	-1276	-1945	-31	-361	-364	-109	95
	200	14341	-38%	-4153	-1309	-1945	-31	-388	-371	-109	104
	Max	12069	-48%	-6425	-1780	-1981	-31	-1029	-1316	-289	816
Greece 2030	**Baseline**	**18623**	**-19%**								
	10	16433	-29%	-2190	-392	-1419	0	-228	-32	-119	7
	20	15895	-31%	-2728	-450	-1899	0	-228	-32	-119	17
	30	15844	-31%	-2779	-450	-1899	-36	-238	-37	-119	19
	40	15566	-32%	-3057	-728	-1899	-36	-238	-37	-119	28
	50	15501	-33%	-3122	-728	-1899	-36	-238	-102	-119	31
	70	15451	-33%	-3173	-728	-1899	-36	-238	-153	-119	34
	100	14537	-37%	-4086	-1339	-1899	-36	-238	-456	-119	104
	200	14389	-37%	-4234	-1372	-1899	-36	-270	-539	-119	126
	Max	12013	-48%	-6610	-1871	-1921	-36	-800	-1683	-299	841
Hungary 2005	**Baseline**	**17742**									
Hungary 2020	**Baseline**	**15007**	**-15%**								
	10	13377	-25%	-1630	-417	-741	0	-322	-25	-125	4
	20	12988	-27%	-2020	-803	-745	0	-322	-25	-125	8
	30	12982	-27%	-2025	-808	-745	0	-322	-25	-125	9
	40	12653	-29%	-2354	-1137	-745	0	-322	-25	-125	20
	50	12254	-31%	-2754	-1137	-1086	0	-322	-84	-125	39
	70	12237	-31%	-2771	-1140	-1086	0	-322	-98	-125	40
	100	11319	-36%	-3689	-1942	-1086	0	-322	-214	-125	107
	200	11312	-36%	-3695	-1944	-1090	0	-322	-214	-125	108
	Max	10060	-43%	-4947	-2604	-1410	0	-406	-249	-279	492
Hungary 2030	**Baseline**	**14709**	**-17%**								
	10	13197	-26%	-1512	-449	-685	0	-225	-25	-128	4
	20	12872	-27%	-1836	-769	-689	0	-225	-25	-128	8
	30	12863	-28%	-1846	-774	-689	0	-225	-30	-128	8
	40	12508	-30%	-2201	-1129	-689	0	-225	-30	-128	21
	50	12120	-32%	-2589	-1129	-1009	0	-225	-97	-128	38
	70	12094	-32%	-2615	-1132	-1009	0	-225	-121	-128	40
	100	11085	-38%	-3624	-1994	-1009	0	-225	-268	-128	114
	200	11075	-38%	-3633	-1996	-1012	0	-225	-272	-128	116
	Max	9815	-45%	-4894	-2707	-1313	0	-282	-314	-278	491

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Ireland 2005	**Baseline**	**22586**									
Ireland 2020	**Baseline**	**21850**	**-3%**								
	10	20643	-9%	-1207	-845	-190	0	-106	-54	-12	6
	20	20539	-9%	-1311	-948	-191	0	-106	-54	-12	8
	30	20488	-9%	-1362	-948	-191	-38	-118	-55	-12	9
	40	20066	-11%	-1784	-1370	-191	-38	-118	-55	-12	25
	50	19929	-12%	-1921	-1370	-191	-38	-118	-192	-12	30
	70	19906	-12%	-1944	-1370	-191	-38	-118	-215	-12	31
	100	18707	-17%	-3142	-2382	-191	-38	-118	-401	-12	120
	200	18469	-18%	-3381	-2620	-191	-38	-118	-402	-12	144
	Max	17319	-23%	-4531	-3552	-224	-38	-161	-459	-97	492
Ireland 2030	**Baseline**	**22184**	**-2%**								
	10	20975	-7%	-1208	-860	-177	0	-96	-55	-20	6
	20	20863	-8%	-1320	-971	-178	0	-96	-55	-20	8
	30	20791	-8%	-1393	-971	-178	-48	-106	-69	-20	10
	40	20365	-10%	-1819	-1397	-178	-48	-106	-69	-20	26
	50	20194	-11%	-1990	-1397	-178	-48	-106	-240	-20	32
	70	20153	-11%	-2031	-1397	-178	-48	-106	-281	-20	35
	100	18884	-16%	-3300	-2419	-178	-48	-106	-528	-20	129
	200	18647	-17%	-3536	-2649	-178	-48	-106	-534	-20	154
	Max	17505	-22%	-4679	-3586	-196	-48	-128	-608	-112	496
Italy 2005	**Baseline**	**75454**									
Italy 2020	**Baseline**	**70824**	**-6%**								
	10	63226	-16%	-7598	-1629	-4420	0	-1282	-120	-147	16
	20	62215	-18%	-8608	-2608	-4452	0	-1282	-120	-147	34
	30	61932	-18%	-8891	-2608	-4452	-180	-1376	-128	-147	42
	40	60664	-20%	-10159	-3876	-4452	-180	-1376	-128	-147	86
	50	59237	-21%	-11587	-4270	-4452	-180	-1376	-1161	-147	145
	70	58964	-22%	-11860	-4270	-4452	-180	-1376	-1434	-147	161
	100	54549	-28%	-16275	-6499	-4452	-180	-1376	-3621	-147	511
	200	53520	-29%	-17304	-7000	-4452	-180	-1899	-3627	-147	652
	Max	48202	-36%	-22622	-9026	-5031	-180	-2985	-4298	-1102	2579
Italy 2030	**Baseline**	**69360**	**-8%**								
