Estimation and decomposition of Member States' distance to the Effort-Sharing Decision Targets in 2020

Master Thesis (30 ECTS)

Author: Filippos Anagnostopoulos

Student number: 3428931

Supervisor: Robert Harmsen

Utrecht University
M.Sc. Sustainable Development
Track Energy and Resources

ABSTRACT

The purpose of this thesis is to assess the progress of Member States and of the European Union towards those targets by consulting projections of greenhouse gas emissions for 2020; and to attribute the distance between Member States and their targets to the effects of energy demand and fuel mix. The main conclusion is that under current policies and according to projections, the European Union will not meet its non-ETS emissions reduction target, even though a number of Member States will, and the reason is increased energy demand.

Acknowledgements

I would like to thank a number of people for their support and for sharing unforgettable moments in the two years of the Sustainable Development master programme, which cumulated to the writing of this thesis.

First of all, I would like to thank the staff of Utrecht University for their services; and the academic personnel of the Sustainable Masters programme for the knowledge they passed on. I would especially like to thank my thesis supervisor, Robert Harmsen, for devoting his time and supporting me through this process with observations and accurate remarks. I would like to thank my fellow master students with whom we shared ideas and worked towards realizing projects in and outside the University, with as a highlight the organization of the TEDxUtrechtUniversity in 2011. I am sure this master programme has been an important step for all of us and I hope you will keep your ideals and work towards sustainability in every way imaginable.

In the past two years, studies have been joyfully combined with social life since one supported the other in many ways. I therefore thank Myrto, Vally, Panayota, Harris, Samer, Adam, Gareth, Ilektra, Irini, Kuba, Yanique, Stefan, Knos, Enzio, Ole and Nikki, Frances, Saad, Arne, Evert, Tim, Leah, Nadia and Phil and the art & theater groups of Dr Seltsam and AMITU. Lastly I would like to thank the numerous anonymous people in the Netherlands who knowingly or unknowingly enriched my stay in this part of the world and of course my family for always being there for me

Utrecht, September 2012
Filippos Anagnostopoulos

Glossary

CEP - Climate and Energy Package	This group of European Union (EU) legislation seeks to , by 2020,reduce GHG emissions 20% of to 1990 levels, increase the share of renewable energy to 20% and reduce primary energy consumption by 20% compared to projected figures through improving energy efficiency.
ESD - Effort Sharing Decision	Decision 406/2009/EC sets greenhouse gas emission targets for all EU Member States. Wealthy countries are required to decrease their emissions while countries with a GDP /capita lower than the EU average are permitted to increase their emissions. The targets are relative to 2005 non-ETS emissions.
EU ETS	EU Emissions Trading Scheme. A cap-and-trade system for CO_2 emissions aiming at reducing emissions from energy intensive sectors by 21% of 2005 levels.
GHG - Greenhouse gas(s)	Greenhouse gas: carbon dioxide (CO_2), methane (CH4), nitrous oxide (N2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6).
Monitoring Mechanism (MM)	Decision 208/2004/EC. Set up a system for reporting annual GHG emissions to the UNFCCC and additionally requires GHG emissions projections to be submitted every two years by all Member States
MS – Member State(s)	The 27 Member States of the European Union: Austria (AT), Belgium (BE), Bulgaria (BG), Cyprus (CY), Czech Republic (CZ), Denmark (DK), Estonia (EE), Finland (FI), France (FR), Germany (DE), Greece (EL), Hungary (HU), Ireland (IE), Italy (IT), Latvia (LV), Lithuania (LT), Luxemburg (LU), Malta (MT), Netherlands (NL), Poland (PL), Portugal (PT), Romania (RO), Slovakia (SK), Slovenia (SI), Spain (ES), Sweden (SE), United Kingdom (UK).
non-ETS	GHG emissions not covered by the EU ETS. Targets for non-ETS emissions set under the Effort-Sharing Decision.
NP - National Projections	Projections of GHG emissions prepared by Member States every two years in the context of the Monitoring Mechanism.
PRIMES/GAINS	Two models used (among others) for deriving projections of CO_2 and non-CO_2 emissions respectively and for providing impact assessments of EU climate policies.
UNFCCC	The United Nation Framework Convention on Climate Change.
WEM /WAM	With Existing Measures / With Additional Measures. The two emissions projection scenarios reported by Member States in their National Projections.

Table of Contents

Reading Guide

The present thesis has a straightforward structure whereby the topic is introduced in the beginning and then the methodology used to approach the topic. The results of the methodology are presented next and from those follow conclusions regarding the topic.

Chapter 1 introduces the topic by providing a brief background of climate policies and focuses on the Effort-Sharing Decision. The literature review provides an overview of the scientific community 's approach to the Effort-Sharing Decision and identifies the knowledge gap. Next, the problem definition relating to this knowledge gap and forming the basis of the thesis is presented, which finally leads to the research question.

Chapter 2 provides additional information on aspects of this thesis and it is not necessary to understand the next chapters. It is however an interesting read with information that adds to the understanding of the topic. This chapter provides a short literature review of the method of decomposition analysis in order to justify the choice made to analyse the data and, furthermore, mentions some information on the models used to derive projections of GHG gases.

Chapter 3 describes in detail the methodology followed to answer the research question. It is grouped in two parts in order to direct attention to the processes followed. The first part deals with the estimation of the distance of Member States to their targets, and the second deals with the explanation of this distance.

Chapter 4 presents the results of the thesis and it is also split in parts one and two. The first part present the results on the distance of member States to their targets in 2020 and part two explains this distance with the examples of France and Hungary. Each part constitutes an answer to the two-fold research question.

Chapter 5 provides the conclusions of this thesis on the distance of Member States to the target of the Effort-Sharing Decision and explains this distance according to the results of the previous chapter. In this chapter there is also discussion on the methodology followed and especially on its novelty and its boundaries. Finally, suggestions for additional research are provided which build on the findings and the methodology of the present thesis.

1 Introduction

1.1 Thesis Background

The Arctic sea ice cover reached a record low in the summer of 2012, surpassing the record of 2007 (NSIDC, 2012). The effects of anthropogenic climate change caused by the release of greenhouse gases (GHG) are becoming increasingly obvious as warned in the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC 2007). These reports are published on topics relevant to the implementation of the United Nation Framework Convention on Climate Change (UNFCCC); the international environmental treaty is the outcome of the United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, which is also known as Summit. The ultimate objective of the UNFCCC is the "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UNFCCC, 1992).

This objective agreed on the international level was endorsed 1993 by the European Community in the European Council's Decision 94/69/EC. A major step towards meeting these commitments was the implementation in 2002 of the Kyoto Protocol after the European Council Decision 2002/358/EC also known as the Burden Sharing Decision. Under the Kyoto Protocol the EU set a target[1] to reduce GHG emissions by 8% below 1990 levels. The international commitments of the EU under the Kyoto Protocol, were transfered from the international level to the EU Member States (MS) level through the coutry-specific targets set in the Burden Sharing Decision (European Council, 2002).

The EU expressed the will to take an international lead in 2007 to fight climate change when the European Commission stated: "The EU must adopt the necessary domestic measures and take the lead internationally to ensure that global average temperature increases do not exceed pre-industrial levels by more than 2°C" (European Commission, 2007). Hence, averting the potentially dangerous effects of climate change is an important topic of the EU agenda, addressed through policies at both national and international levels. The EU, seven years after the Burden Sharing Decision of 2002, took the lead in international climate negotiations by adopting the Climate and Energy Package (CEP). This policy package sets legally binding targets for EU-wide GHG emissions reductions; and commits to reducing emissions even further in the

[1] On a side note, emissions embodied in traded goods are not addressed by the setting of targets for emissions reductions. When, for example, production is outsourced overseas, emissions within the EU are reduced. This is a virtual decrease as it simply moves the emissions of GHG at another point of the planet and in doing so does not fight climate change. Most of the EU27 countries are net importers of embodied GHG emissions in the form of traded goods. Peters and Hertwich (2008) argue that "emissions embodied in trade may have a significant impact on participation in and effectiveness of global climate policies such as the Kyoto Protocol". If emissions related to traded goods were also included in emissions mitigation targets, then those targets would become much more demanding. This fact is expounded when considering that the EU is a net importer of traded emissions.

event of an international agreement. The CEP sets targets for 2020, also known as the 20 20 20 targets, whereby the EU commits to reduce its greenhouse gas emissions by 20% compared to 1990 levels, increase the share of renewable energy consumption to 20%, and through energy efficiency measures achieve a 20% reduction in primary energy use compared to projected levels (European Commission, 2008).

The interest of this thesis is on the target of reducing GHG emissions by 20% compared to 1990 levels. These reductions are split in two according to their sources. Specifically, one part of the emissions reduction is planned through the EU Emissions Trading Scheme (EU ETS or simply ETS)[2], which covers GHG emissions from energy intensive sectors including electricity generation, the iron and steel industry, mineral-oil refineries, production and processing of ferrous-metals, cement, lime, ceramics, bricks, glass, pulp and paper, and the like. The remaining part of reductions is determined by the Effort Sharing Decision (ESD) 406/2009/EC, and covers about 55-60% of the planned reductions of EU greenhouse gas emissions (European Commission, 2008). The ESD includes all GHG emissions not covered under the EU-ETS, such as emissions from transportation and buildings as well as non-CO_2 GHGs from agriculture; but excludes emissions of international aviation and international shipping as well as emissions related to land use, land use change and forestry (LULUCF).

The EU ETS (Emission Trading Scheme) directive and ESD (Effort Sharing Decision), which target the ETS and non-ETS sectors respectively and combined cover almost all of EU emissions[3], plan to deliver a reduction of GHG (greenhouse gas) emissions by 20% compared to 1990 levels. This equals a 14% reduction compared to 2005 levels. Splitting emissions into ETS and non-ETS sectors, the targets are a reduction of 21% under the ETS and a reduction of 10% under the ESD, compared to 2005 greenhouse gas emissions (Commission 2010). The 10% reduction target of the ESD is central in this thesis as it is used to evaluate the commitment of the EU in combating climate change. The ESD concerns the period from 2013 to 2020 and allocates[4] targets of maximum allowed GHG emissions to every MS in accordance to its wealth. The amount of GHG a MS is allowed to emit may vary from -20% to +20% compared to their 2005 emissions; and these targets are estimated based on the relative wealth of each MS determined by its GDP/capita. These targets aimed at reducing Europe's non-ETS emissions set under the ESD are the subject of this thesis.

---

[2] Directive 2003/87/EC applies until 31 December 2012 and is subsequently replaced by 2009/29/EC.

[3] Except land use, land use change and forestry (LULUCF) and international maritime shipping and aviation.

[4] The principles and the methods of determining effort sharing among countries should satisfy principles of fairness and operational requirements in order to gain political acceptance (Torvanger and Ringius, 2001. In estimating the targets for Member States, the data and the methodology used should be robust, understood and generally acceptable. These attributes allow for critical analysis of the transparent method and add to the acceptance of the process. The advantage of top down approaches in determining the targets is that it satisfies the abovementioned qualities that lead to political acceptance. The weakness however of top-down methods, also used by the Commission in determining the ESD targets, is that they fail to consider specific national circumstances.

The ESD is therefore one of EU policies aimed at combating anthropogenic climate change by setting targets for EU Member States to collectively reduce their GHG emissions. These targets are the main topic of the present thesis; and more specifically, the issue of them being met or not.

1.2 Literature review

The scientific literature regarding the Effort-Sharing decision is limited and revolves around the targets and the cost effectiveness of the instruments in place. First the literature relating to the cost effectiveness of the ESD is provided and then the literature on the targets.

The costs of the CEP are on the order of *some* €70-90 billion by 2020, and because of that the package is considered by Egenhofer *et al* (2011) to be one of the most important EU legislation of the day. Regarding the cost of the CEP, Böhringer *et al* (2009) argue that it proves to be very costly in comparison to what it sets out to deliver by stating that the overlapping of EU climate policies and the split of emissions into ETS and non-ETS creates excess costs if the only target is mitigation of GHG emissions. Options to reduce the costs of GHG emissions mitigation from ETS and non-ETS sectors were assessed by Toi (2009). Toi states that while the Commission supports that the Effort Sharing targets are distributed in a cost-effective manner, in reality there could be a more cost efficient solution. The issue is that because there is market segmentation in carbon trading, the price of carbon exhibits a significant variation between ETS and non-ETS emissions, and among non-ETS emissions in a number of Member States. Therefore, Toi argues that an integrated market for GHG emissions would lower the overall policy cost. Cap and trade schemes have also been shown to reduce costs in the Agriculture sector (De Cara, 2011).

A policy provision that increases the cost effectiveness of meeting the ESD targets is flexibilities in trading emissions between Member States and internationally in the form of Clean Development Mechanism credits (CDM). The Commission's original proposal on the ESD permitted member states to use offset credits in order to meet up to two-thirds of their emissions reductions*.* In the final agreement on the ESD, achieved in December 2008, further use of flexibilities is allowed for 11 Member States, mainly western European (Egenhofer, 2011).

The majority of the scientific community's involvement with the ESD has been related to the targets and their appropriateness. Most importantly, the Commission required an Impact Assessment of the Climate and Energy Package, which was realized by Capros *et al* (2008). The study used the PRIMES and GAINS models to assess four different methods of determining the ESD targets. From the findings of that study, the Commission chose for the GDP/capita method; according to which MS with a GDP/capita bellow the EU average are permitted to increase emissions whereas MS with a GDP/capita above the EU average have to decrease their emissions accordingly. The rationale behind the Commission's choice has to do with the fact that GDP is positively correlated with GHG because increased economic output requires energy to be spent on services and production. Therefore, MS with a GDP/capita above the EU average can afford to reduce their emissions by investing their wealth towards this goal; and Member States with a low GDP/capita are allowed to increase their emissions in order to become wealthier.

Additional methods of sharing emissions reductions in the non-ETS sectors were examined by Saikku *et al* (2008). Their analysis was based on the variability of parameters, such as GDP growth, population, and carbon intensity of the economy. Their results showed that for a number of MSs, the variability of possible targets that could have been applied is considerable; while for other countries, the range of possible targets is limited and therefore more clearly defined. The article of Saikku *et al* (2008) justifies the Commission's decision based on the finding that the targets fall within the range of possible targets determined in their study.

Similarly, den Elzen *et al* (2007) assessed different methodologies of distributing the reduction targets of the CEP among MS using scenarios based on the variability of parameters linked to emissions. Their analysis produced a range of emissions targets for Member states and they concluded that the effort of each country may be very different from the others; and that even the targets for each country can vary greatly according to the approach used to distribute targets. They further point out that it is more important for MS to agree on the approach to distribute the overall targets rather than the targets themselves.

The targets set forth in the CEP were widely applauded in their entirety by the EU governing bodies. This is displayed by the fact that the Commission's initial proposal on the CEP was only slightly altered because governments provided their full support at the European Council of March 2007 for the key elements of the CEP package (Egenhofer, 2011). However, the targets of the Effort-Sharing Decision were never negotiated regarding the issue of whether or not they were realistic, but were second to talks about the flexibilities of how to attain them. Governments up until the splitting of emissions into ETS/non-ETS did not focus their reduction efforts on the non-EST sectors (buildings, transportation etc.) to achieve emissions reductions since it was easier to burden the ETS sectors (power generation, heavy industry), which have a big substantial reduction potential (Oberthur *et al*, 2010).

Analysis by Harmsen *et al* (2011) using PRIMES/GAINS data of 2009 demonstrated that the methodology of GDP/capita applied in the Effort-Sharing Decision results in imbalances. What this means is that some MS do not need to take any measures beyond the baseline projections in order to meet their targets while others are faced with targets that are too ambitious. The reason for the misallocation rests in the use of the GDP per capita methodology which favors MS with a lower than average GDP/capita by assigning them targets to increase emissions, to allow them to increase their wealth. However, non-ETS emissions include all the non-CO_2 GHGs, which are decoupled from GDP growth. Along with their CO_2 emissions, which allow them to increase their wealth, MS can also increase their non-CO_2 emissions which do not. Therefore even if non-CO_2 GHG increase the wealth of a MS will not. Therefore MS with a high share of non-CO_2 GHG are allowed to increase their emissions even though that will not increase their wealth. The effect of this imbalance in targets is that some MS have little incentives to invest in CO_2 mitigation, since a large share of the reduction are expected to be realized from non-CO_2 GHG because of policies such as the Landfill directive. Toi (2009) also identifies an issue in the allocation of targets, since two MS's emissions in 2020 as projected by the PRIMES/GAINS models are lower than the targets the MS were assigned under the ESD.

The literature regarding the Effort-Sharing Decision has mainly focused on cost effectiveness and target setting and there seems to be a gap in the literature dealing specifically with its implementation. The work of Harmsen *et al* (2011) and Toi (2009) has already touched on this issue by examining the targets in relation to GHG projections. The present thesis adds to the discussion on the ESD decision by further exploring the issue of whether or not the targets will be met. It does so by estimating the distance to the targets according to various projections; and by explaining this distance after decomposing it to the effects of its explanatory factors, namely the fuel mix and the energy demand. The current endeavor builds on past work and provides insights for policymakers to direct GHG reduction policies, aimed at meeting the ESD targets, towards factors that cause the policy gap between targets and projections.

1.3 Problem Definition

A key element in the EU's climate change policy is the reduction of GHG emissions by 20% compared to 1990 levels by the year 2020. Part of these reductions is to be realized in the EU ETS, which is a cap-and-trade policy instrument for GHG emissions. The remaining reductions, which constitute about 55-60% of total GHG emissions, are distributed among MS in the form of emissions targets laid out in the ESD. The emissions covered by the EU ETS are referred to as ETS emissions and the emissions covered by the ESD are referred to as non-ETS emissions. This thesis concerns the 2020 target for non-ETS emissions reductions for the EU as a whole, which is set at 10% lower than 2005 non-ETS emissions levels. Additionally, the 10% reduction target for non-ETS emissions is shared among EU MS and each is assigned a target according to its wealth.

The Effort-Sharing Decision distributes targets for greenhouse gas reductions on the principle of fairness, as stated in the Impact Assessment of the EU Energy and Climate Package: "The European Council in March 2007 recognised that it is necessary to take into account Member States' different circumstances and the reality that differing levels of prosperity have an impact on Member States' capacity to invest"(European Commission, 2008b).

The Commission employed a GDP/capita method for fairly distributing the ESD targets, thus taking into account the economic relation of MSs to each other. The outcome is that on the one hand, MSs with a GDP/capita above the EU average are assigned targets aiming at reducing GHG emissions by at most 20% compared to 2005 non-ETS emissions. On the other hand, MS with GDP/capita below the EU average are allowed to increase their emissions up to 20% compared to 2005 non-ETS emissions. This method seems to justify the principle of fair distribution of targets, but it is not without its shortcomings.

Despite the efforts by the Commission to equitably distribute the ESD targets, there seem to be two factors that distort this ambition, namely the methodology it applied and the effect of the economic crisis.

