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The Italian effort under the EU Effort Sharing Decision:

impact assessment of economic crisis and policy framework in the current and expected progress

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SUMMARY

The European Union has committed itself to become a competitive low carbon economy, being at the forefront in fighting against climate change. Tackling climate change goes hand in hand with shaping a sustainable energy system. A secure, competitive and sustainable energy system is a flagship objective of the European Union. The EU energy and climate goals lie at the root of long-term commitments for 2050 and mid-term targets and obligations for 2020. Counting for the former, the EU *Roadmap for moving to a competitive low carbon economy in 2050* and the *Energy Roadmap 2050* address the challenge of shifting towards a resource-efficient and low-carbon Europe by 2050. Considering the latter, the *Climate and Energy Package* lays down the targets for 2020 through a set of binding legislation measures. The Effort Sharing Decision (Decision No 406/2009/EC) is part of the Climate and Energy Package under the headline target on GHG emission reduction. The Effort Sharing Decision aims to reduce GHG emissions on end-use sectors outside the Emission Trading System by setting national emission targets for 2020. The Commission Decision of 26 March 2013 has then translated these targets into annual emission limits (Annual Emission Allocations) for the period from 2013 to 2020. Under the Effort Sharing Decision, Member States should take on adequate policy efforts to ensure the compliance with the national target by not exceeding any annual emission allocation. Furthermore, Member States are required to monitor and report their effort so as to track the progress towards meeting the target. In the reporting activity, Member States shall provide verified data on GHG emissions every year and projections on the expected progress by developing a set of two scenarios every two years. Thus, the verified data and the scenarios developed from them and well-defined assumptions on the expected evolution of the main system drivers track the achieved and projected progress, highlighting the need for possible future corrective or improving measures.

The present work addresses the Italian effort under the Effort Sharing Decision, which requires Italy to reduce its GHG emissions of non-ETS sectors of 13% from 2005 levels by 2020. The aim is to assess whether Italy is expected to meet the target based on the current and expected future progress in curbing GHG emissions. Furthermore, the study aims to assess to what extent the evolution of the legislative framework and the detrimental and prolonged effect of the economic downturn contribute on the previous results. The approach used in this research is based on a scenario analysis. The most relevant scenarios delivered at EU and national level are reviewed in depth in the main assumptions and in the GHG emission trends up to 2020. The gap analysis is then carried out assessing the Italian effort and the expected progress in complying with the EU obligations. Next, the comparative analysis allows to assess the impact of the economic and policy variables on the previous results. Finally, the energy decomposition analysis of the transport sector is performed to outline the expected impact up to 2020 of the economic downturn in its first stage and of the policy framework on a topical and highly meaningful sector. These results support and complete the previous

outcomes by strengthening the understanding on the effect of the investigated drivers on the development of the energy system.

The work demonstrates the crucial role of the economic crisis in supporting the Italian effort, which compensates to a large extent the verified weakness of the policy framework. However, the study highlights that a policy gap is still expected, proving that Italy needs to take on a more robust policy effort in order to meet the national emission target. The implementation of a coherent policy package addressing the Effort Sharing Decision scope would ensure the compliance with the mid-term target beyond the intrinsic uncertainty affecting the reported and projected data. Furthermore, it would trigger the change towards a more sustainable, low-carbon economy in line with the long-term goal set by the European Union for 2050.

To conclude, the present work provides basic and meaningful understanding and evidence on the Italian effort under the Effort Sharing Decision scope including the main drivers affecting the past and future progress. Consequently, the contents of this research may represent the basis of a number of further studies focused on the Italian effort under the Effort Sharing Decision. Lastly, this study may represents a useful tool for policymakers providing basic insights and evidence on the topic.

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1. INTRODUCTION

1.1 Background

Energy drives modern society, ensuring healthy economic conditions and social wellness. Worlds' primary energy consumption has more than doubled in the last 40 years (EEA, 2010) supported by demographic and economic growth. Energy heavily relies on fossil fuels albeit renewable sources have steadily increased their share in the energy mix over time. Renewables' share is expected to keep on growing also in the next years with power generation at the forefront while renewable share in end-use energy mix (including biofuels in the transport sector) is expected to increase at a slower pace (IEA, 2013a). However, increasing energy demand has hidden past improvements towards a cleaner energy mix and it will do so also in the next years (IEA, 2013b).

Moving from global to the European Union (EU) level the picture change to some extent but fossil fuels still maintain the leading role in the energy mix. The growing trend of energy consumption, which has been supported by fossil fuels harnessing, has characterized the last decades before the 2008 financial crisis arrival. The economic downturn has brought about a temporary negative trend in energy demand and have accelerated renewables' uptake. However, energy demand has already started to recover in 2010. The economic downturn lowers the already decreasing share of fossil fuels in the EU energy mix. Nevertheless, fossil fuels still counted for 76% of the total EU energy consumptions in 2010 (European Commission, 2012a). The rising energy use, as deeply depending on fossil fuels, leads to a number of side effects. The European Union consumes one fifth of total energy use and it is the largest world's importer (European Commission, 2010a). Consequently, energy supply risk is a primary concern as the economic and societal prosperity can be guaranteed only by secure and affordable energy. Besides, the large exploitation of fossil fuels is the main cause of greenhouse gasses release, hence of climate change, which treats people's health, environmental integrity and economic wellness (IPCC, 2007a).

It is undeniable that the climate is changing. As proof of that it can be considered the increase of global average atmospheric and ocean temperatures, and the consequent sea level rise, acceleration of snow melting and the higher incidence of extreme weather events that have been occurred since the industrial times. Greenhouse gasses drive global warming. Human-related GHG emissions have been growing for more than 150 years facing a dramatic increase from 1970s until the earliest years of 21st century (IPCC, 2007a). Therefore the main greenhouse gasses are carbon dioxide ($C0_2$), methane (CH_4), nitrous oxide (N_20), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). In particular CO_2 is the most relevant among the greenhouse gasses, leading growing rate of global GHG emissions and covering more than three fourth of total GHG release. Fossil fuel use is the main cause of CO_2 emissions (IPCC, 2007a).

In one hand the global economy has decreased energy intensity over time, but in the other hand, the gain has been offset by economic and demographic drivers, which have supported increasing energy demand and the related emissions. The long-lasting trends of energy demand and consequently, that of fossil fuels consumption, as well as that of the related GHG emissions, are expected to maintain positive rates also in the next few decades, thus posing increasingly risks on people and economic well-being. In fact, temperature rise of more than 2°C will likely bring about relevant human and economic losses (IPCC, 2007b). For this reason, the international community has agreed the common target of keeping the average global temperature growth below 2°C compared pre-industrial times through the United Nations Framework Convention on Climate Change (UNFCCC) and the following adoption of Kyoto Protocol. Only global coordinated actions aimed at mitigating GHG emissions can lead to successful achievements in curbing global warming. However, international negotiations have failed in their efforts towards scaling up the common effort to achieve the 2°C target so far (www.ec.europa.eu).

1.2 The EU Energy and Climate Context

The European Union contributes around 12% of total annual GHG emissions excluding net CO_2 removals from land use, land-use change and forestry (LULCF) (EEA, 2010). EU GHG emissions have shown an overall decrease in the last decades, albeit energy consumption has steady grown in the same period. This can be explained by energy and carbon intensity reduction due to the economic restructuration (mainly) of eastern countries (European Commission, 2012b), renewables penetration and shift towards low carbon intensive fuels (i.e. gas and biofuels) (European Commission, 2012a) and energy efficiency improvements in the demand side. These improvements mirror the legislative effort of the European Union in tackling climate change while supporting secure, competitive and sustainable growth. The EU Community has long played a leading role at international level in promoting global ambitious actions aimed at curbing GHG emissions worldwide. Besides being at the forefront in the international effort, the Community sets an example through decisive strategies and commitments that required firm and long-lasting contribution of Member States in the climate and energy field.