	10	62308	-17%	-7052	-1619	-3688	0	-1375	-132	-238	15
	20	61297	-19%	-8063	-2600	-3717	0	-1375	-132	-238	32
	30	60862	-19%	-8498	-2600	-3717	-222	-1486	-234	-238	45
	40	59601	-21%	-9759	-3861	-3717	-222	-1486	-234	-238	89
	50	57930	-23%	-11430	-4255	-3717	-222	-1486	-1511	-238	158
	70	57499	-24%	-11861	-4255	-3717	-222	-1486	-1942	-238	183
	100	52699	-30%	-16661	-6467	-3717	-222	-1486	-4530	-238	567
	200	52136	-31%	-17224	-6967	-3717	-222	-1486	-4593	-238	637
	Max	47357	-37%	-22003	-8980	-3999	-222	-2219	-5382	-1200	2345
Latvia 2005	**Baseline**	**3484**									
Latvia 2020	**Baseline**	**2902**	**-17%**								
	10	2745	-21%	-157	-73	0	0	-57	-3	-24	0
	30	2731	-22%	-172	-87	0	0	-57	-3	-24	1
	40	2664	-24%	-239	-154	0	0	-57	-3	-24	3
	50	2559	-27%	-344	-154	-41	0	-57	-67	-24	8
	70	2557	-27%	-346	-154	-41	0	-57	-69	-24	8
	100	2410	-31%	-492	-284	-41	0	-57	-86	-24	19
	200	2134	-39%	-769	-554	-41	0	-64	-86	-24	60
	Max	1940	-44%	-963	-655	-79	0	-80	-91	-57	124
Latvia 2030	**Baseline**	**2959**	**-15%**								
	10	2792	-20%	-167	-80	-1	0	-60	-3	-24	0
	30	2774	-20%	-185	-93	-1	0	-60	-8	-24	1
	40	2702	-22%	-257	-165	-1	0	-60	-8	-24	3
	50	2591	-26%	-368	-165	-41	0	-60	-78	-24	8
	70	2588	-26%	-372	-165	-41	0	-60	-82	-24	8
	100	2422	-30%	-537	-310	-41	0	-60	-102	-24	21
	200	2144	-38%	-815	-580	-41	0	-67	-103	-24	62
	Max	1943	-44%	-1016	-693	-79	0	-80	-109	-55	126

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Lithuania 2005	**Baseline**	**6702**									
Lithuania 2020	**Baseline**	**5783**	**-14%**								
	10	5206	-22%	-577	-158	-81	0	-298	-4	-36	1
	20	5202	-22%	-581	-158	-85	0	-298	-4	-36	1
	30	5141	-23%	-642	-218	-85	0	-298	-5	-36	2
	40	4998	-25%	-785	-361	-85	0	-298	-5	-36	7
	50	4797	-28%	-986	-361	-187	0	-298	-103	-36	16
	70	4794	-28%	-989	-361	-187	0	-298	-106	-36	16
	100	4519	-33%	-1264	-610	-187	0	-298	-133	-36	36
	200	4508	-33%	-1276	-622	-187	0	-298	-133	-36	38
	Max	3960	-41%	-1823	-847	-283	0	-467	-141	-86	196
Lithuania 2030	**Baseline**	**5405**	**-19%**								
	10	4902	-27%	-504	-157	-58	0	-248	-4	-36	1
	20	4898	-27%	-507	-157	-62	0	-248	-4	-36	1
	30	4815	-28%	-591	-234	-62	0	-248	-10	-36	3
	40	4676	-30%	-729	-373	-62	0	-248	-10	-36	8
	50	4496	-33%	-910	-373	-148	0	-248	-105	-36	16
	70	4490	-33%	-915	-373	-148	0	-248	-110	-36	16
	100	4209	-37%	-1196	-620	-148	0	-248	-145	-36	36
	200	4199	-37%	-1207	-629	-148	0	-248	-145	-36	38
	Max	3675	-45%	-1730	-851	-228	0	-412	-155	-84	186
Luxemb. 2005	**Baseline**	**1130**									
Luxemb. 2020	**Baseline**	**1138**	**1%**								
	10	1051	-7%	-87	-25	-44	0	-10	-5	-3	0
	20	1036	-8%	-102	-40	-44	0	-10	-5	-3	0
	30	1033	-9%	-105	-40	-44	0	-13	-5	-3	0
	40	1016	-10%	-121	-57	-44	0	-13	-5	-3	1
	50	1004	-11%	-133	-57	-44	0	-13	-17	-3	1
	70	999	-12%	-138	-57	-44	0	-13	-22	-3	2
	100	919	-19%	-218	-96	-44	0	-13	-62	-3	8
	200	907	-20%	-231	-108	-44	0	-13	-63	-3	10
	Max	833	-26%	-304	-144	-55	0	-19	-75	-11	33
Luxemb. 2030	**Baseline**	**1127**	**0%**								
	10	1033	-9%	-94	-24	-49	0	-12	-5	-4	0
	20	1017	-10%	-111	-41	-49	0	-12	-5	-4	0
	30	1011	-11%	-116	-41	-49	0	-16	-6	-4	0
	40	995	-12%	-132	-57	-49	0	-16	-6	-4	1
	50	981	-13%	-146	-57	-49	0	-16	-20	-4	2
	70	973	-14%	-155	-57	-49	0	-16	-29	-4	2
	100	883	-22%	-244	-94	-49	0	-16	-80	-4	9
	200	872	-23%	-255	-104	-49	0	-16	-82	-4	11
	Max	800	-29%	-328	-138	-55	0	-23	-97	-14	34
Malta 2005	**Baseline**	**319**									
Malta 2020	**Baseline**	**242**	**-24%**								
	10	207	-35%	-35	-12	0	0	-18	-2	-4	0
	20	200	-37%	-43	-19	0	0	-18	-2	-4	0
	30	200	-37%	-43	-19	0	0	-18	-2	-4	0
	40	197	-38%	-45	-22	0	0	-18	-2	-4	0
	50	189	-41%	-53	-22	-4	0	-18	-5	-4	1
	70	188	-41%	-54	-22	-4	0	-18	-6	-4	1