The first factor is the GDP/capita methodology used in determining the equal distribution of ESD targets. Harmsen *et al* (2011) concluded that there was an imbalance concerning ambition level among MS. When the targets are compared against the PRIMES/GAINS 2007 projections used by the Commission to set the targets, three MS meet their targets without implementing any additional policies beyond the baseline projections. In the remaining MSs, the flexibilities provided in the form of non-ETS emissions trading among MS and the use of CDM credits, make target achievement easier. It is very probable that MS could choose for flexibilities and avoid taking domestic measures to mitigate GHG promoting energy efficiency. This happened under the Kyoto Protocol when MS used to overburden the ETS sectors with achieving emissions reductions and not formulating decisive plans for the rest of the economy (Oberthur *et al*, 2010). It becomes clear that one factor that distorts the equitable sharing of GHG reductions is the method of GDP/capita when the effect of non-CO_2 emissions is not taken into account. This method does not provide strong incentives for MS to reduce their emissions.

The second factor the Commission could not have had included in its setting of the ESD targets is the effect of the economic crisis. Because CO_2 emissions are coupled with GDP growth (Raupach, *et al*, 2007), the economic crisis tends to lower emissions. As the ESD targets were agreed upon in the early stages of the economic depression, the PRIMES/GAINS models used in the impact assessment by the Commission did not take the effect of the crisis into account (Capros *et al*, 2008). Indeed, the EEA in its technical report (EEA, 2011) provides evidence that in 2009 the downward trend in emissions was temporally accelerated by the economic recession.

The two factors mentioned, the imbalanced targets and the effect of the economic crisis, have led to moderate ambition levels for some MS to mitigate non-ETS GHG emissions. The second factor has also reduced the distance the EU has to cover to meet its target under the ESD of decreasing non-ETS emissions by10% below 2005 levels.

As 2013 is the first year when the ESD comes into action is topical to estimate the distance of all MS and of the EU as a whole to the ESD targets. Estimating this distance is also important because it evaluates the commitment of the EU in combating climate change as represented in one of its policies. The distance can be found by comparing the targets against projections of GHG emissions. To this end, the effect of the economic crisis and that of any additional policies, since the ESD was agreed upon, should be taken into account. These effects are factored in the latest projections of GHG emissions, and therefore the distance to the targets is estimated more accurately using those updated projections.

There are two types of projections examined in this thesis and used to estimate MS's relation to the ESD targets. The first type is EU wide projections generated by dedicated modeling teams, while the second type of projections are derived on a national level by all MS. Two types of projections are used to display both the EU-wide and the MS-specific viewpoints on the ESD targets, on the EU27 level and on the country level. These two types of projections used in the context of European climate policy are: the EU-wide projections of PRIMES/GAINS used to provide input such as impact assessments for climate policy; and the National projections submitted every two years to the Monitoring Mechanism by all MS.

The PRIMES and GAINS models are regarded in this thesis as the EU perspective and National projections constitute the MS's viewpoint on the distance to the ESD targets.

The distance to the ESD targets will be examined using both National Projections and estimates of PRIMES/GAINS. Distance is defined in the context of this thesis as the amount of emissions between the ESD target and the projections[5]. The desired outcomes are estimates of the distances of individual MS to their targets, as well as of EU27 to its 10% reduction target.

In addition to determining the distance to the ESD targets, this distance will also be explained using explanatory factors present in both types of projections. The amount of projected emissions is determined on a very basic level by the energy demand and the choices of energy sources, or the fuel mix. Emissions can be expressed as a combination of those two explanatory factors and since the distance to the ESD targets consists of emissions, those can also be expressed as a combination of energy demand and fuel mix. The findings from this detailed examination of the distance can be relevant to policymakers when designing policies aimed at closing the distance to the ESD targets.

To summarise, the objective of this thesis is to identify the distance to the Effort-Sharing Decision targets from the EU perspective that makes use of PRIMES/GAINS projections and from the Member States perspective, which derives National Projections in the context of the Monitoring Mechanism. Furthermore, this thesis explains this distance to the targets by identifying to what extent it is influenced by two explanatory factors[6] common to both types of projections.

1.4 Research Question

The commitment of the EU in combating climate change is evaluated by examining the targets of the ESD and by estimating the progress of MS towards achieving them. It is made clear that the focus of this thesis is on the targets of the ESD and more precicely on MSs' and the EU's projected distance in meeting those targets. Futhermore the addedd value of this thesis will derive from explaining this distance.

Research Question 1:
What is the distance to the targets of the Effort-Sharing Decision for Member States and for the EU27?

- What is the distance when PRIMES/GAINS projections are used?
- What is the distance when National projections are used?

[5] For example, if the target is 40MtCO_2eq and the projections estimate that GHG emissions will be 45 MtCO_2eq then the distance to the target is 5MtCO_2eq

[6] These factors are energy demand and the fuel mix.

The methodology for examining this research question is presented in the methodology chapter. The distance to the targets is the amount of emissions by which the Member State is projected to overachieve its target or fall short of. This amount of emissions is the outcome of each MS's projected energy demand and fuel mix. The distance therefore to the targets can be explained as the effect of energy demand and fuel mix and this leads to the second research question

Research Question 2:
How is this distance explained in the effects of energy demand and fuel mix?

This process of attributing the distance to the effects of the two explanatory factors is dealt with in the methodology chapter. Information on the technique used is in the second chapter, which is intended to provide the reader with additional knowledge on aspects of this thesis.

In this chapter a background was provided on the Effort-Sharing Decision and its targets. The knowledge gap in the literature was identified and questions were posed intended to provide answers related to it. The chapter to be read next is chapter 3 where the methodology is presented of how the research questions will be approached. It can already be declared that the first research question will be answered by comparing the targets with projections of GHG emissions; and the second by conducting an Index Decomposition Analysis on the distance between targets and projections.

2 Additional information

In this chapter additional information is provided regarding aspects of this thesis. It is not a crucial chapter for the understanding of the analysis or any other chapter but it is intended to provide the reader with more information on some topics. First the models that are used to derive the projections used in this thesis are mentioned along with their most basic characteristics. Secondly some legislative background is provided on the Effort Sharing Decision and the Monitoring Mechanism. Last but not least, there is a literature review of the method of decomposition analysis employed because it is an important part of the analysis and any additional questions can be answered through this chapter.

2.1 Explanation of models

There are two types of models referenced in this thesis; the EU-wide models represented by PRIMES/GAINS, and Member States' National Projections submitted under the GHG Monitoring Mechanism. The EU-wise models are presented first and the types of models used by Member States to derive projections are mentioned later.

The PRIMES energy-economy model was developed through research programs of the European Commission. The model was designed to focus on the evolution of energy demand and supply by examining marked related mechanisms. It was also designed to be used as a tool for policy analysis and technology assessment and to estimate, among other variables, CO_2 emission projections. PRIMES is a hybrid model that combines engineering technological approaches with economic market equilibrium in order to find solutions for energy supply and demand. In addition to its econometric results, PRIMES also calculates CO_2 emissions by sector and by fuel (E3MLAB, 2005).

GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) is an integrated assessment model and the product of modeling work at the International Institute for Applied Systems Analysis (IIASA). GAINS was developed as an extension of the Regional Air Pollution INformation and Simulation (RAINS) model dealing with costs and potentials for air pollution control and greenhouse gas mitigation. The GAINS model is also used in assessing interactions between policies for emission control strategies with the objective of reducing the impacts of air pollution; as well as for modeling policy outcomes (Klaassen, 2005)

Data referred to as PRIMES/GAINS data are the combination of results from the PRIMES and GAINS models. The PRIMES model is orientated towards CO_2 emissions while the GAINS model provides data for all GHG emissions. The reason they are referred to as PRIMES/GAINS[7] is because the energy data used

[7]PRIMES/GAINS also form part of the EC4MACS project, which stands for 'European Consortium for Modeling of Air Pollution and Climate Strategies'. This project brings together major EU-wide models to derive projections and policy analysis related to GHG emissions.

in GAINS are the input provided by PRIMES and the non-ETS emissions included in PRIMES are supplied by the GAINS model.

National Projections are submitted every two years to the GHG Monitoring Mechanism. Every Member State may derive its GHG projections using any models it finds fit to use. The main types of models used in National projections and reported by Duerinck (2008) are top-down macroeconomic models and the bottom-up technology orientated models. Those models are further split into more categories, which are briefly mentioned in the following paragraphs.

Top-down models are split in two broad categories: general equilibrium models and macro-econometric models. General equilibrium models are models based on market mechanisms. They assume that all economic agents behave in an economically rational manner and optimize their behavior according to the data available to them. These models assume that price mechanisms are in place to equate supply and demand variables and on these grounds reach solutions. Macro-econometric model are econometric models, which relate energy demand to variables such as income, prices of goods and productivity levels. They use econometric equations to relate those variables in final user sectors. In these models important parameters are economic factors represented by GDP growth by sector, taxes and energy prices.

Bottom-up models are split in optimization models, engineering models simulation models and end-use models. Optimization models are linear programming models used to develop GHG scenarios. They display technology options characterized by parameters such as cost, fuel type used, technology type and efficiency. Its results are provided within a limited by technological and environmental constrains range of solutions. The solution computed is the cheapest among a range of technologies that meet energy demand for all sectors. These models are very useful for assessing supply and demand policies to mitigate emissions and for identifying energy efficiency potentials. Engineering models are orientated towards the sectors of the economy (residential, agriculture, energy, etc). Projections of GHG emissions are derived based on activity indicators such as numbers of animals in the agriculture sector or million passenger-kilometers driven for the transport sector. The technological improvements are factored as well as emission factors of each fuel and sector as exogenous data usually from optimization models. There are also Simulation models, which are similar to optimization models, and finally there are also End-use models for energy planning which need to be supplied variables on fuel type use and energy efficiency evolution.

Finally there exist hybrid models which use a combination of bottom up and top down models to derive solution that also include estimates of future GHG emissions.

2.1.1 Decomposition Analysis

The method of analysis in the present thesis is decomposition analysis, and it is necessary to provide some background information regarding its use since it a central part of the analysis employed in this thesis. Decomposition analysis is a mathematical method first applied in the late 1970s in research related to industrial energy demand. Since then new methods of decomposition analysis and a variety of studies has been conducted especially in energy-related environmental analysis (Ang *et al*, 2000).

There are two distinct types of decomposition analysis in the field of Environmental and Economic Accounting used to study GHG emissions: Structural Decomposition Analysis (SDA) and Index Decomposition Analysis (IDA). SDA uses the input–output framework, while IDA uses aggregate sector information. Among the effects that can be studied using IDA and SDA are production effects, of which GHG emissions form a part. Production effects are changes in output from the sectors of the economy. Effects resulting from changes in the structure of production are best analysed by IDA while technological effects are ordinarily analysed by SDA. Changes in emissions can be analysed by both methods and further decomposed into volume of energy use per sector and emission intensity per unit of energy used (Wadeskog and Palm, (2003) in Jungnitz (2008)) .

Dieckmann *et al*. (1999) in Jungnitz (2008) categorized methods of decomposition analysis according to a number of features, which are:

- *The combination of driving forces* which determines the mathematical relation among the factors (addition, multiplication).
- *The level of disaggregation* is important as the analysis may focus on the national or the sectoral level of the economy and each of those levels needs to be examined in terms of its sub-categories. The author cites Rørmose and Olsen (2003), who found that the more the data used in decomposition are disaggregated, the easier it is to identify the effects in a detailed manner.
- *The residual term* implied the mixed effect, or the fact that the aggregated data are not perfectly decomposed.
- *The time concept* defines the relation of the effects in the decomposition analysis, which could be time continuous or discrete, meaning that either the whole time scale of data is examined, or only the first and last time points of the data series.

The variation within the above categories and the possible number of combinations of these categories has the ability to produce a diverse mix of methods of decomposition analysis. All of these approaches may yield different results when examining the same case study even though they are consistent and according to statistical theory, are all equivalent Dieckmann *et al* (1999) concluded that a decomposition problem has no unique solution, and the procedure depends on the data at hand and the objective of the analysis.

Considering the information provided above, decomposition analysis is shown to be not one unique technique, but rather a group of methods to distribute a computational outcome to the influence of its parameters. In general, the outcome of A, caused by the effects of B and C, and explained by the equation, A=B*C can be expressed after decomposition analysis as:

$$A = m \cdot B + n \cdot C \qquad (2.1)$$

where n and m denote the share of influence of each effect.

A variety of decomposition approaches may be followed according to the topic studied. The effects to which the outcome is distributed according to Seibel (2003) are either *isolated effects* or *mixed effects.*

If they are isolated effects, meaning that the change in one effect does not influence the other, then it is possible to fully distribute the outcome to the corresponding influence of each factor. If, on the other hand, they are mixed effects, influencing one another and, as an outcome of the decomposition analysis, there is also a residual amount left, denoting the mixed effect. In this second case, equation (3.1) above would be written as

$$A = m \cdot B + n \cdot C + D, \qquad (2.2)$$

where D is the residual effect.

Seibel (2003) argues that, in principle, this residual effect

- Can be either neglected if it is too small in which case the decomposition analysis is a good approximation, or
- It can be considered to distinguish between isolated and mixed effects, or
- It can be distributed among the different isolated effects.

Choosing decomposition analysis to study GHG emissions in this thesis means that it is necessary to decide between the two general categories of IDA and SDA. According to Hoekstra (2003), IDA requires less data than SDA but SDA is capable of more detailed decomposition of time series. SDA can also distinguish demand and technology effects, which the IDA cannot. For complicated analyses, the SDA is preferred in order to distinguish the indirect effects. Those effects emerge when demand fluctuations in one sector causes changes in the demand of other sectors and in the inputs required by them. These effects are best targeted with an SDA that makes use of the Leontief[8] inverse table, which is able to provide information on the relation between those mixed effects. Thus, according to the above an SDA analysis would not be needed since its detailed capabilities exceed the requirements for this present thesis.

The IDA method is sufficient for this thesis because the two explanatory factors to which the emissions are decomposed (the energy demand and the fuel mix) are considered unrelated (isolated effects). Furthermore, the data needed to conduct the IDA are aggregate sector information, are readily available in the projections related to the topic of this thesis.

---

8 Detailed information on this method can be found in the following publication:
Leontief, W (1970): Environmental Repercussions and The Economic Structure – An Input-.output Approach. The Review of Economics and Statistics LII, nr. 3,

2.2 Legislative background

The two most important legislations related to the topic of this thesis is presented in this section. The first is Effort-Sharing Decision is the central point of this thesis because of the targets it sets for MS regarding their non-ETS GHG emissions. The second is the Monitoring Mechanism decision, which sets up the reporting of National Projections and is therefore important in that the guidelines set forth by it and its accompanying document determine the projection reporting requirements.

2.2.1 The Effort Sharing Decision No 406/2009/EC

The Effort Sharing Decision (ESD) was agreed upon as part of the Climate and Energy Package (EU CEP) in December 2008. The legislation grouped under the CEP aims at meeting the targets of reducing GHG emissions by 20% compared to 1990 levels, increasing the share of renewable energy to 20% by the year 2020 and reducing primary energy use by 20% below projections through using energy efficiency. The first target of reducing GHG emissions by 20% is split in the ETS and non-ETS emission according to the emissions covered under the EU ETS. For the non-ETS emissions the ESD sets targets for to individual Member States for the year 2020.

The ESD comes into effect in 2013, and Member States have to follow a linear trajectory reduction path to the 2020 target. The yearly target is something unprecedented in climate politics and there will be annual monitoring and compliance checks to keep Member States on this trajectory. Moreover, the ESD sets binding targets, meaning that there are penalties for Member States who deviate from a linear reduction path to 2020. In the case that a MS emits more than it is allowed in a year, then it has to reduce those extra emissions multiplied by 8% in the next year.

Targets of the ESD are specific for every Member State and are estimated compared to 2005 emissions. Instead of choosing 1990 emissions levels to set the ESD targets, the year 2005 was chosen as a base year. The two main reasons for this decision are that 2005 was the first year where a ETS /non-ETS split exists, because of the reporting of emissions to the EU ETS; and also in order to account for the de-industrialization of Eastern European Member States. The ESD targets are expressed as a percentage of 2005 non-ETS emissions, and are therefore not set as absolute amounts. These amounts will be available in a Commission report later this year because the 2012 inventories are needed in order to accurately calculate the quantitative targets.

The ESD is based on the principle of fairness and solidarity. Thus, the targets are distributed according to a GDP/capita methodology among the 27 Member States to account for their ability to afford the needed reductions. On the one hand Member States whose GDP per capita exceeds the EU average, decisive targets are assigned, amounting up to 20% below 2005 non-ETS levels. On the other hand, countries with a lower than average GDP per capita are allowed to increase their emissions up to 20% in relation to 2005 non-ETS levels.

Under the Effort-Sharing Decision, there is the option to use flexibilities to comply with the yearly targets. Member States are allowed to trade emissions among themselves, and every year a Member State may transfer up to 3% of its unused annual quantity to another Member State and may carry over the unused part into subsequent years. Banking of emissions is also allowed, meaning that a country may 'borrow' 5% from its expected emissions in the following year to cover the gap to its yearly target. Flexibilities also include the use of CDM credits (Clean Development Mechanism)[9] and JI credits (Joint Implementation)[10] from projects that the country is realizing overseas. These credits can be used to reach the Effort-Sharing target, but only up to 3% of the country's 2005 emissions. However, Member States with reduction or increase targets of less than ±5% are allowed to use extra CDM and JI credits equal to 1% of their 2005 emissions[11].

There are, however, concerns regarding the usage of the flexibility mechanisms. For example, the market for non-ETS emissions is very mall, with only 27 actors, and a price for carbon has not been determined. This fact has consequences for the assessments of Member States regarding the cost effectiveness of trading those emissions. The 3% limit for CDM credits is applied at the Member State level, but the access rights (CDM warrants) are tradable among governments allowing for further decreases in emissions to be derived from CDM credits (Gorecki *et al*. 2009).

2.2.2 The Monitoring Mechanism Decision No 280/2004/EC

The Monitoring Mechanism Decision replaces an older decision[12] from 1993 that embodied similar legislation. These decisions set up a greenhouse gas monitoring mechanism in order for the EU and MS to comply with international climate agreements by report their annual emissions to the UNFCCC. The Monitoring Mechanism is focused is on anthropogenic greenhouse gas emissions, except those covered in the Montreal Protocol, and it evaluates progress towards meeting commitments in respect to those gases. It is set up in a way that strives to provide complete, accurate, consistency and transparent reporting to the UNFCCC secretariat. It also implements the decisions of the UNFCCC and the Kyoto Protocol. Moreover, it works with National Programs, GHG inventories, national systems and registries, and the relevant procedures under the Kyoto Protocol. The emphasis of the Monitoring Mechanism is cantered on setting up national programmes to address climate change and on the reporting of emissions. Furthermore, and of interest to the present thesis is that Article 2(2) of the Monitoring Mechanism establishes the reporting of National Projections every two years in order to assess the projected progress. The guidelines for the implementation of the Monitoring Mechanism published in Commission Decision (2005/166/EC) are partially responsible for the reporting outcomes of Member States.

---

[9] More information on the Clean Development Mechanism is available at: http://cdm.unfccc.int/.