Tackling climate change goes hand in hand with shaping a sustainable energy system. The Treaty of Lisbon has set the guidelines on energy and climate actions. The treaty has laid down the core objectives of EU energy policies, whose aims is to pursue a secure, competitive and sustainable energy system (TEU art. 176A, as amended). The Energy Strategy (European Commission, 2010a) has entered the challenge defining the path that energy policies, which should be less national-dedicated and more EU-oriented, should follow. According to the mentioned provision, Member States must take on robust efforts towards meeting the climate and energy targets set for 2020 by the Climate and Energy Package in order to achieve a secure and sustainable EU energy system. The strategy sets energy efficiency as the key driver towards the change. "Energy efficiency is the most cost effective way to reduce emissions, improve energy security and competitiveness, make energy consumption more affordable for consumers as well as create employment, including in export industries" (European Commission 2010a, p.6). The strategy highlights the need to address the largest untapped cost-effective potentials, which lie in end-use sectors and above all in residential and transport. Besides energy efficiency, a faster penetration of renewable sources is another key factor to steer energy system towards the objective set by the Treaty. Acting to build up a cleaner and efficient energy system will allow the European Union to shape a resource-efficient and low-carbon economy. These are key objectives in the *Resource efficient Europe* flagship initiative developed under the Europe 2020 Strategy for smart, sustainable and inclusive growth (European Commission, 2011a). Such change will lead to dramatic GHG emission abatements in the short and long term. In a short term, this change will enable the Community to go beyond the 2020 climate and energy targets, paving the way for meeting more ambitious goals. In fact, the European Union has offered to step up its effort in reducing GHG emissions for 2020 if a more ambitious international commitment will be agreed (European Council, 2009a). In a long term, the shift towards a resource-efficient and low-carbon Europe will support the EU commitment to curb its GHG emissions between 80% and 95% from 1990 levels by 2050 (European Council, 2009b). This ambitious goal is addressed by the EU *Roadmap for moving to a competitive low carbon economy in 2050* (European Commission, 2011b), which sets an indicative 80% target for 2050, and the *Energy Roadmap 2050* (European Commission, 2011c), which assesses the challenging long-term objective. Thus, by reducing energy and carbon intensity the European Union will be able to provide a substantial contribution in the global fight against climate change.

1.2.1 The Climate and Energy Package

The EU climate and energy targets, as currently set, are embraced by the so called *Climate and Energy Package* and are laid down by the Commission Communication *20 20 by 2020 Europe's climate change opportunity* (European Commission, 2008). The Climate and Energy Package is the core of the EU effort in combating climate change in the short-medium term up to 2020. This highly comprehensive provision adopted the 6 April 2009 is made up by a set of binding legislative measures, which provide the so called *20-20-20* targets on climate and energy for 2020. These headline targets are:

1. the greenhouse gas emission reduction target
2. the renewable energy target
3. the energy efficiency target

The Greenhouse Gas Emission Reduction Target

The GHG emission reduction target calls for a reduction in GHG emissions of at least a 20% compared to the 1990 levels for the whole EU by 2020. The legislative framework behind this target is based on two sets of complementary legislative measures, each set focuses on its own specific target. Hence, the overall 20% reduction target is split up into two sub-targets. Both energy supply and demand sectors must contribute towards the overall target achievement addressing their own sub-target. The legislative key tools to achieve the emission reduction targets are on one hand the Emission Trading Directive (Directive 2009/29/EC) and on the other the Effort Sharing Decision (Decision No 406/2009/EC).

Directive 2009/29/EC (European Parliament & Council, 2009a) regulates the EU Emission Trading System (ETS), which covers heavy energy-using installations in power generation and manufacturing industry as well as air transport. These sectors (ETS sectors) bring about around 45% of EU GHG emissions (www.ec.europa.eu). The addressed greenhouse gasses are carbon dioxide (CO_2), nitrous oxide (N_2O) and perfluorocarbons (PFCs). Under the Emission Trading System the European Union commits itself to reduce GHG emissions of 21% from the 2005 levels by 2020 (ETS target). The EU ETS is an EU-wide system trading greenhouse gas emission allowances, whose volume is submitted to the "cap and trade" principle. In fact, the European Commission has set an EU-wide cap, which controls and reduces yearly GHG emissions towards meeting the 2020 ETS target.

Decision No 406/2009/EC (European Parliament & Council, 2009b) regulates the sectors not covered by the Emission Trading System (non-ETS sectors) namely residential, tertiary, transport (except for air and seaborne transport), industry outside the ETS, agriculture and waste. The greenhouse gasses addressed by the non-ETS target are the ones covered by the Kyoto Protocol (see below). Under the Effort Sharing Decision the EU should reduce its non-ETS GHG emissions of 10% compared to 2005 levels by 2020. The overall target is split up among Member States through national binding targets. Member States limit their emissions from 2013 to 2020 according to the national target by following a linear path defined by the annual emission allocations set by the Commission Decision of 26 March 2013. A more complete description of the non-ETS target and of the Effort Sharing Decision is provided in the next section.

The Renewable Energy Target

The renewable energy target lies in reaching a 20% share of energy from renewable sources in Europe for 2020. Furthermore, it includes a specific target addressing renewables in the transport sector. The two targets are embedded in Directive 2009/28/EC (European Parliament & Council, 2009c). The Directive sets national binding targets that Member States must take on to contribute to the common 20% renewables target. On the other hand, the transport target is the same for all Member States demanding the increase of renewable energy in the transport sector to a 10% share for each EU country by 2020.

In order to effectively deal with the renewables targets, Member States must adopt a National Action Plan for Renewable Energy (NAP-RES). The action plan sets the national framework to meet the targets, which are split up into sectorial targets (transport, electricity and heating/cooling). The sectorial targets define the share of energy from renewables that must be consumed by each sector in order to achieve the overall target set by the Commission. The Renewable Directive highlights the remarkable contribution that energy efficiency and energy savings may provide. For this reason the national plan should address and assess the expected effect of planned policies and measures addressing energy efficiency and energy savings. Finally, Member States must comply with monitoring and reporting requirements in order to assess and provide results on the effect of policies and measures aimed at supporting renewables' penetration.

The Energy Efficiency Target

The energy efficiency target calls for a 20% increase in energy efficiency, hence a 20% reduction in energy consumptions in the European Union by 2020. The target is set by Directive 2012/27/EU (European Parliament & Council, 2012), which establishes a common framework to enhance energy efficiency for 2020 and afterwards. This is the only indicative target within the Climate and Energy Package. According to the Directive, Member States must set indicative targets for 2020 defining the existing and planned policies and measures that are expected to take the mentioned target on. To this scope, the National Energy Efficiency Action Plan is the pivotal legislative instrument that Member States are required to adopt. Moreover, Member States have to monitor and report every year their progress towards the target achievement.