	100	173	-46%	-69	-29	-4	0	-18	-15	-4	2
	200	173	-46%	-69	-29	-4	0	-18	-15	-4	2
	Max	146	-54%	-97	-35	-8	0	-26	-17	-11	14
Malta 2030	**Baseline**	**250**	**-22%**								
	10	217	-32%	-33	-14	0	0	-13	-2	-4	0
	20	208	-35%	-41	-22	0	0	-13	-2	-4	0
	30	208	-35%	-42	-22	0	0	-13	-2	-4	0
	40	205	-36%	-45	-25	0	0	-13	-2	-4	0
	50	194	-39%	-56	-25	-7	0	-13	-7	-4	1
	70	192	-40%	-57	-25	-7	0	-13	-8	-4	1
	100	175	-45%	-75	-32	-7	0	-13	-18	-4	2
	200	175	-45%	-75	-32	-7	0	-13	-19	-4	2
	Max	146	-54%	-104	-39	-13	0	-19	-22	-11	14

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Netherl. 2005	**Baseline**	**31395**									
Netherl. 2020	**Baseline**	**28965**	**-8%**								
	10	26672	-15%	-2293	-787	-969	0	-237	-115	-185	7
	20	26644	-15%	-2321	-787	-997	0	-237	-115	-185	7
	30	25727	-18%	-3238	-1636	-997	-57	-246	-117	-185	29
	40	25322	-19%	-3643	-2042	-997	-57	-246	-117	-185	44
	50	25029	-20%	-3936	-2042	-997	-57	-246	-409	-185	55
	70	24780	-21%	-4185	-2198	-997	-57	-246	-502	-185	71
	100	22427	-29%	-6538	-3806	-997	-57	-246	-1247	-185	261
	200	21512	-31%	-7453	-4719	-997	-57	-246	-1249	-185	397
	Max	19565	-38%	-9400	-5845	-1228	-57	-345	-1478	-448	1098
Netherl. 2030	**Baseline**	**29225**	**-7%**								
	10	26954	-14%	-2271	-800	-890	0	-243	-119	-219	7
	20	26927	-14%	-2298	-800	-917	0	-243	-119	-219	7
	30	26008	-17%	-3217	-1624	-917	-62	-253	-143	-219	29
	40	25606	-18%	-3618	-2026	-917	-62	-253	-143	-219	43
	50	25288	-19%	-3936	-2026	-917	-62	-253	-461	-219	56
	70	25003	-20%	-4222	-2167	-917	-62	-253	-605	-219	74
	100	22506	-28%	-6719	-3801	-917	-62	-253	-1468	-219	273
	200	21572	-31%	-7653	-4715	-917	-62	-253	-1488	-219	412
	Max	19722	-37%	-9503	-5815	-1030	-62	-361	-1749	-487	1093
Poland 2005	**Baseline**	**63132**									
Poland 2020	**Baseline**	**60702**	**-4%**								
	10	49294	-22%	-11408	-871	-8674	0	-1688	-14	-161	27
	20	47834	-24%	-12868	-2321	-8684	0	-1688	-14	-161	46
	30	47604	-25%	-13097	-2549	-8684	0	-1688	-15	-161	53
	50	46228	-27%	-14474	-3264	-9118	0	-1688	-242	-161	118
	70	46151	-27%	-14550	-3264	-9118	0	-1688	-319	-161	122
	100	43702	-31%	-16999	-4981	-9236	0	-1688	-934	-161	356
	200	36442	-42%	-24260	-9757	-11719	0	-1688	-935	-161	1471
	Max	33588	-47%	-27113	-11260	-12127	0	-1911	-1065	-751	2606
Poland 2030	**Baseline**	**59382**	**-6%**								
	10	48006	-24%	-11376	-882	-8243	0	-2058	-16	-177	26
	20	46424	-26%	-12958	-2454	-8253	0	-2058	-16	-177	47
	30	46204	-27%	-13178	-2654	-8253	0	-2058	-36	-177	53
	50	44785	-29%	-14596	-3378	-8679	0	-2058	-303	-177	120
	70	44647	-29%	-14734	-3378	-8679	0	-2058	-442	-177	128
	100	41956	-34%	-17426	-5117	-8802	0	-2058	-1271	-177	383
	200	35147	-44%	-24235	-9887	-10828	0	-2058	-1284	-177	1423
	Max	32349	-49%	-27033	-11401	-11229	0	-2201	-1450	-752	2516
Portugal 2005	**Baseline**	**19351**									
Portugal 2020	**Baseline**	**15544**	**-20%**								
	10	13614	-30%	-1930	-293	-1021	0	-483	-29	-103	3
	20	13233	-32%	-2311	-670	-1026	0	-483	-29	-103	7
	30	13201	-32%	-2343	-670	-1026	-29	-485	-30	-103	7
	40	13026	-33%	-2518	-845	-1026	-29	-485	-30	-103	14
	50	12932	-33%	-2612	-845	-1026	-29	-485	-123	-103	17
	70	12906	-33%	-2638	-845	-1026	-29	-485	-150	-103	19
	100	12353	-36%	-3190	-1185	-1026	-29	-485	-362	-103	62
	200	12268	-37%	-3276	-1269	-1026	-29	-485	-364	-103	71
	Max	10526	-46%	-5018	-1563	-1052	-29	-1557	-540	-276	579
Portugal 2030	**Baseline**	**15633**	**-19%**								
	10	13717	-29%	-1915	-295	-958	0	-518	-30	-114	2
	20	13338	-31%	-2295	-670	-962	0	-518	-30	-114	6
	30	13291	-31%	-2341	-670	-962	-35	-520	-39	-114	8
	40	13110	-32%	-2523	-852	-962	-35	-520	-39	-114	14