[10] More information on Joint Implementation is available at: http://ji.unfccc.int/

[11] This is applicable for the MSs mentioned in Annex III of the ESD: Belgium, Denmark, Ireland, Spain, Italy, Cyprus, Luxembourg, Austria, Portugal, Slovenia, Finland, Sweden

[12] 93/389/EEC: Council Decision of 24 June 1993 for a monitoring mechanism of Community CO_2 and other greenhouse gas emissions.

3 Chapter 3: Methodology

3.1 Introduction

The purpose of this methodology is to explain the two parts of the analysis. The first part is the procedure followed for determining the distance of Member States to the 2020 targets of the Effort-Sharing Decision. The second part is the procedure followed for explaining this distance through a decomposition analysis.

The first part of the methodology describes how to calculate the distance to the ESD targets by subtracting the ESD target emissions from projected GHG emissions. The distance to the Effort-Sharing Decision targets is examined from two viewpoints, representing the GHG projections used: the EU-wide viewpoint of PRIMES/GAINS and the country-specific of National Projections. The results are added to reveal EU's distance to the overall target of -10% non-ETS emissions compared to 2005.

The second part of the methodology and the most complicated, describes how to distribute this distance between projections and the ESD targets, to sectors of the economy; and how to explain it using a decomposition analysis, as the effect of two explanatory factors: the energy demand and the fuel mix. As a first step the energy demand and fuel mix corresponding to the ESD targets are calculated according to their observed trend in every sector resulting in the non-ETS target emissions. These data are needed for the decomposition. An outcome of this approach is the possibility to distribute the estimated distance between targets and projections, to the sectors of the economy. The following step is to conduct an Index Decomposition Analysis (IDA) on every sector to examine the distance as the effects of energy demand and fuel mix. Finally, the results of each sectoral distance are added up to explain the distance between targets and projections as the effects of energy demand and fuel mix.

3.2 Methodology flow chart

The steps followed in the methodology are briefly explained in Figure 3.1. The flow chart is split in parts 1 and part 2, which exhibit the process followed to answer the first and the second research questions respectively. The darker boxes are the available data and the lighter boxes are the outcome of calculations in the analysis. The arrows indicate which data lead to the indicated results.

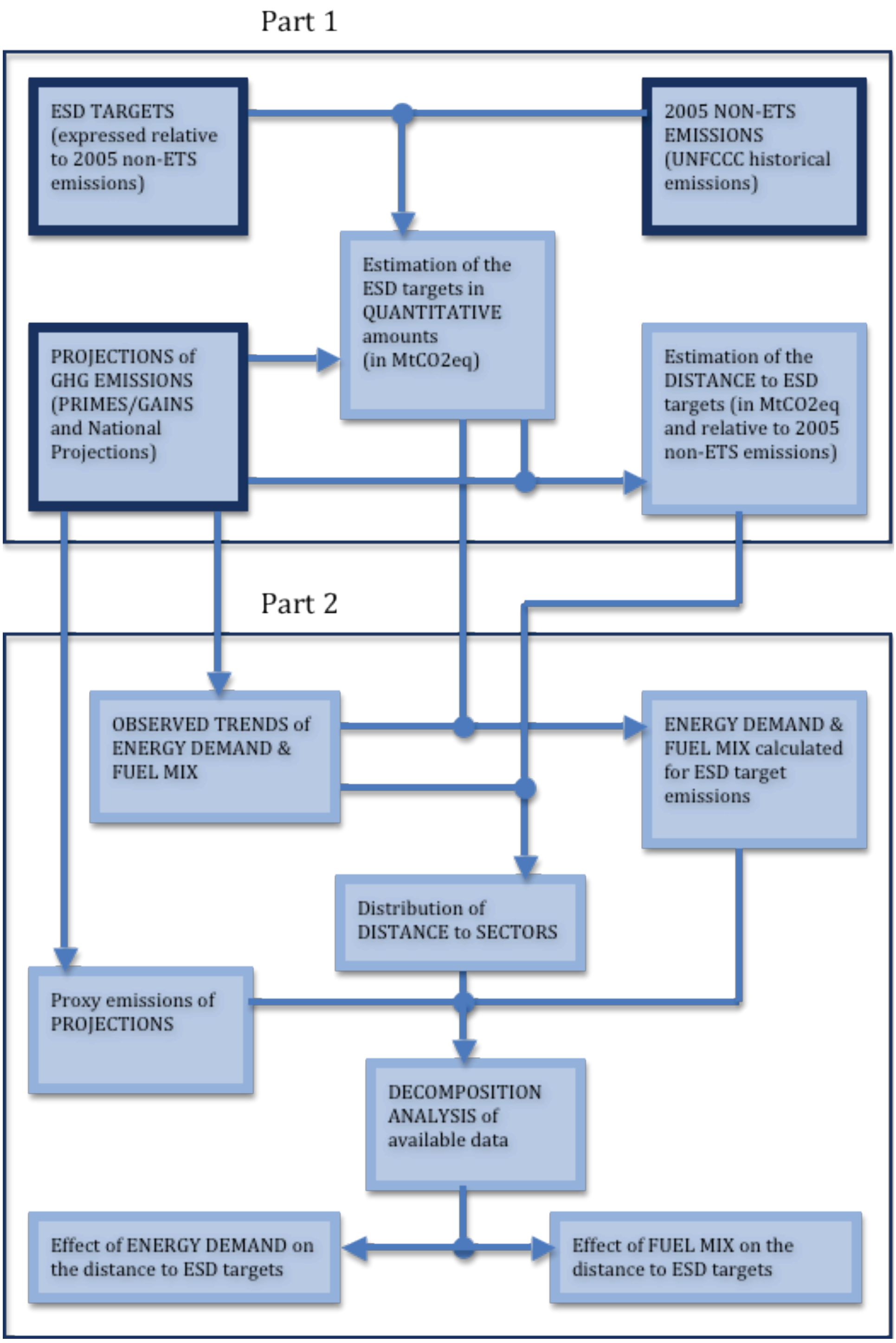

Figure 3.1 Methodology Flow Chart

3.3 Data collection

The data needed for this thesis are GHG projections and the targets of the ESD. The first are derived from the PRIMES/GAINS combination of models and National Projections; while the second are found in the Effort Sharing Decision.

When additional sourced of secondary data are used (i.e. emissions factors), their source is provided in the methodology. The analysis is carried out using Microsoft Excel spreadsheets

3.3.1 PRIMES/GAINS

PRIMES/GAINS data are retrieved from Capros *et al* (2010) and from IIASA online (Mitigation of Air Pollution and Greenhouse Gases, 2012). The IIASA (or GAINS ONLINE) site provides a variety of data depending on the scenario chosen. Emissions projections and activity indicators needed for this thesis are obtained by selecting the PRIMES 2009 BASELINE SCENARIO. Emission projections are retrieved from the Emissions tab and the explanatory factors of those emissions are retrieved form the Activity Data tab. Emissions are generated in a separate window and the models used for the generation of those results are referenced. For more information on how the site functions, the reader is advised to read the Tutorial for Advanced Users (Gains Online: Tutorial for Advanced Users, 2009).

3.3.2 National projections

Data of GHG emission projections are collected from the 2011 reports of Member States submitted to the Monitoring Mechanism as required by Article 3.2 of directive 280/2004/EC. These are mentioned as National projections or NP for short. These projections are divided in two scenarios; the With Existing Measures scenario (WEM) and the With Additional Measures scenario (WAM). The reported projections of Member States up to 2020 are retrieved from the Reporting Obligations Database (ROD)(Eionet Reporting Obligations Database, 2012) of EIONET (European Environment Information and Observation Network) which is part of the European Environment Agency (EEA). National projections undergo quality and consistency checks by the Commission and the European Environment Agency (Okamura *et al* 2012).

3.4 Part 1: The Distance to the Effort-Sharing Decision Targets

The first part of the analysis aims at answering the first research question relating to the distance of Member States to their targets. The outcome of this analysis also allows determining the EU's distance to its ESD target of 10% less non-ETS emissions compared to 2005. Since these distances are estimated using PRIMES/GAINS and National Projections, it is also possible to compare their respective the EU-wide and the MS-specific viewpoints.

The distance to the ESD targets is defined as the amount of GHG emissions resulting from the difference between projections of non-ETS GHG emissions for 2020 and the targets set forth in the Effort-Sharing Decision.

$$\text{Distance} = \text{GHG Projections} - \text{ESDTargets}$$

Proper calculation of the distance to the ESD targets requires projections of non-ETS GHG emissions, with estimates for the year 2020, and the targets of the ESD[13]. Projections are provided by National Projections and by PRIMES/GAINS projections and are reported in quantitative amounts in million tonnes of CO_2 equivalent GHG emissions ($MtCO_2eq$). Targets of the Effort Sharing Decision are specific for each Member State and defined in relation to 2005 non-ETS emissions. It is not possible to directly subtract Targets from Projections in the form they are retrieved because the targets need to be first estimated in quantitative amounts as well.

3.4.1 Estimation of the ESD targets in quantitative amounts

The targets of the Effort-Sharing Decision are laid out in Annex II of the decision and are defined as a percentage relative to 2005 non-ETS emissions. As previously explained, it is not possible to estimate the distance if targets appear as they do in the ESD. No official release by the Commission of the quantitative targets is available yet[14]. Consequently, before anything else, it is important to estimate the targets in quantitative amounts by making use of 2005 non-ETS emissions. Historical emissions of GHG are not definite for non-ETS sectors, since they are subject to updates and corrections. Moreover, because there are two projections used to determine the distance and because each projection might be based on different historical data, it is necessary to explain in detail the source of historical data as they are of utmost importance in determining the ESD's quantitative targets.

The methodology followed for assessing the ETS targets in quantitative amounts should be the same as the one the Commission used in determining the targets so as to have the same base year emissions. In the Impact Analysis for the EU Climate package, the PRIMES/GAINS models were used and it is stated that 2005 figures for non-ETS emissions were based on UNFCCC statistics (Capros, *et al* 2008). The same base year emissions are used in this analysis as well and are retrieved from PRIMES/GAINS and specifically the PRIMES 2009 baseline scenario (Capros *et al*, 2010). The PRIMES baseline scenario uses Eurostat figures for CO_2 historical emissions and GAINS data for the non-ETS emissions. The GAINS data are model-generated data designed to fit UNFCCC historical data. The GAINS model develops a baseline projection of GHG, by following the IPCC recommended approaches and by using information from the national GHG inventories reported by Member States to the UNFCCC. The GAINS model uses a regression process to fit the model generated 2005 non-ETS emissions to the UNFCCC data (Höglund-Isaksson *et al*, 2010).

Therefore, UNFCCC historical emissions are the source of PRIMES/GAINS for the non-ETS shares of 2005. The 2005 non-ETS data are submitted by

[13] Member States are also allowed to use flexibility mechanisms present in articles 3 and 5 of Decision 406/2009/EC to meet their targets but those are not factored in the analysis because Member States' decisions on the use of those flexibilities are uncertain.

[14] The European Commission is working on a report due to be released in late 2012 where it will estimate in absolute numbers the targets of the ESD. The methodology it follows is to subtract the verified ETS emissions from the 2005 UNFCCC totals (excluding LULUCF) for the year 2005. In this present work, the targets of the ESD are also estimated using the principle stated above. More information on this method can be found in the Appendix

Member States in their annual reporting of GHG emissions to the UNFCCC. Hence, the historical emissions used to estimate the targets are common to both projections.[15]

The next step is to calculate the quantitative targets (targets in $MtCO_2eq$) from the targets as defined in the ESD by multiplying them with 2005 non-ETS emissions. The equation used is

$$T_Q = T_{ESD} \cdot nonETS_{2005} \qquad (3.1)$$

where[16] :
T_Q is the ESD target in quantitative amounts ($MtCO_2eq$)
T_{ESD} is the ESD target as defined in the ESD
$nonETS_{2005}$ are the non-ETS emissions of 2005 as retrieved from PRIMES/GAINS.

3.4.2 Estimation of the distance

The distance is estimated for all 27 Member States where each has its own target. The distance is also calculated on the EU27 level where the EU has set a collective reduction target of 10% below 2005 non-ETS emissions levels.

3.4.2.1 Member States

The distance to the ESD targets is the difference between the quantitative targets estimated in the previous step and the projections of non-ETS GHG emissions for the year 2020. These projections are provided by PRIMES/GAINS and by National Projections' "With Existing Measures" and "With Additional Measures" scenarios.

The distance is calculated by subtracting the target from the projected non-ETS emissions as illustrated in equation (3.2):

$$\Delta Target = (T_Q - nonETS_{2020}) \qquad (3.2)$$

The distance is expressed relative to 2005 non-ETS emissions for comparison with the relative ESD targets as defined in Annex II of the decision.

$$\Delta Target_R = \Delta Target \ / \ nonETS2005 \qquad (3.3)$$

$\Delta Target$: Distance to target T_Q expressed in quantitative amounts
$\Delta Target_R$: Distance to ESD target expressed relative to 2005 non-ETS emissions.
T_Q: The quantitative target

---

[15] Estimating the ESD targets using data from PRIMES/GAINS and data from National projections produces a margin of error of less than 1%

[16] The application of this equation is shown for the case of Austria, where the 2020 quantitative target emissions in the non-ETS sectors are:
$T_Q = T_{ESD}$ x $nonETS_{2005}$ = -16% x 60.2 $MtCO_2eq$ => T_Q = 50.6 Mt CO_2eq

$nonETS_{2020}$: The amount of non-ETS emissions in 2020 as projected by PRIMES/GAINS and National Projections' scenarios
$nonETS_{2005}$: The amount of non-ETS emissions in 2005 based on emissions reported to the UNFCCC

The distance to the ESD targets can take the form of a policy gap or overshoot. Policy gap means that the target is not projected to be achieved and overshoot denotes that the projected emissions are lower than the target. This distance may be expressed in positive percentage points (overshoot of the target) or negative percentage points (policy gap). Figure 3.2 demonstrates visually the method of estimating the distance to the target of the ESD.

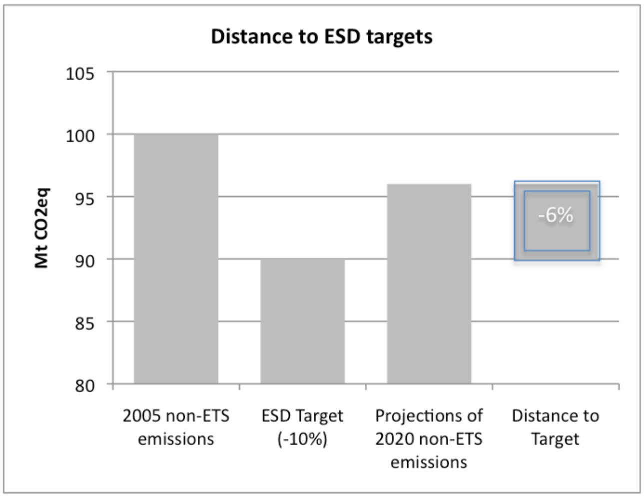

Figure 3.2 Estimation of the distance between targets and projections

First 2005 non-ETS emissions are retrieved and multiplied by the ESD target of each MS. Then, this result is deducted from projections of GHG emissions for 2020. The difference is expressed relative to 2005 non-ETS emissions and represents the projected distance of MS to their targets.

3.4.2.2 EU27

The distance of the EU as a whole to the ESD target (a 10% reduction of 2005 levels) is also estimated by adding up all the MS-specific distances and dividing the sum by EU27's non-ETS emissions of 2005.

$$\Delta Target_{EU} = (\Delta Target_{AT} + \ldots + \Delta Target_{UK})/nonETS_{2005\text{-}EU} \qquad (3.4)$$

Since there are three projections of GHG used (PRIMES/GAINS, NP WEM, NP WAM) there are three distances expected. However in order to estimate the distance MSs should provide a split of their total GHG emissions into ETS and non-ETS. In case a Member State did not report an ETS/non-ETS split in their National projections, then there is no official non-ETS split to be used for determining the distance to the ESD targets. As all MS's non-ETS emissions are needed to estimate EU27's distance to the ESD target in three scenarios, the share of non-ETS emissions is taken from PRIMES/GAINS and applied to NP's total GHG emissions. This procedure is only followed to provide MS's viewpoint on Europe's distance to the targets and it is not used in determining the distance of individual Member States.

3.5 Part 2: Decomposition of the distance to the ESD targets

The second part of the methodology, describes how to examine in detail, with the use of a decomposition analysis, the distance between targets and projections estimated in the previous part. This distance is made up from emissions and can be expressed as an equation of energy demand and fuel mix. As a first step, energy demand and fuel mix variables are calculated for the ESD targets by using the trend of these two explanatory factors as observed in reported non-ETS projections. In the second step, the distance to the ESD targets is distributed among the sectors of the economy according to the same evolution of energy demand and fuel mix. Finally, the distance is decomposed according to the Index Decomposition Analysis (IDA) method since the required data are readily available from projections and because the effects of the two explanatory factors are not related. The results are presented as the shared influence of Energy Demand and Fuel Mix in each sector on which the distance to the ESD targets is distributed.

3.5.1 GHG emissions connected to Fuel mix and Energy demand

The distance between the ESD targets and the projected emissions is to be explained by the effects of energy demand and fuel mix. Hence, it is necessary to define the relation between the emissions and their explanatory factors. GHG emissions are connected to the energy demand and the fuel mix in the following manner:

$$\text{Emissions} = \text{EnergyDemand} \cdot (a \cdot \alpha + b \cdot \beta + c \cdot \gamma) \qquad (3.5)$$

Where α, β, γ are the emissions factors corresponding to the fuels with a, b, c shares in the fuel mix. The fuels examined are Gas, Solid fuels (coal) and Oil (for the transport sector this is divided in diesel oil and gasoline). Renewable and Nuclear energy have no GHG emissions.

The emission factors are defined as the mass of CO_2 produced for every unit of energy contained in the combustible fuel (kg CO_2/MJ). These emission factors are very specific for each type of fuel and very important in determining emissions. Projections make no distinction of the fuels used in more detailed categories so as to allow the use of very specific emission factors. For the present analysis generic emissions factors are retrieved from Blok (2007 intro to energy analysis)[17], which provides a good approximation for estimating emissions from fossil fuels. Emission factors for N_2O, CH_4 are not included in the calculations because they are one or more orders of magnitude smaller than CO_2 emission factors and their influence is therefore minimal.

[17] Very detailed emission factors can also be supplied through the IPCC Emissions Factor Database http://www.ipcc-nggip.iges.or.jp/EFDB/main.php.

3.5.2 Proxy emissions for projections

Proxy emissions are calculated based on energy demand and fuel mix data. However those data are provided for total GHG emissions and not specifically for non-ETS emissions. There is a need therefore to extract from the reported explanatory factors those responsible for non-ETS emissions. This is tackled by excluding data that are definitely not included in non-ETS such as energy demand from coal in the energy sector. In addition, data on electricity use of every sector are also excluded to avoid double counting because electricity generation is typically a process taking place in the energy sector and covered under the EU ETS. Finally, the non-ETS data for energy demand and fuel mix are calculated by taking into account the share of non-ETS emissions in every sector as reported in projections and using it to divide the remaining energy demand and fuel mix data into their non-ETS parts.