The aforementioned headline targets are closely linked each other, showing trade-offs and synergies. Member States should implement policies and measures aiming to trigger effective and efficient efforts to meet the targets. In doing so, the legislative effort should be oriented towards policies and measures able to maximize positive synergies as well as to successfully deal with trade-offs between the targets scopes. This approach would assure to largely overtake the binding targets. Moreover, it would enable to meet the only target that the European Community will fall behind with the policies and measures currently in place, i.e. the energy efficiency target (European Commission, 2011a; Ecofys & Fraunhofer ISI, 2010). Energy efficiency overarches the other targets within the Climate and Energy Package. In fact, Directive 2009/28/EC as well as Decision No 406/2009/EC states the crucial role of energy efficiency towards meeting the respective targets. The implementation of policies and measures aimed at improving energy efficiency is among the most effective way to increase the share of renewable sources in gross final consumption of energy (European

Parliament & Council, 2009c). Moreover, it represents the most cost-effective and rapid way to abate GHG emissions in the short term (European Commission 2010a). High cost-effective potentials concern end-use sectors; i.e. the sectors regulated by the Effort Sharing Decision (Ecofys & Fraunhofer ISI, 2010). In particular, the built environment shows the highest untapped cost-effective potentials which should be addressed in the next years in order to reduce energy demand and the related GHG emissions (Fraunhofer ISI, 2012). To conclude, great benefits would derive by setting a binding energy efficiency target. Such edge would boost the change towards a resource-efficient and low carbon Europe, enabling the Community to meet its medium-term targets and to get on track towards its long-term objectives.

1.2.2 The Effort Sharing Decision

Decision No 406/2009/EC (European Parliament & Council, 2009b), known as Effort Sharing Decision, complements the legislative framework of the Emission Trading System (ETS) in the headline target of the Climate and Energy Package on the greenhouse gas emissions reduction for 2020. This piece of legislation regulates the sectors outside the ETS, hence called non-ETS sectors, which are residential, tertiary, transport (excluding aviation and maritime transport), industry outside the ETS, agriculture and waste. The greenhouse gasses addressed by the Decision are carbon dioxide ($C0_2$), methane (CH_4), nitrous oxide (N_20), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Under the Decision, the European Union as a whole is required to reduce its GHG emissions at least of 10% compared to the 2005 levels by 2020. In order to achieve such target, the Decision lays down national binding targets, which may require Member States either to reduce or to limit GHG emissions depending on the domestic GDP per capita. In order to achieve the national 2020 non-ETS target set in the Decision, Member States must not exceed any of the annual emission allocations set for the period from 2013 to 2020 along a linear trajectory. The *Annual Emission Allocations* are defined as "annual maximum allowed greenhouse gas emissions in the years 2013 to 2020" (European Parliament & Council 2009b, art. 2(2)) and they translate the reduction or limiting percentages listed in Annex II of the Decision (i.e. the national binding target for 2020) into absolute annual emission values. Commission Decision of 26 March 2013 (European Commission, 2013) laid down the annual emission allocations, which hence spell out Member States' effort towards non-ETS target achievement. In order to meet every annual emission limit Member States should implement effective policies and measures addressing the end-use sectors under the Decision scope. In this regards energy efficiency measures should be at the forefront (European Parliament & Council 2009b, art. 4). In addition, Member States may reach part of the reduction (not more than 3% yearly with some few exceptions) by implementing emission reduction projects in developing countries in compliance with the Clean Development Mechanism (CDM) set in Article 12 of the Kyoto Protocol. Besides, Member states may apply between 2013 and 2019 some flexibility instruments provided by Article 3 paragraphs 3, 4 and 5 of the Effort Sharing Decision. These flexibility instruments allow Member States emitting less than the maximum allowed limit set by law, to carry forwards from the following year part of their annual emission allocation (no more than 5%) or to carry over the exceeding part of the annual emission allocation of a given year to the following ones. On the other hand, Member States exceeding the binding annual limit may transfer a maximum amount of 5% of the annual emission allocation to another Member State. If a Member State falls behind the annual emission allocation, even though making use of the flexibility instruments, it must develop corrective actions as set by Article 7 of the Decision. Finally, the Effort Sharing Decision calls for a robust monitoring and reporting action in concert with Decision No 280/2004/EC (the so called *Monitoring Mechanism Decision*). According to Article 6, Member States must report GHG emissions data, information on the used CDM credits, the projected progresses towards the target achievement and information on the existing and planned policies addressing the scope of the Effort Sharing Decision (European Parliament & Council 2009b).

1.2.3 The Monitoring and Reporting Obligations

The effort addressing the binding targets under the Climate and Energy Package requires a coordinate action of Member States, overarched by the European Commission, in order to achieve the common success. Monitoring and reporting activities are essential to track the progress towards meeting the EU targets and the international commitments (i.e. Kyoto Protocol). Every year Member States have to report their progress towards meeting their climate and energy targets to the European Union. Concerning the emission reduction targets, Member States perform these activities in compliance with EU and international requirements. This activity allows to assess where each Member State as well as the European Union as a whole stands in relation to the domestic and international effort to curb GHG emissions.

The Monitoring Mechanism Decision (Decision No 280/2004/EC), which has been recently revised, regulates the monitoring and reporting activity on GHG emissions of Member States, as well as of the European Union. According to Article 3(1) of the Decision (European Parliament & Council, 2004), Member States have to prepare and submit to the Commission a *National Inventory Report* (NIR) every year. The report provides verified data on emissions by sources and removals by sinks of Kyoto Protocol's greenhouse gasses. Furthermore, Article 3(2) requires Member States to provide every two years the data and information on the following items:

- sectorial national legal provisions addressing GHG emissions reduction by sources or removals by sinks, considering their scope and the estimated effectiveness;
- national projections on GHG emissions by sources and removals by sinks on 5-years steps at least until 2020, highlighting the policies and measures applied to develop the scenarios.

The information and data provided by Member States in compliance with Article 3 paragraph 2 of Decision No 280/2004/EC are included into reporting tables and biennial reports. The former is prepared following a strict template according to the UNFCCC guidelines (FCCC/CP/1999/7). The latter is the *National Climate Policy Progress Report*, which describes and explains the data reported in the tables.

The data and information issued by Member States in compliance with EU and UNFCCC reporting requirements are applied at EU level to assess and report the national and Community actual and projected progress towards meeting the national and EU GHG emission targets and towards the realization of the international commitments under the UNFCCC and the Kyoto Protocol. Thus, the monitoring and reporting activity enables to assess whether Member States and the European Union are expected to fall behind the targets achievement, hence highlighting if further policies and measures are needed to be implemented to get on track.

1.3 Tracking the Progress: the Scenario Analysis

The short-medium term binding targets (for 2020) and the long-term objectives (up to 2050) for the European Union and Member States as well as the option to go beyond the current targets require a clear understanding of the achieved progress and the future expected results. The European Union and Member States have built up their efforts in fighting against climate change by using scenarios that try to represent the evolution of the energy system in the following decades. Scenarios are developed from verified data provided by monitoring and reporting activity carried out by Member States and from well-defined assumptions on the expected evolution of the main system's drivers.