	50	12997	-33%	-2636	-852	-962	-35	-520	-152	-114	19
	70	12951	-33%	-2682	-852	-962	-35	-520	-198	-114	21
	100	12323	-36%	-3309	-1207	-962	-35	-520	-470	-114	70
	200	12215	-37%	-3418	-1298	-962	-35	-520	-487	-114	83
	Max	10436	-46%	-5197	-1606	-977	-35	-1583	-705	-290	595

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Romania 2005	**Baseline**	**41269**									
Romania 2020	**Baseline**	**36684**	**-11%**								
	10	27165	-34%	-9520	-927	-7728	0	-787	-48	-29	19
	20	27142	-34%	-9543	-927	-7751	0	-787	-48	-29	20
	30	26657	-35%	-10028	-1411	-7751	0	-787	-49	-29	31
	40	25948	-37%	-10736	-2120	-7751	0	-787	-49	-29	56
	50	25452	-38%	-11232	-2120	-8117	0	-787	-180	-29	79
	70	25444	-38%	-11241	-2124	-8117	0	-787	-184	-29	79
	100	23900	-42%	-12784	-3579	-8117	0	-787	-273	-29	191
	200	23900	-42%	-12784	-3579	-8117	0	-787	-273	-29	191
	Max	21780	-47%	-14905	-4757	-8460	0	-1058	-277	-353	893
Romania 2030	**Baseline**	**35759**	**-13%**								
	10	26990	-35%	-8769	-984	-7104	0	-604	-49	-29	17
	20	26968	-35%	-8791	-984	-7126	0	-604	-49	-29	18
	30	26493	-36%	-9266	-1446	-7126	0	-604	-62	-29	28
	40	25749	-38%	-10011	-2190	-7126	0	-604	-62	-29	55
	50	25213	-39%	-10546	-2190	-7495	0	-604	-228	-29	79
	70	25201	-39%	-10558	-2195	-7495	0	-604	-237	-29	80
	100	23512	-43%	-12248	-3758	-7495	0	-604	-363	-29	202
	200	23512	-43%	-12248	-3758	-7495	0	-604	-363	-29	202
	Max	21399	-48%	-14361	-5026	-7841	0	-785	-368	-340	870
Slovak R. 2005	**Baseline**	**7297**									
Slovak R. 2020	**Baseline**	**6576**	**-10%**								
	10	5165	-29%	-1410	-142	-1054	0	-141	-12	-62	3
	20	5163	-29%	-1413	-142	-1057	0	-141	-12	-62	3
	30	5117	-30%	-1458	-187	-1057	0	-141	-12	-62	4
	40	5003	-31%	-1572	-301	-1057	0	-141	-12	-62	8
	50	4972	-32%	-1604	-301	-1057	0	-141	-44	-62	9
	70	4966	-32%	-1610	-301	-1057	0	-141	-50	-62	9
	100	4632	-37%	-1944	-589	-1057	0	-141	-96	-62	34
	200	4562	-37%	-2014	-589	-1106	0	-161	-96	-62	47
	Max	3867	-47%	-2709	-827	-1152	0	-475	-109	-146	292
Slovak R. 2030	**Baseline**	**6735**	**-8%**								
	10	5210	-29%	-1525	-150	-1133	0	-166	-12	-63	3
	20	5207	-29%	-1528	-150	-1136	0	-166	-12	-63	3
	30	5169	-29%	-1566	-186	-1136	0	-166	-15	-63	4
	40	5048	-31%	-1687	-307	-1136	0	-166	-15	-63	8
	50	5012	-31%	-1723	-307	-1136	0	-166	-51	-63	10
	70	5002	-31%	-1734	-307	-1136	0	-166	-61	-63	10
	100	4638	-36%	-2098	-608	-1136	0	-166	-125	-63	37
	200	4566	-37%	-2170	-608	-1184	0	-189	-126	-63	50
	Max	3854	-47%	-2881	-858	-1229	0	-505	-143	-146	296
Slovenia 2005	**Baseline**	**3616**									
Slovenia 2020	**Baseline**	**3347**	**-7%**								
	10	2761	-24%	-586	-117	-361	0	-92	-5	-11	2
	20	2753	-24%	-594	-124	-361	0	-92	-5	-11	3
	30	2748	-24%	-598	-129	-361	0	-92	-5	-11	3
	40	2712	-25%	-635	-166	-361	0	-92	-5	-11	4
	50	2700	-25%	-647	-166	-361	0	-92	-17	-11	4
	70	2695	-25%	-652	-166	-361	0	-92	-22	-11	5
	100	2547	-30%	-800	-272	-361	0	-92	-64	-11	16
	200	2539	-30%	-808	-272	-369	0	-92	-64	-11	18
	Max	2374	-34%	-972	-356	-377	0	-119	-77	-43	86
Slovenia 2030	**Baseline**	**3022**	**-16%**								
	10	2638	-27%	-384	-120	-197	0	-49	-5	-13	2
	20	2627	-27%	-395	-131	-197	0	-49	-5	-13	2
	30	2626	-27%	-396	-131	-197	0	-49	-6	-13	2
	40	2588	-28%	-434	-170	-197	0	-49	-6	-13	3
	50	2576	-29%	-446	-170	-197	0	-49	-18	-13	4
	70	2568	-29%	-455	-170	-197	0	-49	-26	-13	4
	100	2404	-34%	-618	-282	-197	0	-49	-77	-13	17
	200	2396	-34%	-626	-282	-204	0	-49	-78	-13	19
	Max	2239	-38%	-784	-370	-211	0	-65	-93	-45	82

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO_2 GHG emissions (cumulative)							Total cost (cumu-lative)
				Total	whereof Agricul-ture	whereof Energy	whereof Indu-stry	whereof Waste	whereof AC & refrig.	whereof Other	