According to equation 3.5, the combination of energy demand, emission factors and fuel mix should produce the projected emissions but it does not. Emissions estimated using the explanatory factors are by a few percentage points different from the projected emissions.
Since it is not possible to estimate the reported emissions from the available energy demand, the decomposition analysis will make use of proxy emissions. Proxy emissions are the emissions resulting from the available data when the generic set of emission factors is used[18]. Proxy emissions are adjusted to fit the reported emissions using a technique based on the observed trend of emissions. This technique is explained in the following section. This adjustment is presented in the results as uncertainty.

3.5.3 Energy Demand by fuel and sector calculated for ESD's target emissions

The energy demand and fuel mix of projections is known but the targets have none of those. For the effect of the fuel mix and energy demand in the distance to the ESD target to be assessed, the target emissions need to consist of those explanatory factors as well. Since the targets of the ESD do not consist of data on energy demand by fuel, assumptions need to be made in order to fill this gap. A very helpful question to be asked at this point is: What would those data be if the targets were reached?

This question points to the fact that at some point in time the targets will be met if the current trend in energy demand and fuel mix continues. For every set of these energy demand and fuel mix trends, corresponding emissions are estimated. The trends followed until the resulting emissions equal the ESD target emissions. Based on their observed evolution in projections towards the ESD targets, energy demand and fuel mix values are retrieved for every sector and fuel. This procedure provides very detailed results since the emissions resulting from all fuels in all sectors are estimated.

[18] The emission factors used are 0.056 kg CO_2/MJ for Gas, 0.078 kg CO_2/MJ for Oil and 0.093 kg CO_2/MJ for solid fuels.

In short energy demand and fuel mix values are assigned to the ESD target emissions based on projections of when those emissions will be met.

The equation on which emissions are based for this analysis is presented here. Note that all its elements are known. The variable 'emissions' is the amount of target emissions and is made up of emissions for each fuel. Values for energy demand (ED) reported and the emissions factors of fuels (CO_2ef) are known. The term TimeStep is steady in all.

$$Emissions_f = (ED_{2025}/ED_{2020})_f \cdot TimeStep \cdot (ED_{PROJECTIONS})_f \cdot EF_{CO2} \quad (3.6)$$

- ED is the reported or projected energy demand
- ED_{2025}/ED_{2020}: the rate of change of the energy demand for defined sector and fuel
- TimeStep: the adjustment factor needed to balance the equation
- EF_{CO2}: the CO_2 emission factor of each fuel
- f = oil, gas or coal

The application of equation 3.6 is illustrated in the example of Figure 3.3. Energy demand and fuel mix trends are displayed to the year 2030 which were reported in projections. Emissions resulting from the combination of fuel mix and energy demand are plotted using the dotted line. At some point in time the emissions represented by the dotted line equal the target emissions of the ESD. In this example the target is 55 $MtCO_2eq$ and is reached around 2023. The fuel mix and energy demand values corresponding to the ESD target in 2023 are the points where the dashed vertical line meets the fuel trends. The energy demand and fuel mix values of 2023 are attributed to the target of the ESD.

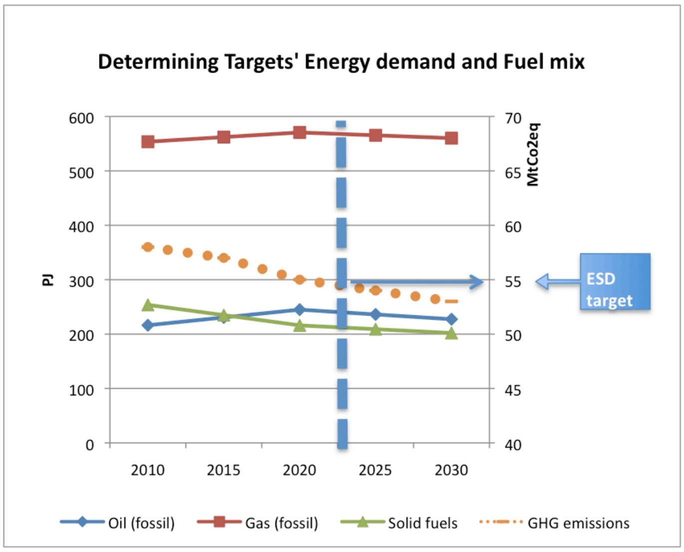

Figure 3.3 Target's energy demand and fuel mix

To parallel equation 3.6, the term 'Emissions' is the dotted line and the term '$ED_{PROJECTIONS}$' are the amount of each fuel (in Peta-Joules). The term TimeStep is the same for all fuels and is represented by the vertical dashed line that adjusts the equation (moves left and right) so that it meets the ESD target emissions. When it does, the data for fuel mix and energy demand are the points where the dashed like meets the trends of each fuel.

3.5.4 Uncertainty

The aforementioned technique, based on energy demand by fuel, is also used in correcting the discrepancy between proxy emissions and reported emissions caused by the use of generic emission factors as mentioned earlier. The technique of equation (3.6) is followed for energy demand and fuel mix data provided in projections and the corresponding emissions are estimated without the use of the TimeStep variable. If the results are not the same as the ones reported due to generic emission factors, then the results are corrected to meet the reported emissions by assigning the appropriate value to the TimeStep. This correcting of the effect of emission factors is reported as uncertainty along with the results of the decomposition analysis.

3.5.5 Distribution of distance in sectors

The distance is distributed in sectors to determine the influence of each sector on the distance between projections and targets. The distribution results from deducting sector level targets estimated in the previous step from reported sector level projections. Proxy emissions are available and target emissions have been worked out using the observed trends. Those emissions are very detailed and there are values for the emissions produced by every fuel in every sector. The distribution of emissions in sectors is estimated by subtracting the target emissions from the proxy (projected) emissions for every sector.

$$Distance_{SECTOR} = Projections_{SECTOR} - Target_{SECTOR} \qquad (7)$$

The sum of the sector distances equals the distance of a MS to the ESD target

$$\Delta Target = Distance_{SECTOR1} + Distance_{SECTOR2} + \ldots + Distance_{SECTOR5} \qquad (8)$$

The sectors in which the distance is split are the Energy sector, the Industry sector, the Transport sector and the Built Environment comprising of the Residential and Commercial sectors.
The emissions of the Agriculture and Waste sectors are determined by multiplying the rate of change of their projected emissions with the TimeStep estimated for the other sectors.

$$Emissions = (Emissions_{2025}/Emissions_{2020}) \times TimeStep \qquad (9)$$

3.5.6 Decomposition of available data

The following part is the core of the method used answer the second research question. The decomposition method explained below is just one of the many possible methods of decomposition[19]. It is the last step of the analysis used to distinguish the effects of fuel mix and energy demand responsible for the observed distance between targets and projections.

[19] This variety is explained in 2.1.1 Decomposition Analysis.

The Index Decomposition Analysis (IDA) is the method employed to distinguish the impact of two separate, in this case, developments (energy demand and fuel mix) on the evolution of the parameter in focus (difference of target and projected non-ETS emissions). The effects of the explanatory factors are regarded as unrelated even though there is price elasticity for fuel use in different sectors, which is able to cause changes in the fuel mix and in energy demand. However, these effects are considered not applicable on the present decomposition analysis because of its relative short timeframe.

Moreover, the decomposition is carried out on the sector level and provides detailed information, improving the results of an IDA. The result of an IDA are improved because the more disaggregated are the data used for IDA, the more accurately the aggregated data are decomposed into the effects of the explanatory factors. This means that if the IDA is performed on the sector level, then the accuracy of the method in explaining the distance between targets and projections is increased.

The decomposition analysis in essence transforms the relation between emissions and the explanatory factors to a form that can distinguish between the effect of fuel mix and energy demand on emissions. The procedure is explained below. For ease of presentation the emission factors are included in the fuel mix term. Equation (3.5) can be written as:

$$E = FM \cdot ED$$

Decomposition analyses are conducted in time series because there is a need for this expression at a second point in time. In the present analysis the two points are the ESD targets and the Projections. The distance between those is written as:

$$\Delta E = E_P - E_T = FM_P \cdot ED_P - FM_T \cdot ED_T \qquad (3.10)$$

The effect of energy demand on the distance is observed by equalizing it between projections (or between the two point in time)

$$\Delta E_1 = \Delta FM \cdot ED_P \qquad (3.11a)$$

then by equalizing the fuel mix, its effect is observed

$$\Delta E_2 = FM_T \cdot \Delta ED \qquad (3.11b)$$

these two effects are added up to explain the distance to the ESD targets

$$\Delta E = \Delta E_1 + \Delta E_2 \Leftrightarrow \Delta E = \Delta FM \cdot ED_P + FM_T \cdot \Delta ED \qquad (3.12)$$

- Δ denotes difference
- ED is the term for Energy Demand
- FM is the term for Fuel Mix. The emission factors are included in the fuel mix term.
- The subscripts are P for Projected and T for Target emissions.

The decomposition is carried out by re-estimating the ESD target emissions for every sector using the energy demand of projections. The result is deducted from the ESD target emissions and that difference is the effect of energy demand for each sector. The effect of the fuel mix is calculated by deducting the effect of energy demand from the sectoral distance between projected and target emissions.

The process is explained using the fictional Scenarios 1 and 2 whose emissions are represented in Figure 3.4. Just as with the target and projected emissions, each scenario has its own energy demand and fuel mix that results in the emissions observed on the left side of the graph. Once Scenario 1 uses the energy demand present in Scenario 2, than its emissions increase. This increase is the effect of the energy demand. The effect of the fuel mix is the remaining distance to the top of the higher bar. In this way, the effect of the fuel mix and the effect of energy demand on the distance to the targets is determined.

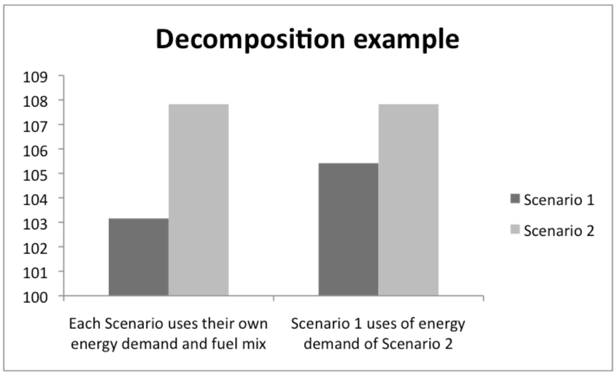

Figure 3.4 Example of decomposition analysis

3.5.7 Choice of Member States

A decomposition analysis into the distance to the ESD targets requires that the sample be reduced from 27 countries, to only a few because of the time consuming nature of this process. The following data selection criteria are adopted in order to narrow down the sample to a couple of Member States. With the following criteria, it is examined whether or not projections comply with quality requirements in the context of this thesis and its objectives.

- Member State should score well on EEA's Assessment of MS's GHG projections (Okamura *et al*, 2012). This assessment has examined MS reporting on completeness, timeliness, consistency of projections and economic parameters and accuracy. The MS chosen therefore have met the quality standards of the EEA who is responsible for examining the submitted projections before they are submitted to the UNFCCC.
- Figures of 2025 non-ETS emissions and Energy Demand should be provided so as to use the observed trend towards the emissions of the ESD target.
- The distance to the targets of chosen Member States according to projections should be comparable in a way that allows insights into their relation and enhance the probability of the IDA to produce interesting results. For example, National Projections should exhibit a small

difference to the projections of PRIMES/GAINS for one MS and for the other, the projections should disagree on meeting the target.

France and Hungary are chosen because they both score exceptionally well (9/9) in EEA's assessment, and they both provide values for the explanatory factors needed to estimate the trajectory of their emissions. Additionally, the first has a reduction target and the second has a increase limit target and what makes their choice even more appealing is that the fuel mix share of France is dominated by nuclear energy and the fact that while Hungary has the ability to increase its emissions, its projections show a decrease. These aforementioned facts make those two Member States a good choice to conduct a detailed analysis on.

To sum up, the process mentioned in this chapter provides the method to answer the research questions. The two questions are concerned with finding out and explaining Member States' distance to the ESD targets. The first one is tackled using the methodology of part one; and the second, using the methodology of part 2. What those parts include can be described in a few words. In part one the distance is calculated by deducting the ESD targets from projections. This is estimated for all MSs and consequently for the EU as a whole. In part two, a decomposition analysis is conducted based on projections in order to determine the influence of the fuel mix and of energy demand on the distance between targets and projections.

The results of methodology's first part will determine what is the policy gap or overshoot of the ESD targets for all Member States and for the EU; thus answering the first research question. The second part will provide the influence of energy demand and fuel mix on the distance between targets and projections. It will therefore explain to what extent those explanatory factors have an effect on a Member State's overshoot or policy gap.

4 Chapter 4: Results

4.1 Introduction

The results deriving from the methodology are presented in this chapter. The first part is related to the projected distance to the ESD targets and the second part to the decomposition of this distance. Initially, the ESD 2020 targets are presented as defined by the Commission and as estimated in quantitative amounts for all MS. In the next step, the projections of PRIMES/GAINS and National Projections' scenarios for the emissions of non-ETS GHGs in 2020 are graphed. After non-ETS GHGs for 2020 are graphed, the distance to the ESD targets is introduced and which MS meet or overachieve their targets and which do not reach them and present a policy gap is determined. The distance of EU27 towards meeting the collective target of a reduction 10% compared to 2005 non-ETS emissions is also graphed. Finally, the decomposition analysis results regarding the distance to the targets are presented. These results depict the influence of energy demand and fuel-mix on the distance between projected and target emissions at the sector level and at the aggregate level.

4.2 Results of part 1: Targets, Projections and their Distance

The first part of the analysis deals with the first research question, which aims at estimating the distance of MS to the ESD targets. This distance is calculated based on GHG emissions anticipated by PRIMES/GAINS and National Projections. The outcomes of the analysis are presented in graphs. The computed results are also available in tabular format in the Appendix.

4.2.1 The ESD targets

The first step in estimating the distance to the targets is to figure out the amount of GHG emissions they represent. For this task, the 2005 non-ETS emissions are retrieved because the targets are set relative to those base year emissions.

The targets as defined in the ESD are plotted on the right axis of Figure 4.1. The 2005 non-ETS emissions, to which the targets are relative, are represented with the grey bars and the blue bars indicate the targets expressed in quantitative amounts. These quantitative targets are compared to projections at the next step.

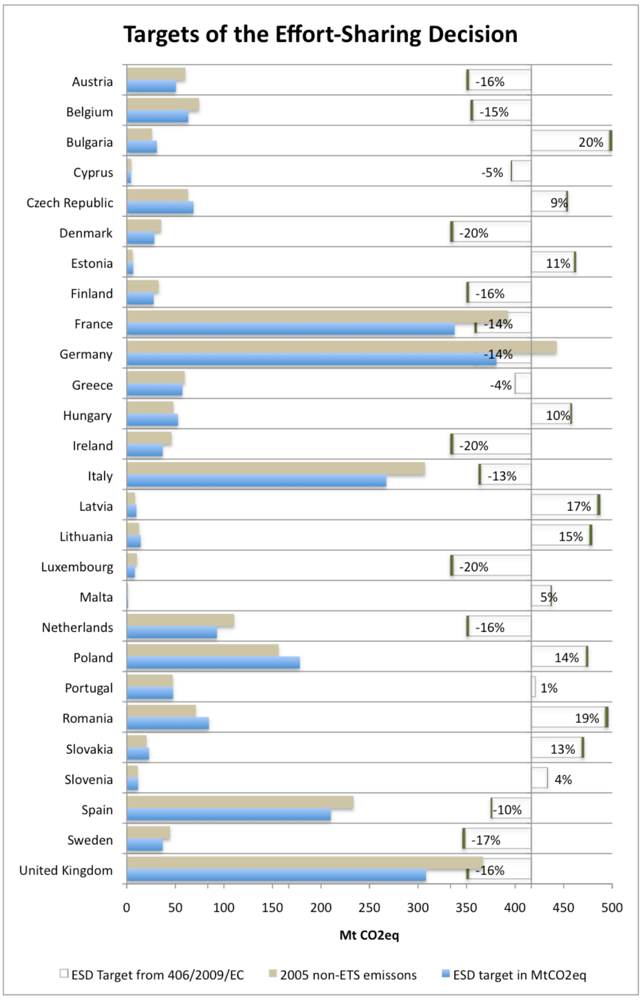

Figure 4.1 Targets of the Effort-Sharing Decision

4.2.2 Non-ETS emissions projections

The targets have to be contrasted against non-ETS GHG projections for the year 2020 to determine the distance between them and answer the first research question. Projections are supplied by the EU-wide models PRIMES/GAINS and by Member States' National projections estimated at the country level. These projections provide the viewpoint of EU-wide models and of MSs and on what the non-ETS GHG emissions will be in 2020. These projections take into account implemented and planned EU and national policies and have modeled the effect of the economic crisis. Projections for non-ETS greenhouse gas emissions in 2020 are presented in Figure 4.2.

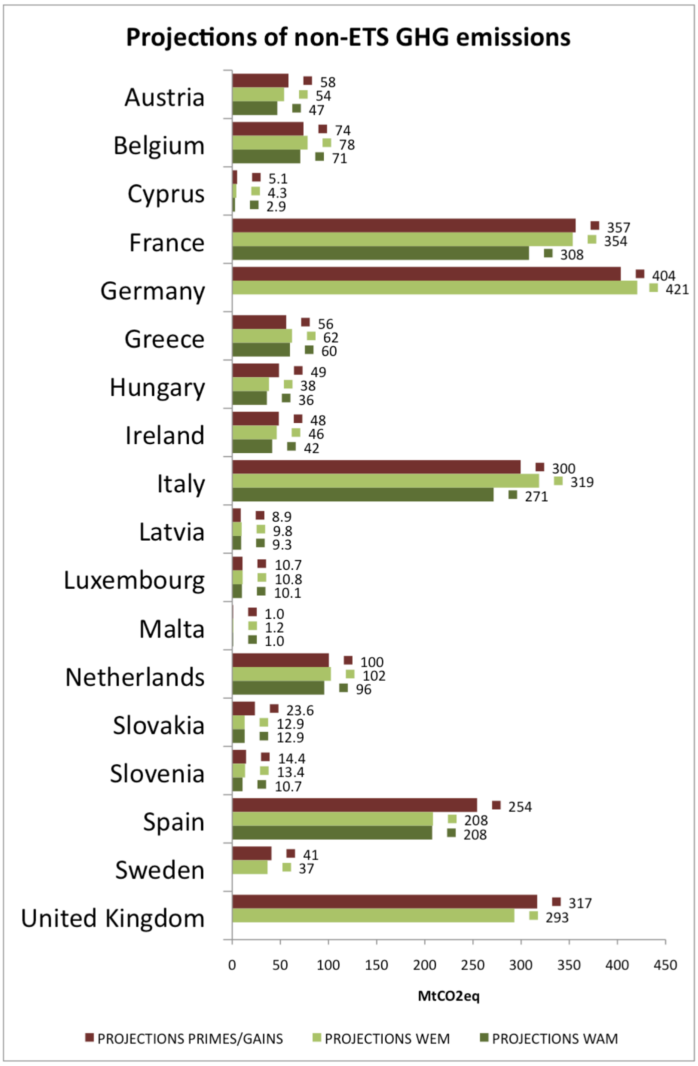

Figure 4.2 Projections of GHG emissions

In Figure 4.2 there are nine countries missing[20] because only MS for which there are both types of projections available are. The data are missing from the National projections as it is not obligatory to report an ETS/ non-ETS split. PRIMES/GAINS, on the contrary, provided data for all MS and they can be found at Table 3 in the Appendix.