The monitoring and reporting activity and the subsequent scenario development and analysis help Member States and the European Union to assess past actions, current progress and any possible future corrective or improving measure. These activities are crucial under the Effort Sharing Decision scope as they track the achieved and projected progress. Monitoring and reporting data outlines the achieved progress and it contributes to trace out the path towards 2020. Additional actions planned or envisaged as well as the expected evolution of the main drivers of the energy system namely demographic trends, economic and sectorial wealth, fuels prices and development, and penetration of new low-carbon technologies (Capros et al., 2008; 2010) complete the picture. Thus, the verified data and the assumed development of the energy system under economic, demographic, technical and policy drivers outline the projected energy use and hence the projected emissions in the non-ETS sectors in the next years. Afterword, the comparison between the projected emissions and the targets allows to highlight whether the given Member State is expected to meet the targets set by law. If the comparison shows an emission gap, this means that not enough effective policies and measures addressing the non-ETS scope have been implemented yet, hence the Member State is facing a policy gap. As a consequence of this result the Member States should implement further policies and measures in order to close the gap. The mentioned comparison allows to highlight the emission gap (and hence the policy gap) in absolute terms. However, the complexity of the system, which is controlled by a large number of variables, the interrelationship with the ETS sectors, which may bring about sectorial carbon leakage (Fraunhofer ISI et al., 2012a), and the legislative improvements resulting for instance in attribution's change (e.g. aviation has been including into the Emission Trading Scheme since 2012 only) (EEA, 2011a) may affect the accuracy of the verified data. The application of barely accurate data, although considering correct assumptions on the development of the energy system, affects the results of the projecting activity (i.e. the expected future progress). Nevertheless, a meaningful analysis can be carried out also in this case, but the resulting outcomes provide understanding on a relative basis. In fact, the comparison addresses the projected results on the one hand and the limiting or reduction trajectory (depending on the target set in Annex II of the Decision) that should be followed by the projection (based on its own baseline data) in order to meet the target set for 2020 by the Effort Sharing Decision on the other. Hence, the relative analysis on the emission gap does not set whether the expected progress of a given Member State will allow it to meet the annual binding targets (i.e. the annual emission allocations). On the other hand, it assesses the strength of the policies and measures taken into account, providing a clue of the need for further policies and measures.

1.3.1 Scenarios

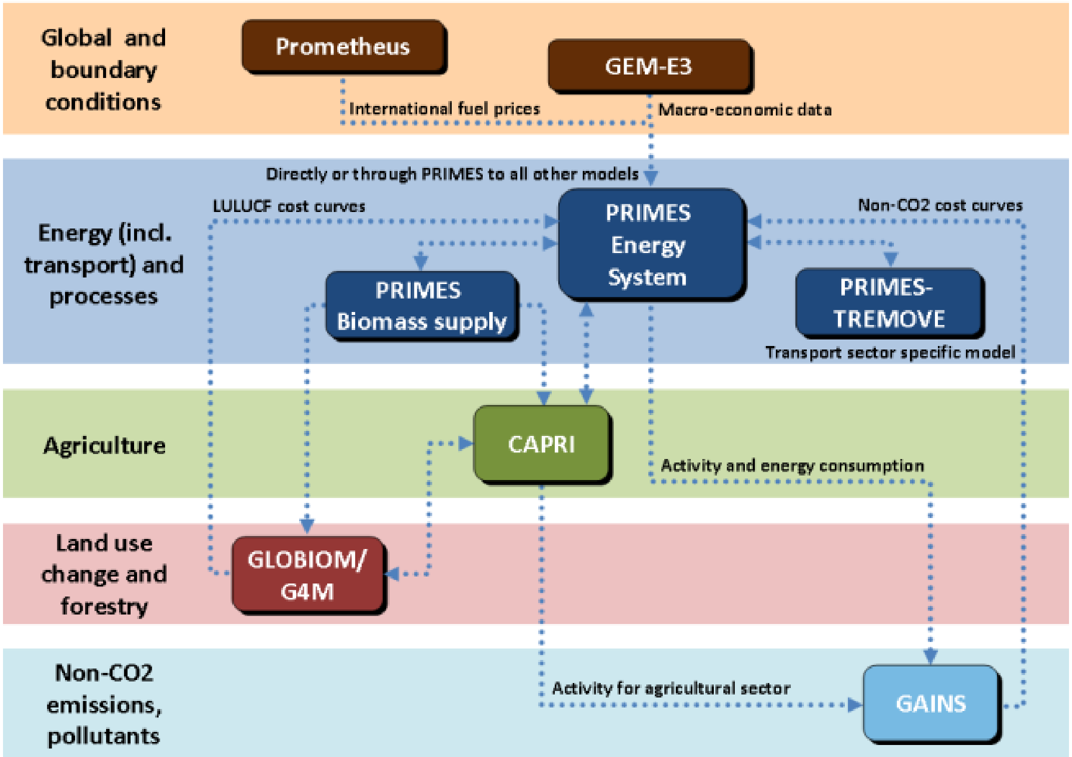
Scenarios are powerful tools to define where the European Union and Member States stand on their effort to meet the ambitious commitments to fight climate change. Moreover, scenarios are used to analyze additional policy options that have been implemented in the past or are under discussion right now. For instance, the European Commission has been using scenario projections to carry out impact assessment analysis on relevant measures, policies and policy packages addressing or affecting both the climate and the energy field.

The scenarios taken under consideration for policy assessment and policy making purposes describe how the EU and Member States energy system is shaped and may evolve over a medium/long term horizon. They are based on a set of assumptions that mainly address the expected market evolution, the hypothetical future economic context and technological development as well as policy and environmental constraints. The results are data and trends covering energy demand and supply and the related GHG emissions at a sectorial level. Some relevant indicators that mirror system efficiencies/inefficiencies are also provided. Several scenarios showing these features and purposes are available. Nevertheless, the projections may strongly differ from one to another since a scenario is by definition "a plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships" (IPCC 2007c, p. 951). Thus, the results are tightly linked to specific data, supposition and the mathematical models employed to develop the scenario. Furthermore, scenario projections may differ to some extent from each other due to some sources of uncertainty, again related to the scenario basis (i.e. input data and assumptions and modelling process). Data uncertainties primarily depend on the quality, appropriateness and validity of the input data available through monitoring activities, which, in turn, may also deal with errors and uncertainty (e.g. data attribution) (IPCC, 2000). Then, assumptions' uncertainties are mainly due to the high complexity of the energy system as it makes barely predictable the future development of system drivers and variables. Finally, the modeling process provides, by nature, a simplified representation of the system based on approximations that further increase the unpredictability related to the model outputs. To sum up, scenarios are characterized by both intrinsic and extrinsic uncertainty, but they are still considered useful tools in supporting policy makers and official monitoring and reporting agencies.

1.3.2 Mathematical Models behind Scenarios

Scenarios are the result of modeling processes performing by mathematical models. The large number of scenarios aiming at representing the likely future evolution of the energy system mirrors the abundance of mathematical models running such scenarios (Goldstrein & Tosato, 2008). The models are divided in two broad categories depending on their distinctive approach, i.e. bottom-up or top-down. Bottom-up models formulate a single overarching equilibrium problem for the energy supply side and they are driven by energy service demand options that are usually exogenously determined (Loulou & Labriet, 2008). This approach results in scenarios whose use is particularly suitable to carry out impact assessment analyses on new technologies and to carry out marginal cost analyses (Bahn et al., 2004). Top-down models are based on a wider equilibrium framework encompassing both the demand and the supply side that are fully integrated in the economic frame (Bosetti et al., 2009). Here, the system is driven by aggregate economic variables while technology options are often not made explicit (IPCC, 2007b). The resulting scenarios are often applied for policy assessment purposes (Bahn et al., 2004).

The European Commission and Member States benefit of a suite of mathematical models that provides projections representing the potential developments of the energy system both at the aggregate (EU-wide) and disaggregate (Member State) level. Every model focuses on specific sub-systems, but their complementarity and correlation provide a consistent picture of the system as a whole. In fact, starting from global as well as national boundary conditions (Prometheus and GEM-E3) and including specific economic, technology and policy assumptions, the suite of models encompasses energy supply and energy demand sectors (PRIMES and GAINS), the land use, land use change and forestry (LULUCF) sectors (CAPRI, GLOBIOM and G4M), assessing both CO_2 (PRIMES) and non-CO_2 (GAINS) emissions as well as CO_2 removals by sinks (G4M). The complex framework formed by the interlinked models can be schematically represented as in the following figure.