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	kt CO_2eq	million €/year
Spain 2005	**Baseline**	**71659**									
Spain 2020	**Baseline**	**72734**	**1%**								
	10	68692	-4%	-4042	-1625	-302	0	-1456	-173	-485	9
	20	63895	-11%	-8839	-6400	-325	0	-1456	-173	-485	57
	30	63774	-11%	-8960	-6400	-325	-76	-1496	-178	-485	61
	40	62522	-13%	-10212	-7652	-325	-76	-1496	-178	-485	105
	50	62038	-13%	-10696	-7652	-325	-76	-1496	-662	-485	125
	70	61781	-14%	-10952	-7652	-325	-76	-1496	-918	-485	140
	100	56798	-21%	-15936	-10570	-339	-76	-1496	-2970	-485	531
	200	56415	-21%	-16318	-10742	-529	-76	-1496	-2990	-485	582
	Max	49095	-31%	-23638	-12902	-790	-76	-3281	-5309	-1280	2895
Spain 2030	**Baseline**	**74149**	**3%**								
	10	69855	-3%	-4294	-1572	-269	0	-1728	-180	-545	9
	20	65027	-9%	-9123	-6377	-292	0	-1728	-180	-545	58
	30	64817	-10%	-9332	-6377	-292	-100	-1782	-235	-545	64
	40	63606	-11%	-10544	-7589	-292	-100	-1782	-235	-545	107
	50	62964	-12%	-11186	-7589	-292	-100	-1782	-877	-545	133
	70	62529	-13%	-11620	-7589	-292	-100	-1782	-1311	-545	158
	100	57062	-20%	-17087	-10435	-306	-100	-1782	-3919	-545	593
	200	56559	-21%	-17590	-10607	-388	-100	-1782	-4168	-545	665
	Max	48821	-32%	-25329	-12686	-525	-100	-3533	-7120	-1364	3087
Sweden 2005	**Baseline**	**13542**									
Sweden 2020	**Baseline**	**12775**	**-6%**								
	10	12080	-11%	-696	-308	-159	0	-125	-72	-31	2
	20	12073	-11%	-702	-308	-165	0	-125	-72	-31	2
	30	12072	-11%	-703	-308	-165	0	-125	-74	-31	2
	40	11800	-13%	-975	-580	-165	0	-125	-74	-31	12
	50	11627	-14%	-1148	-580	-165	0	-125	-247	-31	19
	70	11499	-15%	-1276	-650	-165	0	-125	-304	-31	27
	100	10545	-22%	-2230	-1143	-165	0	-125	-766	-31	102
	200	10544	-22%	-2232	-1143	-165	0	-125	-767	-31	103
	Max	9739	-28%	-3036	-1608	-179	0	-157	-908	-184	370
Sweden 2030	**Baseline**	**12828**	**-5%**								
	10	12182	-10%	-646	-313	-77	0	-131	-75	-50	2
	20	12176	-10%	-652	-313	-83	0	-131	-75	-50	2
	30	12160	-10%	-668	-313	-83	0	-131	-91	-50	3
	40	11886	-12%	-942	-587	-83	0	-131	-91	-50	12
	50	11678	-14%	-1150	-587	-83	0	-131	-299	-50	21
	70	11524	-15%	-1304	-649	-83	0	-131	-392	-50	30
	100	10452	-23%	-2376	-1161	-83	0	-131	-951	-50	116
	200	10439	-23%	-2389	-1161	-83	0	-131	-965	-50	118
	Max	9590	-29%	-3238	-1636	-90	0	-167	-1135	-210	399
UK 2005	**Baseline**	**94533**									
UK 2020	**Baseline**	**78966**	**-16%**								
	10	68288	-28%	-10678	-2247	-6747	0	-1182	-140	-363	30
	20	68093	-28%	-10873	-2247	-6941	0	-1182	-140	-363	33
	30	67274	-29%	-11692	-2247	-6967	-28	-1936	-151	-363	57
	40	66049	-30%	-12917	-3472	-6967	-28	-1936	-151	-363	100
	50	64666	-32%	-14300	-3472	-6967	-28	-1936	-1534	-363	156
	70	64306	-32%	-14660	-3472	-6967	-28	-1936	-1894	-363	177
	100	56275	-40%	-22691	-6858	-8428	-28	-1936	-5077	-363	846
	200	55531	-41%	-23435	-7597	-8428	-28	-1936	-5082	-363	947
	Max	49790	-47%	-29177	-10152	-8953	-28	-3029	-5630	-1384	3049
UK 2030	**Baseline**	**76578**	**-19%**								
	10	67075	-29%	-9503	-2266	-5231	0	-1262	-155	-590	28
	20	66927	-29%	-9651	-2266	-5379	0	-1262	-155	-590	30
	30	65923	-30%	-10655	-2266	-5392	-33	-2093	-281	-590	59
	40	64674	-32%	-11904	-3515	-5392	-33	-2093	-281	-590	104
	50	63049	-33%	-13529	-3515	-5392	-33	-2093	-1906	-590	169
	70	62453	-34%	-14125	-3515	-5392	-33	-2093	-2502	-590	204
	100	53990	-43%	-22588	-6925	-6489	-33	-2093	-6459	-590	906
	200	53187	-44%	-23391	-7675	-6489	-33	-2093	-6512	-590	1015
	Max	47940	-49%	-28638	-10281	-6728	-33	-2748	-7183	-1666	2908

Table II: Reduction potentials and costs for non-CO_2 GHGs in ETS-sectors, by country.