Regarding the amounts of projected non-ETS GHG emissions, there are differences between the estimates of National Projections and PRIMES/GAINS because of the methodology used and the policies included in each. The relation between the two scenarios of National Projections is also variable and, as expected, the WEM scenario's emissions are always increased compared to WAM.

Due to the fact that the projections differ in their view of future emissions, it follows that the distance to the ESD targets is not unique; rather, it depends on which projection is chosen. Consequently, there are three distances estimated to the target of the ESD calculated for every MS.

[20] Bulgaria , Czech Republic, Denmark, Estonia, Finland, Lithuania, Poland, Portugal, Romania

4.2.3 Distance to the ESD targets for Member States

The data presented up to this point are the Effort-Sharing Decision targets for 2020 and the non-ETS projected emissions for 2020. The distance to the ESD targets for each country is calculated using all the available projections. There are PRIMES/GAINS projections for all MS, but National projections' ETS/ non-ETS splits are missing from nine MS, as stated earlier. These nine countries are not represented in the next graph, but their distance according to PRIMES/GAINS can be found in Table 3 in the Appendix .

In the following figure, MSs' distances to the targets are expressed in relative amounts (as a percentage) compared to 2005 non-ETS emissions. A bar at the right-hand side of the axis indicates the targets that are projected to be overachieved, and the bar to the left-hand side of the axis indicates the policy gap and remaining effort needed to be realized in order to meet the targets.

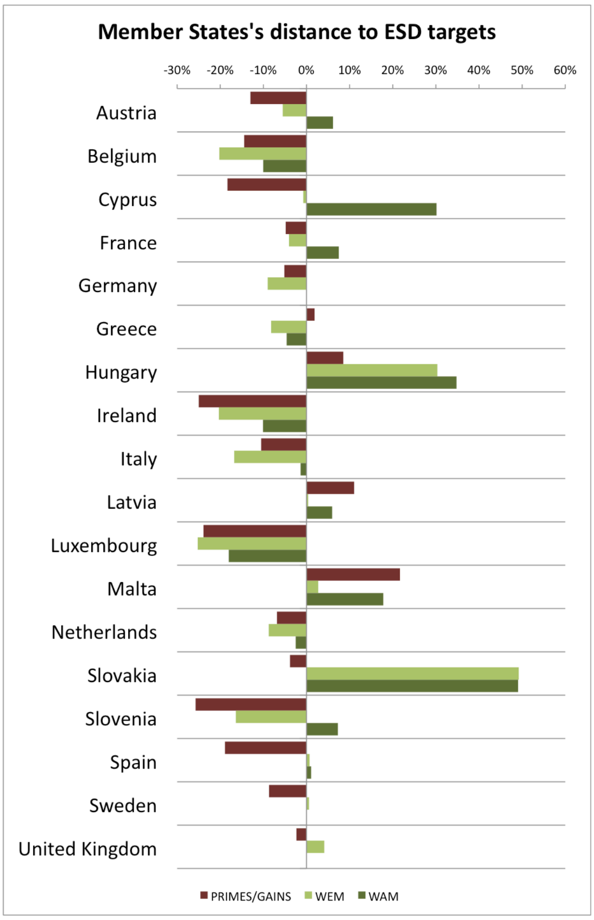

Figure 4.3 Distance to the ESD targets for Member States

A first glance at the above graph, three aspects are easily observable :

1. There are more MS with a policy gap than MS that go beyond their targets.
2. There are MS where the distance is very similar (i.e. Luxemburg, Belgium) or very dissimilar according to the three scenarios (i.e. Austria, Latvia)
3. Some MS are very close to the target for all projections, regardless of direction (i.e. France, Germany, Greece, the Netherlands, Sweden, UK)

4.2.3.1 Policy gap and overachievement of ESD targets

The following table presents MS's direction to the target. Note that the distance to the targets is not represented here. What is represented is the view provided by projections on whether a MS will achieve its target (✓), or whether it needs additional effort (+).

Table 1 Overshoot or policy gap for Member States

Overshoot (✓) or policy gap (+) in relation to the Effort-Sharing Decision targets

ESD target		PRIMES/ GAINS	N.P. With Existing Measures	N.P. With Additional Measures
-16%	Austria (AT)	+	+	✓
-15%	Belgium (BE)	+	+	+
20%	Bulgaria (BG)	✓	N/A	N/A
-5%	Cyprus (CY)	+	+	✓
9%	Czech Republic (CZ)	✓	N/A	N/A
-20%	Denmark (DK)	+	N/A	N/A
11%	Estonia (EE)	✓	N/A	N/A
-16%	Finland (FI)	+	N/A	N/A
-14%	France (FR)	+	+	✓
-14%	Germany (DE)	+	+	N/A
-4%	Greece (EL)	✓	+	+
10%	Hungary (HU)	✓	✓	✓
-20%	Ireland (IE)	+	+	+
-13%	Italy (IT)	+	+	+
17%	Latvia (LV)	✓	✓	✓
15%	Lithuania (LT)	✓	N/A	N/A
-20%	Luxemburg (LU)	+	+	+
5%	Malta (MT)	✓	✓	✓
-16%	Netherlands (NL)	+	+	+
14%	Poland (PL)	+	N/A	N/A
1%	Portugal (PT)	✓	N/A	N/A
19%	Romania (RO)	✓	N/A	N/A
13%	Slovakia (SK)[21]	+	✓	✓
4%	Slovenia (SI)	+	+	✓
-10%	Spain (ES)	+	✓	✓
-17%	Sweden (SE)	+	✓	N/A
-16%	United Kingdom (UK)	+	✓	N/A

[21] The extreme overshoot of the targets predicted by Slovakia's National Projections is the result of flawed reporting in National Projections. A more detailed explanation is provided in the discussion.

4.2.4 Distance to ESD targets for Europe

In addition to the distance to the ESD target for every MS, it is also appropriate to examine whether or not the EU as a whole will meet its target. The ESD aims at a 10% decrease of GHG emissions in the non-ETS sectors compared to 2005. The following graph displays the distance to the ESD targets relative to 2005 non-ETS emissions.

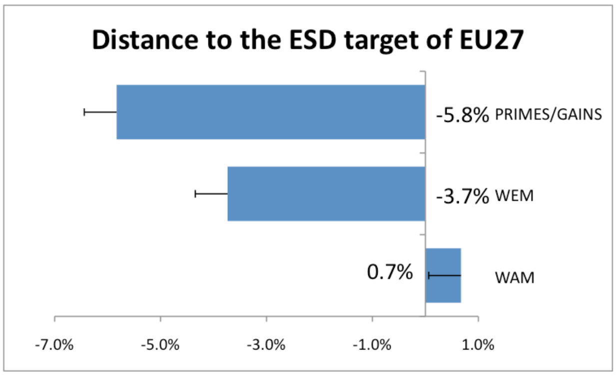

Figure 4.4 EU27 distance to the ESD target

From the results presented it is important to make clear that the distribution of the targets to MSs does not aim for a -10% reduction as stated in the ESD but rather for a -9.4%. This becomes apparent when deducting 10% off of 2005 non-ETS emissions and comparing it with the sum of the quantitative ESD targets.

$$ESD_{TARGET1} = nonETS_{2005} \text{ x } 90\% = 2691 \text{ MtCO}_2\text{eq x } 90\% = 2422 \text{ MtCO}_2\text{eq}$$

$$ESD_{TARGET2} = ESD_{AT} + \dots + ESD_{UK} = 2438 \text{ MtCO}_2\text{eq}$$

This gap of 16Mt equals 0.6% compared to 2005 non-ETS emissions but it is not very significant and therefore not included in the distance of EU27 to the target. The thin line denotes this error relating to the setting the overall targets and the distance projected by Member States are represented in Figure 4.4 by the length of the thick bars.

Regarding the relation among scenarios, a decreasing trend in distance is observed. There is a distinct policy effect in the difference of those projections since PRIMES/GAINS baseline scenario does not include policies after 2009 while the WEM and WAM scenarios of National projections were released in 2011. Furthermore the WAM scenario is the policy intensive scenario of National Projections and thus predicts lower emissions.

In conclusion, the distance to the EU 27 target varies among projections. The three scenarios provide variable estimates of the distance to the targets, which seem to be due to the policy assumptions of each. PRIMES/GAINS agree with the With Existing Measures scenario that the -10% target will not be reached while the With Additional Measures scenario predicts that the target will be reached.

4.3 Results of part 2: Decomposition analysis of the distance to the ESD targets

The estimated distance to the Effort-Sharing Decision targets is further explored in detail in this second part of the analysis. The difference between projections and ESD targets, which were calculated in the first part of the analysis, is distributed in sectors. Specifically, sector-related emissions are estimated from the data on energy demand by fuel and by sector provided in projections. For each sector this difference is explained by calculating the effect of the fuel mix and the effect of the energy demand using an Index Decomposition Analysis (IDA). The advantage of a disaggregated (in sectors) IDA is that the effects of the explanatory factors (energy demand, fuel mix) when added reflect more accurately the aggregated parameter of focus (distance to target). Thus the effect of energy demand and fuel mix is determined both at the sector level and at the aggregate level of the total distance to the ESD targets.

The Decomposition analysis is carried out for France and Hungary, which fulfill the criteria mentioned in the methodology. The results for the two countries are presented according to the projection used to estimate the fuel mix and energy demand of target emissions as outlined in the methodology in paragraph 3.5.3. The next figures present the results in a relatively compact fashion, as they distribute the distance to targets and decompose them. In order to make their reading more clear, the main points to be observed are suggested:

- The bar ‘Total’ represents the projected distance to the target in quantitative amounts.
- The total distance is distributed among sectors of the economy. The share of distance on each sector is referred to as ‘sector’s distance’.
- The addition of the effects of energy demand and fuel mix equal the total distance.
- The addition of sectoral effects of the two explanatory factors is equal to the sector’s distance.
- Positive values represent effects towards overachievement of the target.
- Negative values represent effects towards a policy gap.
- Uncertainty is the difference between reported projections and proxy emissions.

4.3.1 France

The target of the ESD for France is a14% reduction compared to 2005 non-ETS emissions, and in quantitative amounts that target equals 337.6 Mt CO_2eq. The PRIMES/GAINS projections of 2020 non-ETS emissions and National Projections, as well as the distance to the target in quantitative and relative amounts, is presented in the following table.

Target: 337.6 MtCO_2eq	PRIMES/GAINS	WEM	WAM

Projections	357	354	308
Distance to target	-19	-16	+29
% (to 2005 non-ETS)	-5%	-4%	7%

The distance to the targets for France differs according to each scenario as mentioned in the first part of the results. These differences are explained by applying the decomposition analysis process described in the methodology chapter to each projection's distance to the target. As an outcome, the difference between the ESD targets and projected emissions is distributed in sectors and the impact of energy demand and fuel mix are estimated.

4.3.1.1 PRIMES/GAINS

France's distance to the target, represented in Figure 4.5 below as 'Total', is distributed in sectors. Each sector's emissions are split between the effect of energy demand and the effect of fuel mix. Uncertainty levels are determined by the difference between emissions estimated from reported parameters and reported emissions in sectors. In the following paragraphs the results are explained for each sector.

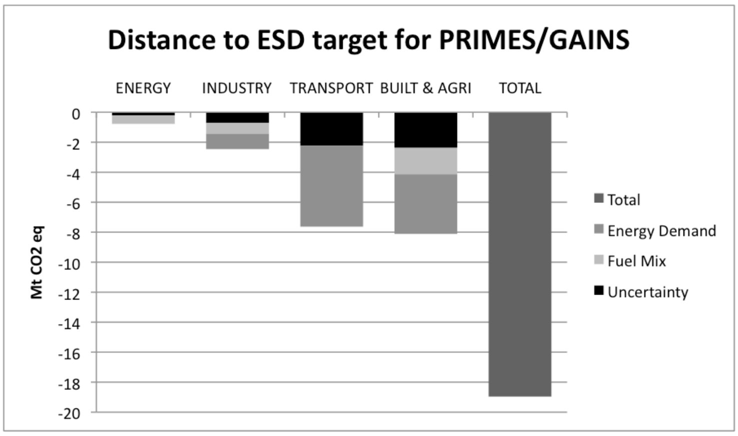

Figure 4.5 Decomposition analysis using PRIMES/GAINS for France

The two biggest contributors of emissions to the policy gap are the transport sector and the built environment, and almost all of these sectors' emissions[22] are part of the non-ETS emissions.

The transport sector makes up 40% of the distance to the ESD targets. The decomposition analysis finds that the projected distance of this sector to its target emissions owns practically fully to the energy demand. This means that the transport sector's energy demand is to a large extent responsible for France not meeting its ESD target under PRIMES/GAINS projections. The needed reductions in this sector would probably be more effective if policies targeted the energy demand rather than attempting to change the fuel mix. Of course,

[22] 95% for Transport and 99% for the Built Environment according to National Projections shares.

policy measures in both directions are needed, especially if they take advantage of synergies.

The built environment in aggregated PRIMES/GAINS data contains the Residential and Commercial sectors as well as Agriculture and contributes 42% to the distance. For those sectors combined, the fuel mix has an important effect because the shares of gas and oil decrease while the share of renewable energy increase. Their increase, however, is not so big so as to meet the decrease of oil and gas. The difference between the two is displayed in the graph as the effect of energy demand.

The remaining part of the distance to the ESD targets from the Energy and Industry sectors is related to the fuel mix and forms about 18% of the distance to the targets. Emissions from these sectors are principally covered under the EU Emissions Trading Scheme (ETS) and their share of non-ETS emissions is usually from small installations that can opt out of the ETS.
Finally, the uncertainty of this analysis proves moderate because it does not distort the findings.

4.3.1.2 National projections' WEM scenario

National Projections paint an overall similar picture as PRIMES/GAINS, but with increased detail since they include agriculture and waste as separate sectors. However, these sectors are only displayed in their total amounts and not as the effects of fuel mix and energy demand. This is the case because on these sectors the necessary data are provided in projections to conduct a decomposition analysis. It has to be noted that this is not an issue of missing data, but something to do more with the nature of those sectors. The emissions resulting from the agriculture and waste sectors are, to a large extent, emissions of non-CO_2 GHGs that are produced mostly through biological processes. Due to this fact, they cannot be split in the effects of energy demand and fuel mix, which are terms that mainly refer to energy supply.

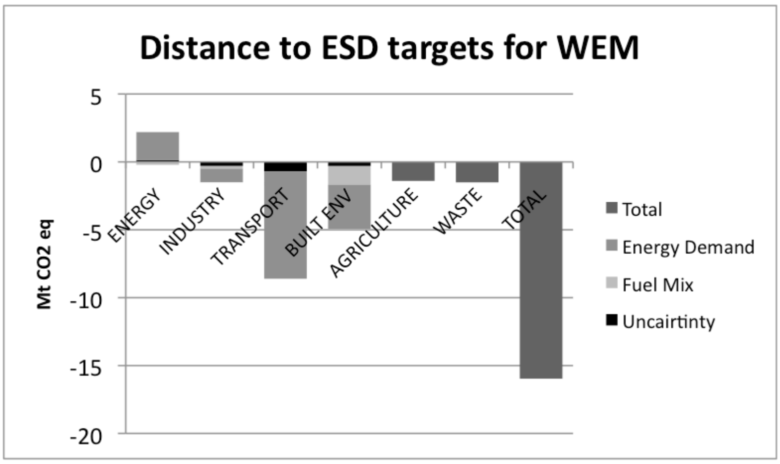

Figure 4.6 Decomposition analysis using NP's WEM for France

The decomposition analysis is carried out for the other four sectors and its results point to the effect of energy demand as a dominant explanatory factor of the policy gap. More specifically, the transport sector has a leading position as a source of non-ETS emissions, contributing 50% to the remaining distance to the ESD targets. Under the WEM scenario, the transport sector's distance to the ESD target is entirely due to the energy demand, just as it was observed in PRIMES/GAINS projections.

The two projections also concur on the emissions of the built environment, as they estimate that the remaining reductions are on the order of 5-8 $MtCO_2eq$. Most of the distance to the targets is due to the effect of the energy demand and a smaller share is due to the effect of the fuel mix.

As for the Energy sector, in the WEM scenario, it is a driving force towards decreasing the distance to the target. The distance indicating an overshot for this sector can be accounted for due to a considerable decrease in the energy demand for gas. Unlike PRIMES/GAINS projections, in WEM, energy is the only sector that contributes to lessening the distance to the ESD target. Lastly, industry's distance contributes to the total distance of the ESD targets. Unlike PRIMES/GAINS, the WEM scenario attributes the Industry sector 's distance to energy demand.

4.3.1.3 National projections' WAM scenario

The WAM scenario of National Projections predicts that France will considerably overachieve its ESD target by a considerable margin. As in the other two scenarios, in the WAM the distance to the target is driven by the effect of energy demand.

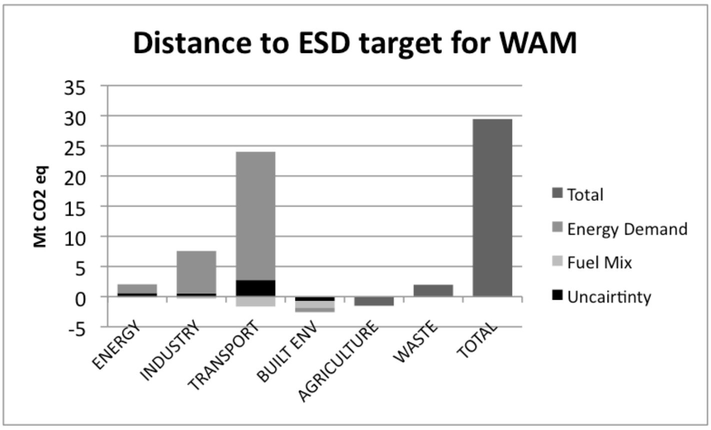

Figure 4.7 Decomposition analysis using NP's WAM for France

The most important decrease in emissions according to the WAM scenario, which causes approximately 75% of the overshoot, is due to the effect of decreasing energy demand in the transport sector. The effect of the fuel mix is seen as diminishing the mitigating impact of energy demand on emissions.
This effect might seem counter intuitive if compared to the WEM scenario where the effect of fuel mix is absent. It is nonetheless supported by the mathematical theory of this method (see section 3.5.6) and is attributed to the nature of the IDA. What occurs, in brief, is that energy demand over-explains the sector distance and the share of the fuel mix has to take a negative value in order to

meet the distance. For the particular example the energy demand explains 95% of the distance, the fuel mix a 7% reduction, and there is an uncertainty of 12%. Coming back to the figures and comparing the WAM to the WEM scenario it is observed that the projected difference in emissions from the energy sector remained stable. This could be explained by a lack of additional policies in this sector despite examining a more policy intensive scenario. Yet, further decreases of emissions are projected in the industrial sector, which will be almost entirely the effect of energy demand. The industrial sector contributes to the overshoot of the targets by 6 $MtCO_2$. In addition, the waste sector is also projected to decrease its emissions and contribute to overachieving the ESD target.