Source: www.euclimit.eu (31/07/2013)

Figure 1 – Framework of the suite of mathematical models performing the EU most relevant scenarios

The Prometheus and GEM-E3 models represent the foundations of the models framework. The former is a World energy model, based on a set of stochastic equations processing the main macro-economic, technology, environment and policy drivers in the field of energy system. The modelling process results in a set of stochastic data on energy-related supply, demand and emissions as well as on world energy prices (www.euclimit.eu). The outputs addressing world energy prices are applied as inputs to the PRIMES modelling system (Capros et al., 2008; 2010). The latter is a globally applied general equilibrium model focused on the relationships between economy, environment and energy system. The computations result in a set of economic, environmental and energy-related balances (www.euclimit.eu). Outputs addressing macro-economic variables have been applied as assumptions to run sectorial projections in the domain of PRIMES (Capros et al., 2008; 2010).

The PRIMES model represents the energy system in its complex framework, based on supply and demand branches, which are further divided into sub-sectors. The wide PRIMES Energy System Model can be integrated by two more specialized models, i.e. the PRIMES Biomass Supply Model and the PRIMES-TREMOVE Transport Model that can be applied both as satellite and stand-alone models (www.euclimit.eu). In addition, other models, which are not based on PRIMES standards, complete the system. The CAPRI model is specialized on agriculture, while GLOBIOM (Global Biosphere Management Model) integrates agricultural, bioenergy and forestry sectors (www.euclimit.eu). Counting for the forestry sector, G4M (Global Forestry Model) quantifies sectorial activity impacts on biomass and carbon stocks and, therefore, on emissions and removals (www.euclimit.eu).Finally, the GAINS model (Greenhouse and Air pollution Interactions and Synergies) covers the domain of the most relevant air pollutant (e.g. SO_2, NO_x, particulate matter, volatile organic compounds) and non-CO_2 GHG emissions (CH_4, N_2O, F-Gases). The GAINS modelling process, based on economic, technical and pollutant-specific features (Amann et al., 2008), results in emission scenarios that integrate PRIMES projections on energy and processes-related CO_2 emissions and G4M projections on GHG emissions addressing LULUCF, leading to a complete estimation of emissions and removals of the system on a medium to long term horizon.

As can be inferred from Figure 1, the PRIMES modelling system is at the core of the suite of models used at EU level to represent the whole system. Its prominent role justifies the support given by the resulting scenarios to the relevant policy analyses carried out at national and EU level.

At national level, Member States can choose from a variety of mathematical models. MARKAL and TIMES are the most widely-used. Among their EU users are included France, Germany, Italy, the Netherland and Spain. MARKAL and TIMES models have been developed under a long-lasting multinational project (ETSAP: Energy Technology Systems Analysis Program) coordinated by the International Energy Agency (IEA) (www.iea-etsap.org). TIMES represents an evolution of MARKAL model including new features to enhance its functions (Loulou & Labriet, 2008). From the MARKAL and TIMES frame, users tailor the mathematical model in order to provide the most suitable representation of the specific energy system. Hence, versatility has largely contributed to the widespread use and development of MARKAL/TIMES family of models. Moreover, by applying models belonging to this family, users benefit from the exchange of shared information, progress and results (Chiodi et al., 2013).

1.4 Problem Definition and Research Goal

The present work addresses the Italian effort towards meeting the national emission reduction target set by the Effort Sharing Decision. The research investigates the progress of Italy in this field and the main intrinsic and extrinsic factors affecting the success in the effort. In doing so, the analysis aims to answer the following research questions:

1. Does Italy face a policy gap to meet the non-ETS target?
2. To what extent do the economic crisis and the policy framework affect the previous results?

1.4.1 The Effort Sharing Decision in Italy

According to the Treaty on the Functioning of the European Union (TFEU), Member States are responsible to implement the EU law and pursue the Community objectives. Hence, Italy is called for playing its role in supporting the change towards a more competitive, secure and sustainable Europe by dealing with the binding and unbinding legislative instruments set at EU level. In the field of the global and EU fight against climate change, Italy is committed to make the required effort to succeed in dealing with the binding targets set by the European Commission. Under the Climate and Energy Package, only the ETS target (GHG emission reduction sub-target) is based on an EU-wide objective (21% reduction from 2005 levels by 2020). On the other hand, the non-ETS target (complementary to the ETS sub-target) and the renewables target feature national-specific binding goals. The non-ETS target and the renewables target for Italy set by Decision No 406/2009/EC and Directive 2009/28/EC respectively are the following:

- 13% reduction in GHG emissions from domestic non-ETS sectors compared to 2005 levels by 2020;
- Increasing to 17% the share of energy from renewable sources in gross final domestic consumption of energy by 2020.

According to the Effort Sharing Decision (European Parliament & Council, 2009b), Italy is required to reduce its emissions of Kyoto Protocol's greenhouse gasses from non-ETS sectors according to the reduction percentage laid down in Annex II. Such target has been translated into absolute terms (expressed in tonne of carbondioxide equivalent) by the Commission Decision of 26 March 2013. This Decision defines the reduction path that Italy must follow until 2020 by setting out the Annual Emission Allocations from 2013 to 2020. According to Annex I of the Decision (European Commission, 2013), Italy should reduce domestic non-ETS GHG emissions from 310.12 $MtCO_2$ eq. in 2013 to 296.28 $MtCO_2$ eq. in 2020. The annual emission allocations were defined as a linear trajectory between the ones addressing the year 2013 and 2020.

In order to achieve the reduction target set by the Effort Sharing Decision, keeping up with the annual emission allocations, Italy has to implement effective measures addressing the non-ETS sectors. Dedicated policies and measures can be implemented both by legislative and by administrative authorities, acting from national to local level. The central government has full responsibility to enact climate policies, although the legislative role of regions has increased in the recent years (Franceschelli, 2013). However, the Italian effort towards meeting the non-ETS target strongly rely on the EU law (OECD, 2013a). In fact, the EU legislation addressing the Effort Sharing Decision scope is abundant and increasingly comprehensive bringing large benefits to Member States. Nevertheless, based on the principle of subsidiarity (see TFEU) every Member State has to make a contribution beyond the EU legislative effort to enable the Community to reach the overall 2020 non-ETS target. However, based on a recent review carried out by the OECD (2013a), the Italian legislative effort is too weak, therefore further policies and measures need to be implemented at national and sub-national level.

The implementation of an adequate policy package is essential to comply with the EU requirements. To do so, Italy needs to carefully assess the current and the expected progress in order to be aware on where it stands in relation to the obligation set by the Effort Sharing Decision. This would assure the compliance with the annual emission allocations by taking on corrective strategies if required, i.e. if a policy gap (expressed in terms of emission gap between the expected emissions for a given year and the annual emissions limit for the same year) is expected to occur. The scenarios developed at national level provide the most updated and accurate information on the expected progress, and hence on the expected policy gap if existing. Nevertheless, the complexity of the energy system requires a more comprehensive analysis to track the expected progress so as to deal with the EU requirements effectively. In fact, several drivers and variables contribute in shaping the non-ETS branch of energy system, therefore changes in these drivers may alter the expected evolution of energy consumption and the resulting GHG emissions. Consequently, it is crucial to deeply understand the impact of the drivers in both the achieved and the expected progress in order to gain correct understanding on the outcomes of the scenario analysis assessing the emission and hence the policy gap.

Generally speaking, the policy framework and the economic context are the major drivers in the evolution of domestic GHG emissions, and hence of the progress towards meeting the non-ETS target. Thus, the assessment of their respective weight on the expected progress has a pivotal role in supporting the implementation of adequate policy actions towards and beyond the need to meet the mentioned target.