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO2 GHG emissions in ETS sectors (cumulative)	Total cost (cumu-lative) million
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	€/year
Austria 2005	**Baseline**	**271**			
Austria 2020	**Baseline**	**218**	**-20%**		
Austria 2030	**Baseline**	**222**	**-18%**		
Belgium 2005	**Baseline**	**3032**			
Belgium 2020	**Baseline**	**1195**	**-61%**		
Belgium 2030	**Baseline**	**1202**	**-60%**		
Bulgaria 2005	**Baseline**	**950**			
Bulgaria 2020	**Baseline**	**214**	**-77%**		
Bulgaria 2030	**Baseline**	**233**	**-75%**		
Czech Rep. 2005	**Baseline**	**940**			
Czech Rep. 2020	**Baseline**	**230**	**-76%**		
Czech Rep. 2030	**Baseline**	**243**	**-74%**		
Finland 2005	**Baseline**	**1028**			
Finland 2020	**Baseline**	**209**	**-80%**		
Finland 2030	**Baseline**	**198**	**-81%**		
France 2005	**Baseline**	**7032**			
France 2020	**Baseline**	**2148**	**-69%**		
	70	1307	-81%	-841	50
France 2030	**Baseline**	**2310**	**-67%**		
	70	1341	-81%	-970	58
Germany 2005	**Baseline**	**13142**			
Germany 2020	**Baseline**	**2933**	**-78%**		
Germany 2030	**Baseline**	**2916**	**-78%**		
Greece 2005	**Baseline**	**509**			
Greece 2020	**Baseline**	**180**	**-65%**		
Greece 2030	**Baseline**	**194**	**-62%**		
Hungary 2005	**Baseline**	**1015**			
Hungary 2020	**Baseline**	**306**	**-70%**		
	100	160	-84%	-146	13
Hungary 2030	**Baseline**	**317**	**-69%**		
	100	154	-85%	-163	14
Italy 2005	**Baseline**	**8071**			
Italy 2020	**Baseline**	**381**	**-95%**		
Italy 2030	**Baseline**	**395**	**-95%**		
Lithuania 2005	**Baseline**	**1628**			
Lithuania 2020	**Baseline**	**480**	**-71%**		
Lithuania 2030	**Baseline**	**582**	**-64%**		
Netherl. 2005	**Baseline**	**5647**			
Netherl. 2020	**Baseline**	**1352**	**-76%**		
Netherl. 2030	**Baseline**	**1437**	**-75%**		
Poland 2005	**Baseline**	**4028**			
Poland 2020	**Baseline**	**1051**	**-74%**		
	100	992	-75%	-59	5
Poland 2030	**Baseline**	**1089**	**-73%**		
	100	1032	-74%	-57	5
Portugal 2005	**Baseline**	**326**			
Portugal 2020	**Baseline**	**67**	**-79%**		
Portugal 2030	**Baseline**	**76**	**-77%**		

Country/year	Marginal cost (upper limit)	Remaining non-CO_2 emissions	Reduc-tion relative 2005	Reduction potential non-CO2 GHG emissions in ETS sectors (cumulative)	Total cost (cumu-lative) million
	€/t CO_2eq	kt CO_2eq		kt CO_2eq	€/year
Romania 2005	**Baseline**	**2651**			
Romania 2020	**Baseline**	**1083**	**-59%**		
	70	483	-82%	-600	36
Romania 2030	**Baseline**	**1022**	**-61%**		
	70	447	-83%	-575	34
Slovak Rep. 2005	**Baseline**	**1341**			
Slovak Rep. 2020	**Baseline**	**285**	**-79%**		
Slovak Rep. 2030	**Baseline**	**304**	**-77%**		
Slovenia 2005	**Baseline**	**54**			
Slovenia 2020	**Baseline**	**80**	**47%**		
Slovenia 2030	**Baseline**	**89**	**64%**		
Spain 2005	**Baseline**	**1747**			
Spain 2020	**Baseline**	**620**	**-65%**		
	100	559	-68%	-60	5
Spain 2030	**Baseline**	**722**	**-59%**		
	100	661	-62%	-61	5
Sweden 2005	**Baseline**	**827**			
Sweden 2020	**Baseline**	**434**	**-48%**		
	100	139	-83%	-295	26
Sweden 2030	**Baseline**	**471**	**-43%**		
	100	141	-83%	-331	29
UK 2005	**Baseline**	**4555**			
UK 2020	**Baseline**	**1242**	**-73%**		
	100	1190	-74%	-52	5
UK 2030	**Baseline**	**1476**	**-68%**		
	100	1415	-69%	-61	5

Table III: Marginal mitigation cost curve for 2030 by control option, EU-27 aggregated

Gas	Major sector	Activity	Control option	Change in non-CO2 GHG Mt CO2eq	Remaining non-CO2 GHG Mt CO2eq	Total cost (no neg. costs) million Euro (2005)	Marginal cost (mean) Euro/t CO2eq	Marginal cost (range)	
Baseline emissions 2005					**879**				
Baseline emissions 2015					**783**				
Baseline emissions 2020					**766**				
Baseline emissions 2025					**762**				
Baseline emissions 2030					**755**				
Mitigation potentials in non-ETS sectors in 2030:									
FGAS	AC&refrig.	HFCs from refrigerated transport -leakage from equipment in use	Alternative refrigerant: use of open CO2 refrigerant system	-0.9	755	0	0	0	0
CH4	Energy	Long-distance natural gas transmission	Reduced leakage at compressor stations	-17.5	737	0	0	0	0