The Built Environment, which explained a large part of the distance in the other two scenarios, does not contribute to the distance any more than the energy or waste sectors. For this sector, projected and target emissions are in agreement and therefore their difference is small.

4.3.1.4 Aggregated results

In the previous graphs, the share of the effect of energy demand and fuel mix on the bar 'total' were not displayed in order to emphasize the sectoral distances to the target. This section answers the research question by pointing out the effect of the two explanatory factors on the distance to the ESD target. The exact figures are calculated by adding up the shares of energy demand and fuel mix found in all sectors. To sum up, in the following table the effects of energy demand and fuel mix are presented for the distance to the targets for each scenario.

Effects on the distance to the ESD targets

	Uncertainty	Fuel Mix	Energy Demand
NP's WAM	7%	9%	82%
NP's WEM	9%	14%	77%
PRIMES/GAINS	29%	16%	55%

According to data retrieved from PRIMES/GAINS and National Projections, it is concluded that the distance to the ESD targets is predominately due to the effect of energy demand.

4.3.2 Hungary

Hungary is projected in all scenarios to overachieve its target. To provide some background information, Hungary has displayed a downward trend in its emissions since 2005, but despite this trend it is allowed, according to the ESD targets, to increase its emissions in 2020. The 10% target allows Hungary to increase emissions, but despite this fact, Hungary is projected to decrease emissions. The target, in quantitative amounts, for Hungary, is to not increase its non-ETS emissions further than 52.7 $MtCO_2eq$. The projections and the distance to the ESD target are presented in the following table:

(Target: 52.7 $MtCO_2eq$)	PRIMES/GAINS	WEM	WAM
Projections	48.6	38	36
Distance to target	4.1	14.5	16.7
% (to 2005 non-ETS)	9%	30%	35%

The distance to the targets is distributed in sectors in the following graphs and expressed as the effect of energy demand and fuel mix.

4.3.2.1 PRIMES/GAINS

Results for the decomposition analysis carried out on Hungary's overshoot of the ESD target are presented in the following figure. The overshoot of the ESD targets estimated based on PRIMES/GAINS projections and graphed as 'totals', is about 4 $MtCO_2eq$. This amount is relatively small compared to the overshoot anticipated by National projections (about 15 $MtCO_2eq$).

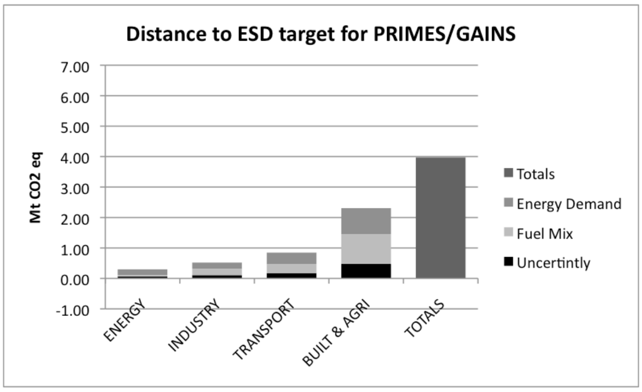

Figure 4.8 Decomposition analysis using PRIMES/GAINS for Hungary

According to PRIMES/GAINS projections, the majority of the emissions contributing to the overachievement of the target will be from the built environment. The influence on emissions reduction in the built environment is split between energy demand and fuel mix at almost equal levels. It is at equal levels because only the energy demand for gas changes between the target and the reported emissions. Consequently, the IDA attributes about half of the emissions to the effect of energy demand and the remaining to the effect of the fuel mix. Agriculture is also included in the same category, but due to the nature of the agriculture sector, its contribution in the total distance is expected to be marginal.

Emissions from the transport sector are the second largest contributor to the overachievement of target emissions. The usual dominant share of this sector in the distance to the ESD targets is not observed in calculations based on PRIMES/GAINS projections. Moreover, the usual explanatory factor of energy demand is also not the principal effect governing this sectoral distance. The effect of the fuel mix contributes in decreasing emissions in a comparable share with energy demand. Likewise, a similar split is observed in the industrial sector, with the energy sector's distance being equally split between the two explanatory factors.

4.3.2.2 National projections' WEM and WAM scenarios

The similarities between the WEM and WAM scenarios of National projections are apparent and will be examined simultaneously. The following graphs indicate that Hungary meets and overachieves its target for all sectors, and it does this principally due to the two main contributors to non-ETS emissions: the transport sector and the built environment. The effect of energy demand is the driving force behind decreased emissions, and the fuel mix, to a lesser extent, contributes to this development as well.

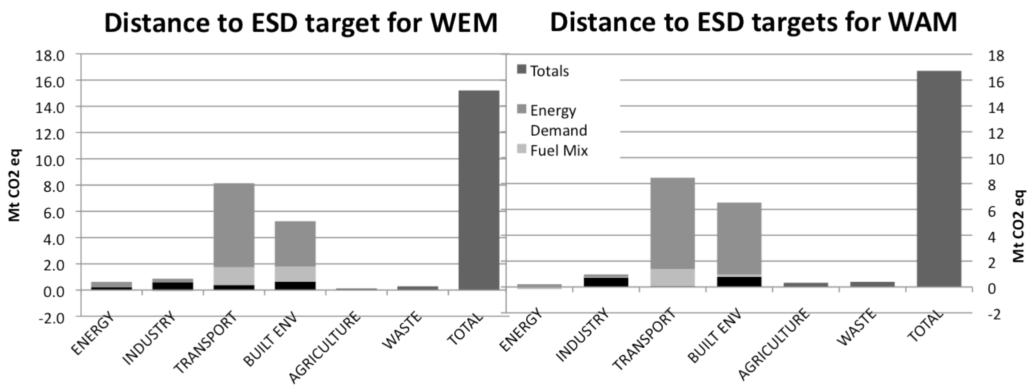

Figure 4.9 Decomposition analysis using NP's scenarios for Hungary

The distance to the targets of the ESD decision in both scenarios of National projections is assigned for the most part to the Transport sector and the built environment. Regarding the transportation sector, the effect of energy demand is expected because this sector is based on consumption of gasoline and diesel, fuels that produce about the same amount emissions per unit of energy. Yet, there is a noticeable effect attributed to the fuel mix, and this is explained by an important increase in the share of biofuels.

The second biggest contributor to the overshoot of the targets is the built environment, and its share is again mostly due to the effect of energy demand. The effect of the fuel mix when compared between the two scenarios comes forth as more important in WEM, where it accounts for almost a third of the sector's share in the overshoot. Unlike the fuel mix's effect in the WEM scenario, its effect in the WAM scenario is marginal even though the shares of both do not significantly differ. The reason for the effect of the fuel mix being lower in WAM is that energy demand in WAM has decreased considerably and is able to account for a bigger share of the difference in emissions.

Apart from the two sectors causing the overshoot of the targets, the energy and industry sectors contribute minimally to the overachievement of the target while the agriculture and waste sectors display borderline impacts on the distance. If these four sectors are examined on their own, it seems as if their contribution is almost non-existent, but in reality they account for 10% and 12% of the overshoot in the WEM and WAM scenarios respectively.

4.3.2.3 Aggregated results

The explanatory factors' influence on the distance to the ESD targets is presented for each scenario in order to add to the results towards answering the second research question. As stated earlier, these data were not presented in the preceding graphs in order to keep the focus on the sector distances. The results of the decomposition analysis performed on those sectoral distances are summed in order to reveal the reason for Hungary's overshoot, and are presented in the following table

	Uncertainty	Fuel Mix	Energy Demand
WAM	10%	8%	82%
WEM	13%	16%	71%
PRIMES/GAINS	21%	39%	41%

The results of Hungary display some resemblance to the results of France in regards to National Projections because they tend to attribute the distance chiefly on the effect of energy demand. On the contrary, PRIMES/GAINS have a more balanced approach and recognize the effect of the fuel mix and the effect of energy demand to be on comparable levels.

In summary, this chapter has presented the results that resulted from the first and second parts of the methodology. The first part provided the results regarding the distance in 2020 between the ESD targets for non-ETS GHG emissions and projections of non-ETS emissions. It did so by comparing targets estimated in quantitative amounts using 2005 non-ETS emissions; and three scenarios that estimate GHG emissions for 2020. The procedure was followed for all Member States and their results were combined to provide estimates of whether or not the EU is projected to meet its ESD target; again according to three projections scenarios. In the second part an Index Decomposition Analysis (IDA) was carried out based on projection estimates and taking into account the ESD targets. The decomposition analysis provided the effect of energy demand and fuel mix on the distance predicted in the first part for two Member States – France and Hungary. The results of these two parts are used in the following chapter to present conclusions and answer the research questions, and also to discuss the methodology followed to deliver those results.

5 Conclusions and Discussion

5.1 Thesis

The objective of this present dissertation was to assess and explain the distance of Member States (MS) to non-ETS emissions targets as set out in the Effort-Sharing Decision (ESD). Towards these ends, first projections of GHG emissions were consulted and secondly the decomposition method of analysis applied.

The results of these two steps were presented in the previous chapter. The following chapter will present the main conclusions

> Under current projections, the EU as a whole is not on track to meet its non-ETS emissions target as set out in the Effort-Sharing Decision, even though certain individual Member States are. The distance to those targets is predominately due to the effect of energy demand.

The supporting argumentation for the thesis stated above is provided in the following conclusions. The findings regarding the Effort-Sharing decision targets are presented first, followed by a brief comparison of the two types of projections. These findings are combined in the analysis and developed into the projected distance to the ESD targets.

The distance is presented for all Member States and for EU17 according to projections provided by the PRIMES/GAINS baseline of 2009 and the two scenarios of National Projections submitted in 2011. Following these results, the conclusions of the Index Decomposition Analysis are presented so as to support the thesis of this present dissertation.

In addition to the conclusions supporting the thesis, a discussion is carried out in to address the limitations of the method as well as its boundaries. Through the discussion, possibilities for additional research are sketched which go towards addressing the limitations of this study.

5.2 Conclusions

The first research question relates to Member States' projected distance to the Effort-Sharing Decision targets. In the next pages, the findings of each step are made clear and are accompanied by discussion. In summary the conclusions from the first part are that a significant number of Member States are not projected to meet their targets and consequently there is a gap in meeting the target for EU27 as well. However, due to limitations in estimating the targets, a similar future analysis will provide more concrete results, particularly if combined with National Projections which will be released in 2013.

5.2.1 The Effort Sharing Decision targets

Targets for GHG emissions are meant to indicate the desirable levels that should be achieved in a specific year. The ESD targets are deficient in terms of determining those levels because they are set relative to historic non-ETS emissions, which are subject to change. Non-ETS emissions are calculated after it is determined which emissions are covered under the EU ETS. Updates on the emissions covered under the EU ETS are still reported by Member States for the year 2005 and this cause the amount of non-ETS emissions of 2005 to change. Consequently the ESD targets which are set relative to 2005 non-ETS emissions are subject to change. Relative targets need to be set according to a base year that is not variable or be expressed in quantitative amounts . The ESD targets will be set as quantitative amounts expressed in $MtCO_2eq$ in a upcoming communication of the Commission due to be released during the last quarter of 2012.

The ESD targets in quantitative amounts were not released at the time of the writing of this thesis. Since the quantitative targets were needed in order for the distance to them to be assessed using projections, they had to be estimated. The methodology used to estimate the targets for this present thesis was based on 2005 emissions reported to the UNFCCC and the ETS / non-ETS split was provided by PRIMES/GAINS. The quantitative targets were estimated by multiplying 2005 non-ETS emissions with the relative targets. This produced the quantitative targets.

In order to be judged as to their realistic nature, they need to be examined from some perspective. The perspectives used to view the targets are the EU-wide and National projections. It is mentioned that the fact which lead to the writing of this thesis was a hint in the articles by Harmsen *et al* (2011) and Toi (2009). This hint was that GHG emissions projections pointed out that some Member States would not need to implement any additional policies apart from those present when the ESD targets were set in order to meet the targets.

As with previous authors, so in this thesis as well, the targets were assessed through the lenses of projections. It was observed that the targets for most MS are demanding when they set goals for emissions mitigation from the non-ETS sectors. Member States with tough reduction targets, i.e. Luxemburg, Belgium and Ireland, not only will they not meet their targets but also depending on the consulted projections, their emissions will stay on the same levels or increase slightly. Contrary to those, for a few Member States such as Hungary and Slovakia, the permission to increase emissions is unfounded since those Member States are projected to decrease their non-ETS emissions. Other MSs, who are also allowed to increase emissions such as Bulgaria and Romania, achieve their targets without adopting additional policies beyond those included in the baseline of projections. These results verify the findings of Harmsen *et al* (2011) and Toi (2009), which suggested that there were issues in setting the targets[23].

[23] This disproportionate allocation of targets as stated above, entails that not all individual Member States will meet the ESD targets and they will have to achieve the necessary reduction through other means. Flexibilities come in to compensate for this effect by allowing trade of emissions between MSs such as Hungary that overachieve their targets and MS such as Luxemburg that can afford to purchase emissions.

5.2.2 Projected non-ETS emissions

Projections were used to answer the first research question, which considers the distance to the targets. This distance is the outcome of the difference between the targets and projections. As such, projections are highly responsible for the outcome of the analysis. Projections of non-ETS GHG emissions were of two types. The first were the PRIMES/GAINS projections of 2009, which were used to provide the EU-wide viewpoint on the distance to the ESD targets. The second were National Projections of 2011 submitted under the requirements of the Monitoring Mechanism Decision, which provided the member States viewpoint. Conclusions on projections are derived from comparing the two types used.

Comparing projections from Figure 4.2 leads to the conclusion that most MS's National projections submitted in 2011 are in a relative agreement with the projections of the 2009 PRIMES/GAINS baseline scenario in terms of whether their targets will be met or not. This holds true especially for the With Existing Measures scenario but not entirely for the With Additional Measures scenario. WAM scenario projections compared to PRIMES/GAINS are more distant because they assume the implementation of additional policies not included in the second[24].

The WEM scenario is within ±10% of the PRIMES/GAINS estimates for Austria, Belgium, France, Germany, Greece, Ireland, Italy, Latvia, Luxemburg and the Netherlands, Slovenia, Sweden and the UK. These two projections are less than ±5% variable only for Belgium, Germany and the Netherlands. The scenarios of National Projections and PRIMES/GAINS are at odds regarding the projected non-ETS emissions of Cyprus, Hungary, Slovakia and Spain.

In conclusion, projections are the second element governing the results of the distance to the targets. It goes without saying that the relation between projections for a Member States is mirrored in its distance to the targets.

5.2.3 Distance to the ESD targets

The first research question is aimed at estimating the distance to the ESD targets for all Member States. The conclusions related to this research question are presented here. As a reminder, the distance to the ESD targets was calculated by subtracting the quantitative targets from three projection scenarios. For this reason, the product was one distance resulting from each of the three projection scenarios: one provided by PRIMES/GAINS and two provided by National Projections in their WEM and WAM scenarios. Depending on the projection used there was some variation of the distance to the ESD targets[25]. In the following

---

[24] The WAM scenario should be compared to the PRIMES Reference baseline of 2009 in additional research.

[25] The distance to the ESD targets is a snapshot in time and in reality it is not stationary. As future policies are included in the succeeding PRIMES/GAINS and National Projections estimates, the policy gap will narrow.

paragraphs conclusions are first provided regarding the MSs and then for the EU27.

With regards to Member States' distance to their targets and according to the projection scenarios of PRIMES/GAINS, WEM and WAM, it is expected that 10, 7 and 9 Member States respectively will overachieve their ESD targets. Those countries, which have projected emissions lower than their targets are designated with a ✓ in Table 1. It was not possible to provide the MS's viewpoint on the distance to the targets for nine Member States (Bulgaria , Czech Republic, Denmark, Estonia, Finland, Lithuania, Poland, Portugal, Romania) because they did not submit a ETS /non-ETS split in their National Projections. As for the Member States with a policy gap PRIMES/GAINS, WEM and WAM scenarios predict that 17, 11 and 9 countries respectively will not meet their targets.

Moreover, a correlation between positive targets (allowance to increase emissions) and meeting the targets set in the Effort-Sharing Decision was observed. Most of the MSs, which are permitted to increase their emissions up to a certain limit, will not go further than that limit according to the projections and will therefore meet their ESD targets.

The number of Member States that overachieve their targets or present a policy gap according to the projections is summarised in the following table

	Overachieve target	Policy gap	Unknown
PRIMES/GAINS 2009 Baseline Scenario	10	17	-
National Projections' 2011 With Existing Measures Scenario	7	11	9
National Projections' 2011 With Additional Measures Scenario	9	9	9

From the table above it does not follow that all countries that meet the target under WAM, also meet the target under PRIMES/GAINS. As noted earlier, these three scenarios predict different outcomes of whether or not a MS meets the target. For this reason it is useful to present a brief comparison of projections in order to highlight their effect in answering the research question. It is shown that the distance to the ESD targets for each MS may vary according to the projection employed.

Concerning the agreement of projections, PRIMES/GAINS and National Projections' scenarios agree on either a policy gap or overachievement of the ESD target for Belgium, Hungary, Ireland, Italy, Latvia, Luxemburg, Malta and the Netherlands. To a lesser extent PRIMES/GAINS is in agreement with the WEM scenario for Austria, Cyprus, France, Germany and Slovenia. Lastly, there is disagreement on meeting the targets for Slovakia, Spain, Sweden and the UK.

Taking the all distances of Member States to their targets into account, and adding them, it is concluded whether or not the EU is predicted to meet its ESD target to reduce non-ETS emissions by 10% below 2005 levels. There are two views on this matter. On the one hand, PRIMES/GAINS and National

Projection's WEM scenario estimate that the EU will not be able to decrease its non-ETS emissions by 10% compared to 2005 and therefore will not achieve its target. The projected policy gap in the WEM scenario is around 4% and in PRIMES/GAINS it is almost 6%. On the other hand, the policy intensive scenario of National Projections, With Additional Measures, estimates that it is possible for the EU to meet the target. In the WAM scenario the EU-wide target is only surpassed by 0.7%. Figure 4.4 illustrates this distance to the combined ESD target for the EU27

In order to more accurately answer the first research question regarding the distance to the ESD targets of all Member States, in the following table the distances of all Member States are displayed in detail relative to 2005 non-ETS emissions and as quantitative amounts.