Economic activity strongly affects energy use and the related GHG emissions, especially in the short to medium period as demonstrated by the recent global financial crisis, which has deeply affected the already weak Italian economy (Crafts & Magnani, 2011. In fact, Italy is the OECD county featuring the lowest annual average growing rate from 2000 to 2010 (OCSE, 2013b) and the detrimental effects of the adverse economic conditions have concerned all the economic sectors. The drop in the economic activity caused the collapse of final energy demand (IEA, 2009) and consequently of GHG emissions. Total EU GHG emissions dropped of around 7% between 2008 and 2009 due to the abrupt effect of the economic downturn. Italy contributes together with Germany and the United Kingdom to around half of the total EU reductions (EEA, 2011b). Non-ETS sectors in Italy have been featuring a steady decrease in GHG emissions since 2005 (with the only exception of 2010), nevertheless the reduction was steeper between 2008 and 2009 (ISPRA, 2012). In fact, the annual growing rate of non-ETS GHG emissions between 2005 and 2008 was -2.7%, while the first impact of the economic crisis lowered it to -4.4% (ISPRA, 2013a). Thus, the economic recession has strongly affected the non-ETS sectors, moreover its effects are still clear and are expected to persist at least until end 2013. In fact, according to the *Interim Economic Assessment* released at the beginning of September from OECD (2013c) Italy is the only major economy expected to maintain negative growing rate also in the whole 2013. Furthermore, based on short-term projections the domestic economy will show positive trends only from 2014 (OECD, 2013b). Nevertheless, the expected growth is barely predictable also in the short run. In fact, the projected annual growth for 2014 fluctuates from 0.4% based on OECD estimations (OECD, 2013b) and 0.7% according to Eurostat to 1.3% when the impact of the structural reforms adopted by the national government in 2012 are partially taken into account (Ministry of Economy and Finance, 2013).

Economic constraints lead to reductions in energy use and consequently in GHG emissions benefitting the effort towards complying with EU obligations. However, many side effects affecting the same effort derive from economic recession and stagnation. In fact, the deterioration of public finance and the weakening of private spending power slow down investments on new and less energy and carbon intensive technologies as well as research and development on these fields (IEA, 2009). Consequently, once the economic recovery occurs emission reduction gains will be offset by robust energy consumptions if no effective policymaking efforts are developed in the meanwhile to reduce energy and carbon intensity of the system. Energy intensity is the amount of energy used per unit of service (or value provided) (Lovins, 2004), while carbon intensity represents the amount of tonne of carbon emitted per unit of energy. These are meaningful indicators of the sustainability of a sector as well as of the whole economy, in fact the lower the indicators' value the higher the sustainability of the system.

Policies and measures addressing the Effort Sharing Decision scope aim to trigger energy and carbon intensity reductions on a given sector or in more than one sector (cross-cutting policies). These actions support economic restructuring towards breaking the link between economic growth and energy consumptions (and hence GHG emissions). In end-use sectors this relationship is sector-specific, depending on the degree to which sectorial activity (expressed for instance as gross value added in industry and in the tertiary or as tonne of goods or number of passengers moved per kilometer in transport) is decoupled from domestic economic growth (generally expressed in terms of GDP). Generally speaking, the less sustainable the less decoupled, although some sectors such as industry and freight transport are by definition tightly linked with the economic context. Nevertheless, improvements towards reducing energy and carbon intensity can be achieved in all end-use sectors by addressing the existing untapped energy saving potentials (Ecofys & Fraunhofer ISI, 2010; Ecofys et al., 2009). Such structural change applied to all end-use sectors would ensure the compliance with the Effort Sharing Decision obligation. Moreover, it would put Italy on track to become a low carbon economy as required by the corresponding long-term goal of the European Union.

Finally, the sectors regulated by the Effort Sharing Decision as well as the Italian economy as a whole are barely sustainable so far. This is proved by the correspondence between the Italian Gross Domestic Product (GDP) dynamic on the one hand and the energy use and GHG emissions on the other, which has been made explicit by the economic crisis arrival. Moreover, the assessed weakness of the policy package addressing the non-ETS scope (OECD,2013a) and the corresponding still sizable unemployed energy saving potentials featuring by all end-use sectors (especially built environment and transport) (Fraunhofer ISI, 2012) provide further evidence of the high energy and carbon intensity of the Italian economy. Consequently, a meaningful analysis of the current progress and of the expected one cannot disregard the impact of the policy variable as well as of the economic variable when assessing the national (existing and required) effort towards meeting the binding target set by Decision No 406/2009/EC in the form of the annual emissions allocations. Hence, such analysis is crucial in order to obtain the correct results to reach the final goal of meeting all the annual emissions allocations as required by law.

1.4.2 Sectorial Analysis: the Transport Sector

The scenario analysis addressing the non-ETS branch at the aggregate level provides meaningful understanding and it supplies policymakers with essential information and data (Fraunhofer ISI et al., 2012b). However, further insight derives by looking at the energy system from a more disaggregate viewpoint, i.e. at sectorial level. In fact, besides cross-cutting policies, the implemented policies and measures usually act on a specific targeted sector. Consequently, the analysis at sectorial level goes a step further providing more specific and accurate data and information that allow policymakers to take adequate and focused policies decisions in the Effort Sharing Decision scope (further information addressing for instance barriers and potentials are also required though) (Fraunhofer ISI et al., 2012b). However, the lack and inconsistency of data often limit the analysis carried out at this stage (IEA, 2007), this issue has been addressed by the Monitoring Mechanism Decision (Decision No 280/2004/EC) and by Community and international programs such as the ODYSSEE program, focusing on monitoring energy efficiency in Europe, supported by the EU

Commission (www.odyssee-indicators.org). Finally, the scenario analysis carried out at sectorial level completes the aggregated one deepening the understanding on the drivers and variables shaping the domestic energy system in the non-ETS branch. In fact, it may help to trace out causes and effects that the aggregate analysis may not detect or may not be able to explain. However, the non-ETS sectors differ in variable extent in their features, drivers and in the typical reliability and availability of their data. Consequently, a given sector may provide more insight compared to another depending on the scope of the investigation.

The Sectorial analysis addressing the transport sector is source of meaningful information within the scope of the Effort Sharing Decision due to the typical features of the mentioned sector that make it highly relevant and representative. Decision No 406/2009/EC regulates only part of the transport sector, in fact aviation and maritime transport are not included. The former has been entered into the Emission Trading Scheme since 2012, the latter is matter of none instrument aimed at internalizing its climate change costs yet.

Transport is the most carbon and energy intensive among the non-ETS sectors and it accounts for around one third of the final energy demand both at EU and Italian level. Furthermore, the transport sector still relies almost entirely on oil and oil products, which accounted for around 96% (European Commission, 2011d) and 94% (ENEA, 2012) of the sectorial energy use at EU and Italian level respectively in 2010. The GHG emission bulk of transport sector results from the volume and energy intensity of the sectorial activity and the carbon intensity of the deployed energy sources (European Commission, 2009). Transport activity mirrors the needs for services, networks and infrastructures (EEA, 2008) and it is typically split up into freight and passenger transport. The former is strongly related to the economic context while the latter is roughly decoupled by the domestic economic activity (European Commission, 2011e). This is proven by the abrupt decrease in goods transport activity on the one hand and by the roughly stable activity of passenger transport on the other starting from the economic downturn arrival (www.epp.eurostat.ec.europa.eu). Thus, the ratio of transport activity on GDP can still provide information on transport intensity, and hence on the sectorial sustainability, for haulage while is barely representative when applied to passenger transport. On the other hand, energy intensity and carbon intensity indicators are more effective in defining sectorial sustainability and energy efficiency gains (Banister & Stead, 2002). However, efficiency enhancements may be offset by increasing demand, such as for road transport, which dominates both goods (around 90%) and people movements (more than 90%) accounting for large part of fuel consumptions and GHG emissions (ISPRA, 2013b). Finally, the transport sector in Italy is barely sustainable, especially in the freight branch, as consequence of a dramatic gap on national policies aimed to tackle energy consumptions and GHG emissions. In fact, transport contributes to the lowest extent among the non-ETS sector in the effort towards meeting the emission reduction target. The policy gap and the need to implement further policies to curb sectorial energy consumptions and GHG emissions is highlighted also by studies carried out at EU (Energy Efficiency Watch, 2013) and at international level (OECD, 2013a).