CH4	Wastewater	Industrial wastewater	Switch from anaerobic treatm. w. flaring to anaerobic treatm. w. gas utilization	-1.2	736	0	0	0	0
FGAS	AC&refrig.	HFCs from refrigerated transport -end-of-life emissions	Switch from good practice to alternative refrig.: open CO2 refrigerant system	-0.7	735	0	0	0	0
CH4	Waste	Solid waste from food industry -10 years lag in emission release to reflect decay rate	Anaerobic digestion with biogas recovery, upgrading and utiliz.	-6.0	729	0	0	0	0
CH4	Wastewater	Wastewater from food industry	Switch from anaerobic treatment with gas recovery and flaring to aerobic treatment	-0.1	729	0	0	0	0
CH4	Agriculture	Open burning of agricultural waste	Ban on open burning of agricultural waste	-0.7	728	0	0	0	0
N2O	Other	Direct use of N2O e.g., for medical purposes	Combined application of N2O with other aenesthetics	-1.0	727	0	0	0	0
N2O	Wastewater	Domestic wastewater treatment	Optimize process parameters towards low N2O yield	-6.6	721	0	0	0	0
FGAS	Other	HFCs emissions from polyurethane one component foam	Alternative blowing agent: many different kinds	-0.3	720	0	1	1	1
N2O	Energy	Fluidized bed combustion for fuel conv. -brown coal/lignite	Combustion modification in fluidized bed combustion	-25.5	695	90	4	4	4
N2O	Agriculture	Nitrogen input on grasslands	Reduced application of fertilizer	-3.7	691	20	5	5	7
N2O	Agriculture	Nitrogen input on arable agricultural land	Reduced application of fertilizer	-10.2	681	58	6	5	7
CH4	Energy	Production of natural gas and oil	Extended flaring instead of venting of associated gas in oil/gas production	-3.0	678	9	8	0	33
FGAS	Other	HFCs emissions from other polyurethane foams	Alternative blowing agent: many different kinds	-1.8	676	16	9	9	9
CH4	Agriculture	Rice cultivation -continuously flooded	Alternative rice strains	-0.2	676	2	9	9	9
CH4	Agriculture	Dairy cows	Mix of feed changes e.g.incr. intake of fat	-3.0	673	13	11	-18	40
CH4	Energy	Oil refinery	Extended flaring instead of venting of	-0.2	673	4	16	16	16
CH4	Agriculture	Rice cultivation -continuously flooded	Switch from alt. rice strains to intermittent aeration fields	0.0	673	0	20	20	20

Gas	Major sector	Activity	Control option	Change in non-CO2 GHG	Remaining non-CO2 GHG	Total cost (no neg. costs)	Marginal cost (mean)	Marginal cost (range)	
				Mt CO2eq	Mt CO2eq	million Euro (2005)	Euro/t CO2eq		
CH4	Agriculture	Pigs, liquid manure management	Farm-scale anaerobic digestion plants	-16.6	656	248	26	7	120
FGAS	Industry	PFC emissions from semiconductor industry	Alternative solvent: use of NF3	-2.1	654	60	29	29	29
CH4	Waste	Solid waste from food industry -10 years lag in emission release to reflect decay rate	Anaerobic digestion with biogas recovery, upgrading and utiliz.	-1.4	653	40	29	29	29
FGAS	AC&refrig.	HFCs from industrial refrigeration -end-of-life emissions	Process modifications including alternative refrigerants	-0.7	652	22	29	29	29
CH4	Agriculture	Rice cultivation -continuously flooded	Combining alt. rice strains and sulfate-containing amendments	-0.6	651	20	33	33	33
N2O	Agriculture	Nitrogen input on grasslands	Timing of fertilizer application	-3.1	648	114	37	36	50
N2O	Agriculture	Nitrogen input on arable agricultural land	Timing of fertilizer application	-8.5	640	328	37	36	50
FGAS	AC&refrig.	HFCs from industrial refrigeration -leakage from equipment in use	Process modifications including alternative refrigerants	-9.5	630	383	40	40	40
CH4	Energy	Mining of brown coal/lignite	Extended mine gas recovery, upgrading and utilization	-2.8	627	51	45	3	180
CH4	Agriculture	Rice cultivation -continuously flooded	Combining alt. rice strains, sulfate-containing amendments and intermittent aeration	0.0	627	1	51	51	51
FGAS	AC&refrig.	HFCs from commercial refrigeration -end-of-life emissions	Process modifications including alternative refrigerants	-3.7	624	216	58	58	58
N2O	Agriculture	Nitrogen input on grasslands	Use of nitrification inhibitors	-7.4	616	543	73	71	99
N2O	Agriculture	Nitrogen input on arable agricultural land	Use of nitrification inhibitors	-20.4	596	1563	74	71	99