Table 2 Member States' distance to the ESD targets

	QUANTITATIVE DISTANCE TO TARGET (in $MtCO_2eq$)				DISTANCE TO TARGET relative to 2005 non-EST emissions		
	PRIMES/ GAINS	WEM	WAM		PRIMES /GAINS	WEM	WAM
Austria	-7.8	-3.3	3.7		-13%	-6%	6%
Belgium	-10.8	-15.0	-7.5		-14%	-20%	-10%
Bulgaria	5.4				21%		
Cyprus	-0.8		1.4		-18%	-1%	30%
Czech Republic	5.5				9%		
Denmark	-4.5				-13%		
Estonia	0.0				1%		
Finland	-1.8				-6%		
France	-19.0	-16.0	29.4		-5%	-4%	7%
Germany	-22.8	-39.9			-5%	-9%	
Greece	1.1	-4.9	-2.7		2%	-8%	-5%
Hungary	4.1	14.5	16.7		9%	30%	35%
Ireland	-11.5	-9.4	-4.7		-25%	-20%	-10%
Italy	-32.3	-51.5	-4.2		-11%	-17%	-1%
Latvia	0.9	0.0	0.5		11%	0%	6%
Lithuania	1.4				11%		
Luxembourg	-2.5	-2.6	-1.9		-24%	-25%	-18%
Malta	0.3		0.2		22%	3%	18%
Netherlands	-7.6	-9.7	-2.8		-7%	-9%	-3%
Poland	-6.4				-4%		
Portugal	5.7				12%		
Romania	6.8				10%		
Slovakia	-0.8	9.9	9.9		-4%	49%	49%
Slovenia	-2.9	-1.8	0.8		-26%	-16%	7%
Spain	-44.2	1.7	2.5		-19%	1%	1%
Sweden	-3.9	0.3			-9%	1%	
United Kingdom	-8.6	15.1			-2%	4%	

In conclusion, based on the data available and on the methodology followed, it is predicted that the majority of MS will not meet their targets and the EU as a whole will not achieve reductions in non-ETS emissions of 10%

compared to 2005. However, the quantitative targets are subject to change and depend on updates of the ETS scope. This fact, in combination with the updated National Projections due to be released by April of 2013, raises the possibility of the distance to the targets diminishing; thus, the EU could meet its Effort Sharing Decision targets.

5.2.4 Explanation of the distance

The second research question aims at explaining the distance to the ESD targets. It was tackled by first estimating the energy demand and fuel mix of the targets and then by conducting a decomposition analysis between the targets and projections. The main conclusion concerning the explanation of the distance and part of the thesis statement in the beginning of this chapter is that:

> The projected distance of three GHG emissions scenarios to the Effort-Sharing Decision targets, as calculated using an Index Decomposition Analysis, is predominately due to the effect of energy demand.

Following the findings of the distance to the ESD targets, an Index Decomposition Analysis (IDA) was carried out. The IDA's purpose is to explain the influence of driving factors governing the projected overshoot or policy gap related to the ESD targets. The analysis was conducted at the disaggregate level of sectors in order to achieve accurate results at the aggregate level(this is a characteristic of IDA) regarding the difference between target emissions and projections. Ultimately, by summing the results the decomposition analysis provided at the sector level, the distance to the ESD targets was explained as the effect of the fuel mix and of the energy demand. In the coming paragraphs the main conclusions of the application of the methodology are exhibited which help in answering the second research question. These conclusions are presented for the two Member States (France and Hungary) on which the analysis was conducted.

5.2.4.1 France

In the case of France, the policy gap predicted in PRIMES/GAINS and the WEM scenarios are, for the most part, an effect of energy demand. Along the same lines, the reductions in emissions further than the ESD target in the WAM scenario are also primarily due to energy demand. These findings are gathered in the following table where the distance to the target is presented as the shared effect of explanatory factors.

Effects on the distance to the ESD targets (France)

	Uncertainty	Fuel Mix	Energy Demand
NP's WAM	7%	9%	82%
NP's WEM	9%	14%	77%
PRIMES/GAINS	29%	16%	55%

In the above table there is also some uncertainty related to the method applied. It is the outcome of adjusting proxy emissions (calculated from energy demand by fuel data) with the reported emissions, which differ somewhat because of the use of generic emission factors for fossil fuels.

5.2.4.2 Hungary

In the case of Hungary, the main reason for the overshoot of the ESD targets is that while the MS has been allocated an allowance to increase non-ETS emissions, it has implemented policies with the objective of mitigating emissions. Both EU-wide and National projections arrive at the same conclusion even though the second predict a much larger overshoot than PRIMES/GAINS.

The influence of the explanatory factors on the overshoot of the ESD targets shows clear differences between the EU-wide projections and MS's estimates on a national level. The PRIMES/GAINS projections estimate that energy demand and the fuel mix equally influence the overshoot of the ESD targets while National projections assign the reductions in emissions chiefly to energy demand.

Effects on the distance to the ESD targets (Hungary)

	Uncertainty	Fuel Mix	Energy Demand
WAM	10%	8%	82%
WEM	13%	16%	71%
PRIMES/GAINS	21%	39%	41%

In examining PRIMES/GAIN and National Projections on two Member States it stands out as a general remark that the first attribute changes in emissions to both explanatory factors while the second allocate them mostly to energy demand.

To sum up, the conclusions presented in this section point to the fact that when the distance to the Effort Sharing Decision targets is examined using projections, the EU will not achieve the anticipated GHG reductions from the non-ETS sectors. In not meeting the targets in 2020 the EU will fail to prove a leader in international negotiations related to climate change; as it is possible that it will fall short of its targets set in the Climate and Energy Package of 2007. The distance between targets and projections estimated, is furthermore found to be caused predominately due to increased energy demand in the transport sector and in the built environment, the two biggest emitters of non-ETS GHG.

These conclusions can be used to support argumentation for additional policies aimed at closing the gap to the ESD targets. The projected gap towards the ESD targets is found to be mostly influenced by energy demand. It is therefore proposed, that further measures directed towards mitigating GHG emissions from the non-ETS sectors should focus primarily on reducing energy demand.

5.3 Discussion

5.3.1 The distance to the targets

The conclusions derived regarding Member States distance to the ESD targets can be used in supporting arguments for EU and national climate policy towards more decisive action plans. However it has to be reminded that those results are the outcome of a methodology that is confined by two parameters. The distance to the targets is estimated by subtracting targets from projections. Any discussion therefore on the methodology used to derive the distances for all Member States is split in discussion on targets and discussion on projections
The two most important discussion points presented in the following sections are that:

1. the ESD targets are so far variable since they are based on base year emissions which are subject to change
2. the projections used are bound by assumptions on policy impacts and the quality of Member States reporting.

5.3.1.1 The ESD quantitative targets

For the analysis to take place it was necessary to estimate the Effort-Sharing Decision targets in quantitative amounts. The targets, set as a percentage related to 2005 non-ETS emissions, were multiplied with those base year emissions to arrive at quantitative targets. However there appear to be some shortcomings because the results of the analysis do not agree on some Member States with a report of the Commission (2011). In that report National Projections were also used. Since the required data to estimate the distance are projections and the targets, then the disagreement of results points to a disagreement in the targets used.

It has been mentioned earlier that the choice of base year emissions is very important for setting quantitative targets as well as for the results which follow. The choice of base year emissions, its influence on the outcome of the thesis and its conclusions are explained below.

Historical non-ETS emissions could have been provided in three ways for this thesis.

1. One way of retrieving base year emissions would be by subtracting ETS emissions from total GHG emissions of 2005.
2. The second would be to retrieve them from PRIMES/GAINS where they are set according to emissions reported to the UNFCCC.
3. A third way would be to use the ETS/non-ETS shares reported in Member States' National Projections for 2010 and apply them on UNFCCC 2005 total GHG emissions.

All of the above methods were applied to get 2005 non-ETS emissions and by multiplying them with the ESD targets the quantitative targets seen in the following graph were estimated:

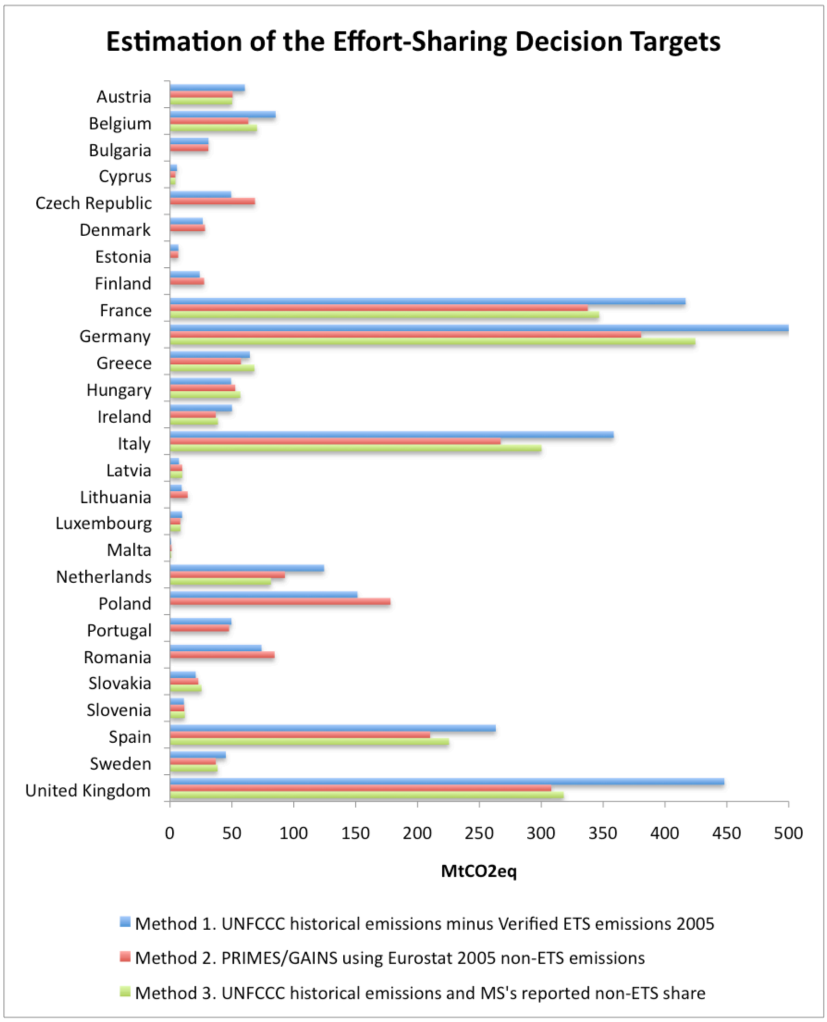

Figure 5.1 Estimation of the ESD targets using three methods

As seen in Figure 5.1, methods 2 and 3 provide very similar results. The third method was therefore assumed to contain errors. Of the other two methods, which are almost identical, method 3 was based on the ETS/ non-ETS split of 2010 and not of 2005. Thus, method 2 was chosen for reasons of precision since the ETS/ non-ETS split is from 2005. Furthermore, method 2 provides targets for all MS while method 3 does not for MS that did not submit a ETS/ non-ETS split.

The abovementioned procedure illustrates the limits of base year in determining emissions targets. If method 1 was chosen then the ESD targets in quantitative amounts would refer to higher emissions. Taking the UK as an example with its projected non-ETS emissions of about 320 MtCO_2eq if the target is set according to method 1, then the UK would overachieve its targets by about 230 MtCO_2eq without the need for additional policies beyond the baseline. If, however, the target is set according to method 2, then the UK almost meets its target.

A recommendation for further research is appropriate at this stage (after having mentioned the information regarding the base year emissions) whose results could be very relevant to upcoming policy discussions. It was mentioned earlier that the Commission will release the quantitative targets of the ESD in late 2012. Those targets will be based on 2005 non-ETS emissions yet those base year emissions will most probably diverge from the ones retrieved from PRIMES/GAINS. This is because installations covered under the EU ETS have the ability to opt out of the trading scheme and when this happens their emissions are considered as non-ETS. An increase in non-ETS 2005 emissions will cause the quantitative targets of the ESD to be higher and as a result of that Member States will achieve them with less effort. In other words, the policy gap to the targets will be smaller for MSs that transferred ETS emissions into the non-ETS. A comparison of the base year emissions would then justify why the EU meets its ESD target. If the hypothesis stated above holds true, then the proposed research could be critical towards the EU targets and could be further used in supporting the argument of moving from 20% to a 30% reduction target in GHG emissions compared to 1990 levels.

5.3.1.2 Projections

Projections of non-ETS GHG emissions were used in this thesis to answer both research questions. For the first research question projections were used to calculate the distance of Member States to their targets. For the second research question they were used to provide energy demand and fuel mix data for the decomposition analysis to be realized. There were two types of projections used: the PRIMES/GAINS and the National Projections. The first were used in order to represent the EU-wide viewpoint, related to the EU-wide scope; the second in order to represent the MS's viewpoint related to projections derived at the national level. The limitations of the results depend to a large extent on the projections provided. In estimating the distance to the targets the reporting of projections is by 50% responsible for the outcome (the other 50% being the targets). The limitations in using projections have to do with the assessment of policies but most importantly, with the quality of the reporting. These two aspects are discussed here and while the first is easy to explain, the second needs some more emphasis.

The first limitation is related to the policies. The projections used include policies that were or would be enacted in the time when those projections were calculated. As PRIMES were calculated in 2009 they did not include the impact of a few policies that were included in the National Projection of 2011. For example, the directive on the energy performance of buildings (Directive 2010/31/EU) and the regulation on emissions standards for light commercial vehicles (Regulation 510/2011) are not included in the PRIMES baseline of 2009.

The second limitation, as it is shown below, are the inconsistencies in the reporting of some countries' National Projections. These were not altered in order to reflect the Member States' viewpoint on the targets. For example, the biggest overshoot (by 49%) of the targets is expected for Slovakia. This figure seemed abnormal and after contacting the EEA it was revealed that Slovakia's submission was flawed in regards to the non-ETS projected emissions. This was made apparent by examining the historical trend and comparing it with reported projections of non-ETS emissions. The figures are displayed below:

Historic data:

	2005	2006	2007	2008	2009
Total emissions	50.09	49.86	47.84	48.17	43.40
ETS	25.23	25.54	24.52	25.34	21.60
non-ETS	24.86	24.32	23.32	22.83	21.81

Reported projections:

National Projections 'With existing measures'	2008	2010	2015	2020	2025	2030
ETS	25.30	23.73	25.94	26.46	28.42	30.60
non-ETS	13.70	13.04	13.62	12.89	13.97	15.61

There is obviously an error in the figures for non-ETS projected emissions since they are about half of the observed historical trend. It is very probable that the error of Slovakia was the inclusion of LULUCF in its total non-ETS emissions.
Therefore the results for Slovakia's distance to the target as estimated in this analysis are erroneous because of the projections the country submitted in 2011. This fact was not altered in the results in order to point out in the discussion the important role of assessing projections submitted under the Monitoring Mechanism.

The example of Slovakia allows discussion on the quality and the trustworthiness of Member State's submission. MS's projections are reported under the Monitoring Mechanism in order to be then reported by the EU as a whole to the UNFCCC. The EEA applies quality checks to those data which are found to be inconsistent or lacking certain parameters. In Figure 5.2 below the policy gap to (+%), and overshoot of (-%) the ESD target is graphed as reported by MS (green) and as adjusted by the EEA (red).

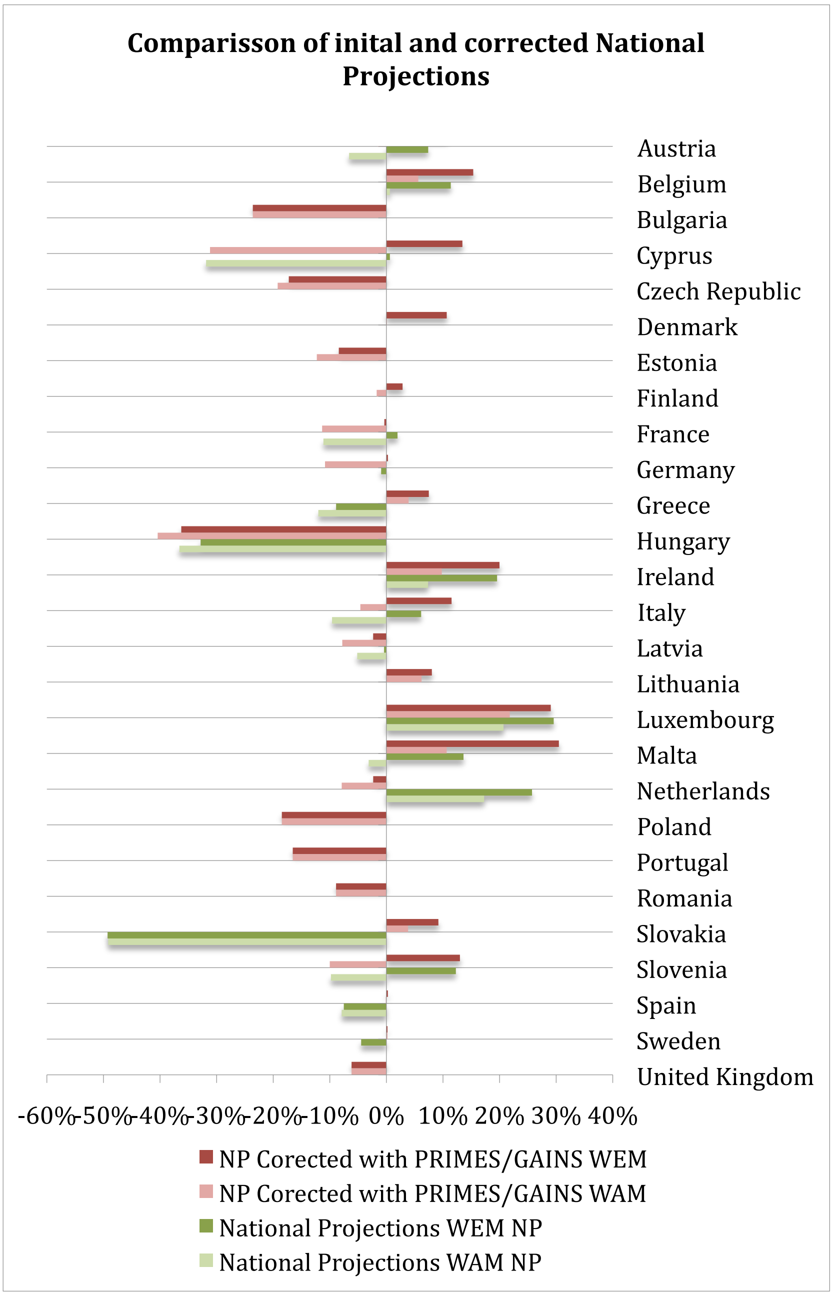

Figure 5.2 Comparison of initial and corrected National Projections

What is communicated from the above figure is that errors are not very common. Member States for which the red and green bars are not diverging, have reported high quality projections. Others, like Slovakia and Latvia, reported very poor projections. To increase the quality of EU projections, National Projections pass quality checks before being submitted to the UNFCCC. These checks are carried out by EEA who consults PRIMES/GAINS projections.

5.3.2 On the method of decomposition

In this part the novelty introduced in the method of decomposition is discussed first along with suggestions for further research. Then, the limitations of the method are discussed, which have to do with the fact that the decomposition is based on projections. Lastly, the boundaries of the method applied are presented along with ideas of how to overcome them.