2. METHODOLOGY

2.1 Research Presentation

Congruently with the problem definition and research goal (section 1.4), the methodology applied to this work aims to answer the following research questions:

1. Does Italy face a policy gap to meet the non-ETS target?
2. To what extent do the economic crisis and the policy framework affect the previous results?

The research performs a scenario analysis. The analysis focuses on the most relevant scenarios developed at European and national level describing the most likely evolution of the Italian energy system until 2020. First, a preliminary analysis of the data sources is performed to highlight inconsistencies and to provide the entire bulk of data so as to allow the research to be carried out. Second, the work reviews in depth the scenarios in their main assumptions and in their results on GHG emissions for the non-ETS sectors. Third, the study carries out the gap analysis to assess the expected progress of Italy in the scope of the Effort Sharing Decision and to assess whether Italy is expected to meet the non-ETS target set by Decision No 406/2009/EC and to keep up with the annual emission allocations for the period 2013-2020. Finally, the outcomes from the gap analysis are corrected and, then, analyzed again according to the gap analysis methods and reviewed through a comparative analysis (Gap analysis revision). This final step adjusts and completes the outcomes of the previous steps, providing the final (more accurate) results of the gap analysis. Furthermore, it comes up with evidence on the effect of the two main drivers affecting the assessed emission (and hence policy) gap, namely economic assumptions and policy assumptions. This analysis is supported by a further step in the research, which moves the focus towards sectorial final energy demand. In this final part, the work carries out a decomposition analysis focuses on transport sector in order to assess the impact of the mentioned variables on the future projected change in such a representative sector.

The research framework as described above in its main steps is schematically reported in the following figure.

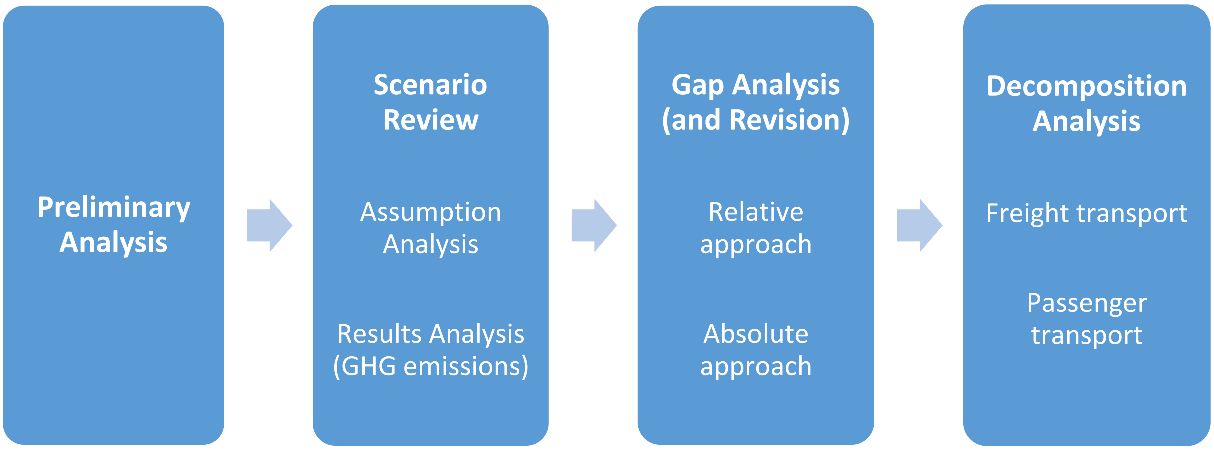


Figure 2 – Research framework

Scenarios are plausible and simplified descriptions of how a given system may evolve in the future under specific assumptions. Energy systems have been widely investigated by making use of a vast range of scenarios, which are developed from models aiming to provide a consistent and comprehensible picture of the likely evolution of the system (in some specific parts) (PROGNOS AG, 2011). The scenario analyses carried out by researchers, analysts and technical bodies are useful tools in supporting policymaking activity. However, there is not a unique and consolidated method to approach the scenario analysis due to the specificity of each analysis in its own purpose and investigated framework. These considerations justify the methodology of this work, which is founded on the paramount objective of providing a comprehensive, representative, and hence meaningful picture and explanation of the likely development of the energy system in Italy in relation to the Italian effort towards meeting the national emission target set by Decision No 406/2009/EC. The analysis has been carried out through a stepwise approach by struggling to overcome issues related to the lack of data and to the quality, timely, representativeness and comparability of the available data. On the other hand, in its final part the research carries out a decomposition analysis, therefore it employs a widely investigated, and hence well-outlined approach, which is often used for policymaking decisions in the field of climate and energy (Ang & Zhang, 2000; Ang, 2004). However, the method itself is characterized by a vast array of decomposition approaches and often more than one approach can be applied to investigate the same issue (Ang & Zhang, 2000). Consequently, this research has applied the decomposition method evaluated as the most suitable for the objective of the analysis.

2.2 Scenarios

The research performs the analysis of four sets of scenarios projecting the evolution of the Italian energy system at least until 2020. Two of these sets of scenarios have been developed at EU level (and hence they are often addressed as *EU-wide* scenarios hereafter) while the other two sets have been developed at national level (consequently they are often addressed as *national-based* scenarios in this work). The choice for these scenarios has been driven by their relevance at EU and national level. In fact, the scenarios taken into account in this research are widely considered the most comprehensive, updated and reliable data sources on the expected evolution of the domestic energy system in Italy at the time the research was carried out. For this reason, they are applied at EU and national level to evaluate past and current efforts as well as to assess possible future progress towards meeting the internal and international commitments on climate and energy. In other words, they represent the reference scenarios applied for policy assessment and policy making purposes by the European Commission and by Member States. Finally, these scenarios are the paramount instruments used by the European Commission in concert with Member States to build up the common efforts in fighting against climate change and in shaping a more sustainable energy system.

2.2.1 EU-wide Scenarios

The most relevant scenarios developed at EU level are the PRIMES scenarios, which represent the development of the energy system for the EU-27, the EU-15 and for each Member State. PRIMES scenarios are run from the PRIMES modelling system, which has been developed by the research laboratory E^3M-Lab of the Institute of Communication and Computer Systems of the National Technical University of Athens (ICCS –NTUA). The E^3M-Lab working group has provided the European Commission and several Member States with supporting instruments to carry out policy analyses and impact assessment studies. Furthermore, it has performed many analyses and produced many publications of high relevance for the European Commission and for national governments. For instance, it drafted the *Trends to 2030* reports for the DG TREN and the Directorate-General for Climate Action, whose first version was published in 2003 and the updated ones were delivered in 2005, 2008 and 2010 (a forthcoming version is going to be available by the end of 2013). The 2008 version was used (together with the GAINS outcomes) for the *Impact Assessment of the Climate and Energy Package*. Moreover, the E^3M-Lab has carried out the PRIMES-based analysis supporting the European Commission Communication *Analysis of options to move beyond 20% greenhouse gas emission reductions and assessing the risk of carbon leakage* (European Commission, 2010b).