CH4	Energy	Fugitive and comb. emissions from natural gas use in stationary boilers	Doubling of leak control frequency of gas distribution network	-1.5	594	85	84	47	186
CH4	Energy	Mining of hard coal	Extended mine gas recovery, upgrading and utilization	-4.6	590	543	86	14	166
CH4	Agriculture	Non-dairy cattle	Mix of feed changes e.g.incr. intake of fat	-3.4	586	269	87	7	167
FGAS	AC&refrig.	HFCs from commercial refrigeration -leakage from equipment in use	Process modifications including alternative refrigerants	-23.5	563	2058	88	88	88
FGAS	Industry	Magnesium production and casting	Alt.protection gas: SF6 replaced by SO2	-0.1	563	12	109	109	109
CH4	Agriculture	Rice cultivation -continuously flooded	Combining alt. rice strains, sulfate-containing amendments and intermitt. aeration	-0.6	562	67	113	113	113
N2O	Agriculture	Organic soils cultivated	Lay fallow	-11.3	551	1674	149	149	149

Gas	Major sector	Activity	Control option	Change in non-CO2 GHG	Remaining non-CO2 GHG	Total cost (no neg. costs)	Marginal cost (mean)	Marginal cost (range)	
				Mt CO2eq	Mt CO2eq	million Euro (2005)	Euro/t CO2eq		
CH4	Wastewater	Wastewater from food industry	Switch from no control to aerobic treatment of industry wastewater	-0.1	551	10	157	157	157
FGAS	AC&refrig.	HFCs from stationary air conditioning -end-of-life emissions	Process modifications including alternative refrigerants	-0.8	550	126	162	162	162
N2O	Agriculture	Nitrogen input on grasslands	Precision farming	-6.1	544	1347	218	212	295
N2O	Agriculture	Nitrogen input on arable agricultural land	Precision farming	-17.0	527	3880	219	212	295
CH4	Wastewater	Dom. wastewater treatm. -centralized collection	Switch fr.none or primary treatm. to anaerobic treatm. w. gas recovery + utiliz.	-0.5	527	103	221	221	221
CH4	Wastewater	Dom. wastewater treatm. -centralized collection	Switch fr.none or primary treatm. to anaerobic treatm. w. gas recov. + flaring	-3.4	523	773	229	229	229
CH4	Wastewater	Wastewater from organic chemical industry	Switch from no control to aerobic treatment of industry wastewater	0.0	523	6	272	272	272
FGAS	AC&refrig.	HFCs from stationary air conditioning -leakage from equipment in use	Process modifications including alternative refrigerants	-9.7	513	2703	278	278	278
CH4	Energy	Fugitive and comb. emissions from natural gas	Replacement of grey cast iron gas distribution	-2.7	511	832	412	263	1403
CH4	Waste	Solid waste from food industry -10 years lag in emission release to reflect decay rate	Waste incineration replacing AD with biogas recovery and utiliz.	-0.7	510	311	425	425	425
CH4	Waste	Municipal solid waste -food, 10 years lag in emission release to reflect decay rate	Anaerobic digestion with biogas recovery, upgrading and utiliz. instead of landfill	-2.5	507	1268	496	494	508
CH4	Agriculture	Dairy cows, liquid manure management.	Farm-scale anaerobic digestion plants	-2.0	505	342	701	76	9062
N2O	Other	Direct use of N2O e.g., for medical purposes	Replace N2O in aenesthetics	-8.1	497	5722	708	708	708
CH4	Agriculture	Non-dairy cattle, liquid manure managem.	Farm-scale anaerobic digestion plants	-1.3	496	405	817	121	5363
CH4	Agriculture	Dairy cows, liquid manure management.	Swich from farm-scale to community-scale AD in Belg, Neth, Denm and Malta	-0.2	496	167	847	764	931
CH4	Wastewater	Wastewater from paper industry	Switch from no control to aerobic treatment of industry wastewater	0.0	496	4	886	886	886
CH4	Agriculture	Pigs, liquid manure management	Swich from farm-scale to community-scale AD in Belg, Neth, Denm and Malta	0.0	496	72	1864	850	2879
Sum maximum technically feasible emission reduction in non-ETS sectors in 2030				**-260**	**496**	**26581**			
Mitigation potentials in ETS sectors in 2030:									
FGAS	Industry	Primary Al prod - SWPB technology	Conversion of SWPB to PFPB	-1.5	494	92	60	60	60
FGAS	Industry	Primary Al prod using VSS technology	Conversion of VSS to PFPB	-0.7	494	59	87	87	87
Sum maximum technically feasible emission reduction in ETS sectors in 2030				**-2**		**151**			
Sum maximum technically feasible emission reduction in all sectors in 2030				**-262**	**494**	**26732**			