There is a degree of originality in the method applied to answer the second research question. The IDA was approached in a fashion that introduced novelty in the application of the method. In researching the scientific literature, a similar application of IDA has not been found yet. The ordinary use of the method and the novelty introduced are described below.

A decomposition analysis is usually carried out for time series of past data. Those data are related using an equation connecting the parameter of focus to explanatory factors (i.e. A=BxC, at time =t). The difference of the parameter of focus between two points in time ($A_{t+1} - A_t$) is attributed to the effects of the explanatory factors (B and C) by examining their change between those two points in time. The novelty introduced is the application of the decomposition analysis to projections.

This procedure was followed to explain the distance between projections and the targets (parameter of focus) since they can be seen as two different points in time ($A_{t+1} - A_t$). This distance was consequently attributed into the effects of energy demand and fuel mix (the two explanatory factors). The new perspective introduced in the application of this method is that instead of two historical points, the analysis examines the difference of two future points. This difference between the two future points is the distance between targets and projections.

The method applied opens up possibilities for further research since it also becomes a tool to assess and to compare projections. A suggestion for application of this novel perspective on IDA would be to use it to compare two sets of GHG projections. An IDA could be conducted on each in order to reveal the effect of certain parameters that are known to impact GHG emissions: energy demand, fuel mix, GDP, population, carbon intensity or other explanatory factors that connect to GHG emissions. This would allow testing the robustness of the idea of applying decomposition analysis to future data.

The overall limitation of the decomposition method constructed to explain the distance is that the outcome of the IDA depends on the quality of projections used. Since the method followed makes use of data derived from projections, the quality of those data is mirrored in the outcome of the decomposition. That being said, the IDA in this thesis makes visible the underlying factors of projections used to estimate the distance to the targets. The way to overcome limitations by increasing the accuracy of the method is discussed first.

Two more specific limitations of the analysis could be said to stem from the accuracy of the results. The first is in the method used to estimate energy demand and fuel mix data corresponding to non-ETS emissions and the second is the method used to develop energy demand and fuel mix data for target emissions.

The first limitation is that the method is based on energy demand and fuel mix data provided for total GHG emissions and not specifically for non-ETS emissions. This led to select which fuels should and which should not be part of the non-ETS depending on their sector. As an example, energy demand for coal in the energy sector is certainly related to electricity production and those installations are part of the EU ETS. Regarding electricity cited as energy demand along with other fuel inputs in projections for the built environment, it was also excluded to avoid double counting of electricity generation. These adjustments were carried out to the best of the author's knowledge but a set with more accurate data on non-ETS energy demand could provide somewhat different end results.

A second limitation was the (expected) lack of explanatory factors for target emissions. The process overcame this by using the evolution of every fuel in every sector towards the target to predict which combination produces the target emissions. Theoretically there are infinite combinations of fuel mix and energy demand capable of delivering the target emissions. However, if projections are consulted and the methodology explained in paragraph 3.5.3, is followed, it is possible to compute a very probable estimate of the targets' explanatory factors. The necessary adjustments were included as an uncertainty in the final results, and especially in the case of PRIMES/GAINS, these values were higher than anticipated. The methodology could be further fine-tuned using a more detailed and automated algorithm to minimize this uncertainty.

The boundaries of the method are related to the choice of data and to the scope of the research. Two boundaries of the method used to examine the distance to the targets are outlined next and finally opportunities for further research are presented.

The first boundary is that the explanatory factors used in the IDA are confined to two. This means that the distance is decomposed to these two effects and not more. The possibility is present of extending the scope to include more elements of emissions in order to explain the distance to the targets in increased detail. Provided an equation exists which links GHG emissions with more explanatory factors such as GDP and population or energy intensity etc, then it is possible to disaggregate the distance into those as well. The energy demand and the fuel mix were used in this disaggregation because there exists a straightforward relationship between them and GHG emissions.

The second boundary is that the method does not reveal the effect of each greenhouse gas on the distance to the targets. This boundary can be transcended in future research using data provided by National Projections on the contribution of each GHG to the sectors' non-ETS emissions.

Overall, the discussion shows that in estimating the distance to the targets, the analysis met its objectives. There exists the possibility to improve the results, especially when updates on the ESD targets and projections are released. The discussion on the decomposition followed to explain the distance shows that there is a degree of novelty in the application of the Index Decomposition Analysis. The fashion in which the IDA was applied, along with an increased scope of the analysis reflected in the inclusion of more explanatory factors, offers the possibility of further research related to projections of GHG emissions.

6 References

Amann M, L. Höglund Isaksson, W.Winiwarter, A. Tohka, F. Wagner, W. Schöpp, I. Bertok, C. Heyes. (2008) *Emission scenarios for non-CO2 greenhouse gases in the EU-27 : Mitigation potentials and costs in 2020. Final Report, May 2008*. International Institute for Applied Systems Analysis (IIASA): Luxemburg, Austria

Ang B.W., Zhang, F.Q..(2000) A survey of index decomposition analysis in energy and environmental studies. Department of Industrial and Systems Engineering: National University of Singapore

Blok, K., (2007) Introduction to Energy Analysis, Techne Press, Amsterdam

Böhringer, C. , Löschel, A., Moslener, U., Rutherford, T.F.. (2009) 'EU climate policy up to 2020: An economic impact assessment'.. *Energy Economics*. Volume 31, Issue SUPPL. 2, 2009, Pages S295-S305

Capros P , Dr. L. Mantzos, N. Tasios, A. De Vita, N. Kouvaritakis. (2010) EU energy trends to 2030 UPDATE 2009. European Commission Directorate-General for Energy in collaboration with Climate Action DG and Mobility and Transport DG. doi:10.2833/21664

Capros P, L. Mantzos, V. Papandreou, N. Tasios. (2008) Report to DG ENV: Model-based Analysis of the 2008 EU Policy Package on Climate Change and Renewables.
http://ec.europa.eu/clima/policies/package/docs/analysis_en.pdf

De Cara, S., Jayet P.A.. (2011*)* 'Marginal abatement costs of greenhouse gas emissions from European agriculture, cost effectiveness, and the EU non-ETS burden sharing agreement'*. Ecological Economics*, Volume 70, Issue 9, 15 July 2011, Pages 1680–1690

Duerinck J, Schoeters K, Renders N, Aernouts K, Daan Beheydt, Wouter Nijs, Anke Herold, Verena Graichen, Jason Anderson, Samuela Bassi. (2008) Assessment and improvement of methodologies used for Greenhouse Gas projections Final report to DG Environment under ser- vice contract no. ENV.C.2/SER/2006/0008, pp.59-62

E3MLAB, 2005, PRIMES model manual - Version 2 Energy System Model: Design and features . [ONLINE] Available at: http://www.e3mlab.ntua.gr/manuals/PRIMREFM.pdf. [Accessed 3 September 2012]

European Environment Agency (2011) Annual European Union greenhouse gas inventory 1990–2009 and inventory report 2011 Submission to the UNFCCC Secretariat EEA Technical report No 2/2011 doi:10.2800/76096

European Environment Agency (2010). EEA greenhouse gas - data viewer. [ONLINE] Available at: http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer

European Environment Agency (2010). EU Emissions Trading System (ETS) data viewer. [ONLINE] Available at: http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer

Eionet Reporting Obligations Database (ROD) (2011). Deliveries for Projections and national programmes. [ONLINE] Available at: http://rod.eionet.europa.eu/obligations/385/deliveries.

Elzen (den) M.G.J., Lucas P.L., Gijsen A., 2007. Exploring European countries' emission reduction targets, abatement costs and measures needed under the 2007 EU reduction objectives. MNP Report 500114009/2007. Netherlands: Environmental Assessment Agency

Egenhofer C, Behrens A and Georgiev A.. (2011) *EU Strategies for Climate Change Policy Beyond 2012.* H.G. Brauch *et al*. (eds.), Coping with Global Environmental Change, Disasters and Security, Hexagon Series on Human and Environmental Security and Peace 5, DOI 10.1007/978-3-642-17776-7_83,

International Institute for Applied Systems Analysis (IIASA) (2009) GAINS model results. [ONLINE] Available at: gains.iiasa.ac.at.

International Institute for Applied Systems Analysis (IIASA) (2009). GAINS Online: Tutorial for advanced users. Available at: http://webarchive.iiasa.ac.at/rains/reports/GAINS-tutorial.pdf.

European Commission, 2011d, COM(2011) 624 final, Report From The Commission To The European Parliament And The Council, Progress Towards Achieving The Kyoto Objectives

European Comission, 2005, decision 2005/166/EC laying down rules implementing Decision No 280/2004/EC of the European Parliament and of the Council concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol

European Commission, 2006, COM(2006)545, Action Plan for Energy Efficiency: Realising the Potential, Brussels 19.10.2006

European Commission, 2007, COM(2007) 2, Limiting Global Climate Change to 2 degrees Celsius The way ahead for 2020 and beyond, Brussels 10.1.2007

European Commission, 2008a, COM (2008) 30, 20 20 by 2020 Europe's climate change opportunity, Brussels 23.1.2008

European Commission, 2008b, SEC(2008) 85/3 Commission Staff Working Document, Impact Assessment, Document accompanying the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020, Brussels 23.1.2008

European Commission, 2010, COM(2010) 569 final, Report from the European Commission to the European Parliament and the Council, Progress Towards Achieving the Kyoto Objectives, Brussels 12.10.2010

European Commission, 2011a, COM(2011) 21, A resource-efficient Europe – Flagship initiative under the Europe 2020 Strategy, Brussels 26.1.2011

European Commission, 2011b, COM(2011) 370 final, Proposal for a Directive of the European Parliament and of the Council on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC. Brussels 22.6.2011

European Commission, 2011c, COM(2011) 789 final, 2011/0372 (COD), Proposal for a Regulation of the European Parliament and of the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change, Brussels 23.11.2011

European Parliament and European Council, 2004, Decision No 280/2004/EC of the European Parliament and of the Council of 11 February 2004 concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol, Official journal of the European Union L49 19.2.2004 page 1

European Parliament and European Council, 2009, Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the Effort of Member States to Reduce their Greenhouse Gas Emissions to Meet the Community's Greenhouse Gas Emission Reduction Commitments up to 2020, Official journal of the European Union L140 5.6.2009 page 136

European Parliament and European Council, 2010, Directive No 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, Official Journal of the European Union L 153/13

European Parliament and European Council, 2011, Regulation No 510/2011 Of The European Parliament And Of The Councilof 11 May 2011 setting emission performance standards for new light commercial vehicles as part of the Union'sintegrated approach to reduce CO2emissions from light-duty vehicles, Official Journal of the European Union, L 145/1

European Council, 2002, Decision 2002/358/EC concerning the approval, on behalf of the European Community, of the Kyoto Protocol to the United Nations Framework Convention on Climate Change and the joint fulfillment of commitments thereunder Official Journal L 130 , 15/05/2002 P. 0001 - 0003

Gorecki P.K., Lyons S, Tol R.S.J.. (2009) 'EU climate change policy 2013–2020: Using the Clean Development Mechanism more effectively in the non-EU-ETS Sector'. *Energy Policy Volume* 38, Issue 11, November 2010, Pages 7466–7475

Harmsen, R., *et al.*, Imbalance in Europe's Effort Sharing Decision: Scope for strengthening incentives for energy savings in the non-ETS sectors. Energy Policy (2011), doi:10.1016/j.enpol.2011.08.024

Hoekstra, R. & Bergh, J.C.J.M. van den.. (2003) 'Comparing structural decomposition analysis and sector-level index number analysis'. Energy Economics, 25, 39-64.

Höglund-Isaksson, Lena et al. (2010), Potentials and costs for mitigation of non-CO2 greenhouse gas emissions in the European Union until 2030. Results. REPORT to the European Com- mission, DG Climate Action.

IPCC, 2007: Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland, 1

Jungnitz, A. (2008) Decomposition Analysis of Greenhouse Gas Emissions and Energy and Material Inputs in Germany, Petre, Resource productivity, environmentaltax reform and sustainable growth in Europe, Accecced online at http://www.petre.org.uk/pdf/sept08/pETRE_WP1a_GWS_Jungnitz.pdf

Klaassen G., Berglund C., Wagner F., (2005), The GAINS Model for Greenhouse Gases – Version 1.0: Carbon Dioxide (CO2). International Institute for Applied Systems Analysis

National Snow and Ice Data Center (2012). Arctic sea ice falls below 4 million square kilometers. [ONLINE] Available at: http://nsidc.org/arcticseaicenews/. [Last Accessed 14 September 2012]

Oberthur, S. and Pallemaerts M(eds). (2010) The new climate policies of the European Union: Internal Legislation and `Climate Diplomacy pg 102-105

Okamura S., Watterson J., Misra A., Stewart R., Griffin A., Mellios g., Mandl n., Rigler E.. (2012) '*Assessment of the Member States' projections submitted under the EU Monitoring Mechanism in 2011*'. European Topic Centre on Air Pollution and Climate Change Mitigation (ETC/ACM) Technical Paper 2011/2

Peters, G. P. and Hertwich, E. G. (2008) CO2 embodied in international trade with implications for globalclimate policy, Environmental Science & Technology, 42

Raupach, M.R. *et al*. (2007) 'Global and regional drivers of accelerating CO2 emissions'. Proceedings of the National Academy of Sciences PNAS June 12, 2007 vol. 104 no. 24 10288-10293 doi:10.1073/pnas.0700609104

Jensen, P.R., Olson, T. (2003): Analysis of Changes in Air Emissions in Denmark 1980 – 2001: Time series, Bridge tables, Decomposition analysis. (Eurostat Grant agreement nr. 200141200007) Statistics Denmark, Copenhagen

Saikku, L., Soimakallio, S., (2008). Top-down approaches for sharing GHG emission reductions: uncertainties and sensitivities in the 27 European Union Member States. Environmental Science and Policy

Seibel S., 2003, Decomposition analysis of carbon dioxide emission changes in Germany - conceptual framework and empirical results, Federal Statistical office of Germany, Environmental Economic Accounting division

Toi Richard S.J., 2009 Intra-union flexibility of non-ETS emission reduction obligations in the European Union, Energy Policy 37

Torvanger, A.,Ringius, L.. (2001). Burden Differentiation: Criteria for Evaluation and Development of Burden Sharing Rules.: Oslo, Norway: CICERO Center for International Climate and Environmental Research

United Nations, (1992),United Nations Framework Convention on Climate Change, (UNFCCC), New York, Article 2

7 Appendix

7.1 Estimation of ESD absolute targets using the 'official' approach

The Commission in its upcoming report will use this methodology where it will express the ESD targets in absolute amounts. Of course it is not as simple as it is described here and many factors come into play when estimating these targets for setting policy targets. The opt in and opt out of installation during the first ETS period has made the estimation of 2005 non-ETS emissions a complicated matter requiring much needed attention. In the estimate of those targets described below, data provided by the EEA are used and no further investigation into the matter is pursued.

For the ESD targets to be estimated the 2005 non-ETS emissions need to be known. For these do be known it is only a matter of subtracting the verified ETS emissions of 2005 from the historical emissions reported to the UNFCCC. The data sources are retrieved from EEA's online tools on greenhouse gas emissions:

I. Historical GHG emissions contained in the Annual European Union greenhouse gas inventory 1990 – 20102 and reported to the UNFCCC are retrieved from EEA using its online GHG data viewer: http://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer.
II. The ETS emissions are found in EEA's relevant data viewer from at: http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-trading-viewer. The EU ETS data viewer provides access the Community Independent Transaction Log (CITL). The CITL records emission trading data and is maintained by the Commission, which conducts checks of the ETS transactions.

7.2 The ESD targets and Member States projected distance

In the following table the ESD targets are displayed in quantitative amounts for all Member States. On the left column are the results of the method described above and on the right the results of the method based on PRIMES/GAINS data.

Targets in $MtCO_2eq$	Targets based on UNFCCC historical emissions minus Verified ETS emissions 2005	Targets based on PRIMES/GAINS 2005 non-ETS emissions
Austria	60	51
Belgium	85	63
Bulgaria	31	31
Cyprus	6	4
Czech Republic	49	69
Denmark	26	28
Estonia	7	7
Finland	24	28
France	417	338
Germany	504	381
Greece	64	57
Hungary	49	53
Ireland	50	37
Italy	359	267
Latvia	7	10
Lithuania	9	14
Luxembourg	10	8
Malta	1	1.3
Netherlands	125	93
Poland	151	178
Portugal	50	48
Romania	74	84
Slovakia	21	23
Slovenia	11	12
Spain	263	210
Sweden	45	37
United Kingdom	448	308

Table 3 Targets, projections and their distance

Calculations for the distance to the ESD targets				PROJECTIONS			DISTANCE TO TARGET RELATIVE TO 2005		
	2005 non-ETS emissions	ESD Target from 406/2009/EC	ESD target for 2020 in $MtCO_2eq$	PRIMES/GAINS	WEM	WAM	PRIMES/GAINS	WEM	WAM
Austria	60.2	-16%	50.6	58	54	47	-13%	-6%	6%
Belgium	74.4	-15%	63.2	74	78	71	-14%	-20%	-10%
Bulgaria	25.8	20%	31.0	26			21%	0%	0%
Cyprus	4.5	-5%	4.3	5.1	4.3	2.9	-18%	-1%	30%
Czech Republic	63	9%	68.7	63			9%	0%	0%
Denmark	35.3	-20%	28.2	33			-13%	0%	0%
Estonia	5.9	11%	6.5	7			1%	0%	0%
Finland	32.8	-16%	27.6	29			-6%	0%	0%
France	392.6	-14%	337.6	357	354	308	-5%	-4%	7%
Germany	442.7	-14%	380.7	404	421		-5%	-9%	0%
Greece	59.6	-4%	57.2	56	62	60	2%	-8%	-5%
Hungary	47.9	10%	52.7	49	38	36	9%	30%	35%
Ireland	46.1	-20%	36.9	48	46	42	-25%	-20%	-10%
Italy	307.1	-13%	267.2	300	319	271	-11%	-17%	-1%
Latvia	8.4	17%	9.8	8.9	9.8	9.3	11%	0%	6%
Lithuania	12.4	15%	14.3	12.9			11%	0%	0%
Luxembourg	10.3	-20%	8.2	10.7	10.8	10.1	-24%	-25%	-18%
Malta	1.2	5%	1.3	1.0	1.2	1.0	22%	3%	18%
Netherlands	110.5	-16%	92.8	100	102	96	-7%	-9%	-3%
Poland	156.3	14%	178.2	185			-4%	0%	0%
Portugal	47.2	1%	47.7	42			12%	0%	0%
Romania	71	19%	84.5	78			10%	0%	0%
Slovakia	20.2	13%	22.8	23.6	12.9	12.9	-4%	49%	49%
Slovenia	11.1	4%	11.5	14.4	13.4	10.7	-26%	-16%	7%
Spain	233.5	-10%	210.2	254	208	208	-19%	1%	1%
Sweden	44.5	-17%	36.9	41	37		-9%	1%	0%
United Kingdom	366.8	-16%	308.1	317	293		-2%	4%	0%