The most relevant and recent PRIMES scenarios, which are counted in this work, are those included into the *Energy trends 2030* publications released in 2008 and 2010, hence the two last versions published at the time this analysis was carried out. The *European Energy and Transport. Trends to 2030 – update 2007* (Capros et al., 2008) prepared for the Directorate-General for Energy and Transport (DG TREN) and published in 2008 includes the 2007 Baseline Scenario (also referred in this work as *PRIMES 2007*). The following version *EU Energy Trends to 2030 – update 2009* (Capros et al., 2010) prepared for the Directorate-General for Energy and the Directorate-General for Climate Action includes the so called 2009 Baseline Scenario and the Reference Scenario (addressed in this work as *PRIMES 2009* when considered at an aggregate stage). To sum up, the EU-wide scenarios addressed in this study are:

- 2007 Baseline scenario (*PRIMES 2007*)
- 2009 Baseline scenario (*PRIMES 2009*)
- Reference scenario (*PRIMES 2009*)

The PRMES Modelling System

The PRIMES is a modelling system aiming at representing the energy system in the EU-27, the EU-15 and the Member States in its current and possible evolution in the medium-long period. The time horizon encompasses the period between 1990 and 2030 (the latest modellings include projections up to 2050) with a 5-year timeframe. The PRIMES is a general-purpose model characterized as followed:

- The structure of the depicted energy system is modular: the supply and demand branches include energy production sub-systems and end-use sectors, i.e. residential, commercial, transport and industry respectively.
- Modules' interactions allow for the definition of the market equilibrium, finding the prices of each energy form for which the quantity producers find best to supply is equal to the quantity consumers wish to use. Thus, the model simulates a closed loop between energy demand, supply and prices. The market equilibrium is constant within each 5-year step, but it evolves over time.
- Hybrid model: market economics as well as the available technologies are taken into account, leading to higher consistency. These drivers, together with energy and environmental policies and measures, affect agent (i.e. sector) behavior.
- Partial equilibrium model: despite the full-scale representation of the energy system considering all sectors as well as all technologies and sectorial-based economic behavior, the model does not seek for an overall economic equilibrium (which would require a more aggregate approach).

- Generalized equilibrium model: each sector is considered as independent, driven by its own behavior, which lies on microeconomic foundations. However, the model can formulate various behavioral conditions, consequently affecting the equilibrium regime.
- The sectorial-based economic behavior (i.e. agent behavior) leads to economic decisions aimed at the highest economic benefit, while dealing with both economic and non-economic constraints (such as engineering, regulatory and environmental issues).

The PRIMES Scenarios

The set of scenarios taken into account in this work are run from 1990 to 2030 on 5-years steps. The data from 1990 to 2005 are verified, although some differences can be observed between the 2007 Baseline scenario and the following set of scenarios due to the application of more updated data. The values from 2010 to 2030 result from the projecting activity. The PRIMES scenarios provide a multitude of information on the energy system encompassing energy balance data, macro-system and energy-system indicators and GHG emissions.

The 2007 Baseline scenario was finalized in November 2007 and it takes into account the economic context as it was at the end of 2006, when the EU-27 and its Member States still showed a sustained economic growth. On the other hand, the 2009 Baseline scenario and the Reference scenario reflect the significant changes in the economic and legislative context that have characterized the European Union and its Member States between 2007 and 2009. The deep economic downturn has dramatically modified the economic and energy outlook, leading to a slowdown in the economic growth and the contraction of energy demand. Furthermore, some relevant measures to combat climate change were implemented between the end of 2006 and the beginning of 2009, contributing to reform the energy market and the demand sector. Thus, the evolution of the economic, energy and legislative context implies a substantially divergent vision towards 2020 in the 2007 Baseline scenario and the 2009-updated version. Moreover, the Reference scenario shows a further interpretation of future trends since it includes a more updated legislative framework compared to the 2009 Baseline. In fact, the Baseline incorporates all the policies and measures implemented and adopted by April 2009, while the Reference takes into account further policies implemented up to December 2009. In addition, the Reference scenario assumes that the two binding targets under the Climate and Energy Package (the renewables target and the emission reduction target) will be met by 2020.

The comparison between the baseline scenarios, which follow business-as-usual trends, gives insight on the extent to which the context has changed mainly due to the economic recession and the relevant policies implemented between 2007 and 2009. The relationship between the two baseline scenarios of PRIMES is crucial for the scope of this research. This is the reason why *PRIMES 2007* is addressed in this work despite a more updated version is available (i.e. *PRIMES 2009*). Moreover, the comparison between the 2009 Baseline and Reference scenarios, which are consistent in their assumptions except for some additional policies included only in the latter, enables to carry out the impact assessment of these policies, which also comprehend the provisions setting the two binding targets within the Climate and Energy Package.

2.2.2 National-based Scenarios

The most relevant scenarios produced at national level projecting the evolution of the Italian energy system are the ones submitted to the European Commission every two years in compliance with Article 3 paragraph 2 of Decision No 280/2004/EC (*Monitoring Mechanism Decision) concerning a mechanism for monitoring Community greenhouse gas emissions and for implementing the Kyoto Protocol* (European Parliament & Council, 2004). The mentioned article requires Member States to report to the Commission information and data to assess the national projected progress in achieving the commitments undertaken at international and EU level. More in detail, Member States should report by 15 March 2005 and every two years thereafter national projections of GHG emissions by sources and removals by sinks in the form of a With Existing Measures (WEM) scenario and of a With Additional Measures (WAM) scenario. The former forecasts GHG emissions and removals resulting from the inclusion into the modelling process of all policies and measures implemented or adopted up to the end of the reference year. The latter adds to the provisions addressed by the corresponding WEM scenario further policies and measures, i.e. those planned until the reference year and reported in official documentation (of the Ministry of Environment, Land and See in the case of Italy). Thus, these scenarios are the most updated and accurate source of data on the expected progress of a Member State towards meeting its national targets set by EU legislation and international commitments.

The set of scenarios delivered every two years by Italy in compliance with the Monitoring Mechanism Decision (MMD) are developed by a working group composed by members of the Ministry of Environment, Land and Sea and of the Ministry of Economic Development, members of ISPRA (Institute for Environmental Protection and Research) and members of ENEA (Italian National Agency for New Technologies, Energy and the Sustainable Economic Development) (ISPRA, 2013a). The projections are submitted following table templates based on UNFCCC reporting guidelines (FCCC/CP/1999/7). In compiling the table templates Member States have to provide all the (mandatory) data and information to conform to the EU and UNFCCC reporting obligations. Moreover, they may include further data and information that are not compulsory, although recommended. The tables provide the bulk of data and information (in a concise form) and they may be revised over time. Besides, some data and information included into the tables are summarized in the related *Climate Policy Progress Report*, which is required by Article 3(2) too (European Parliament & Council, 2004). More in detail, the report describes the implemented, adopted and planned policies and measures which have affected or are expected to affect in a remarkable extent GHG emissions or removals in Italy. The policies and measures are split up into cross-cutting policies, ETS policies and non-ETS policies depending on the addressing sector(s). In addition, it provides information about the implementation of relevant Community legislations and international commitments as well as information about institutional and financial arrangements (ISPRA, 2013a).

In this work only the most recent set of scenarios developed by Italy under the Monitoring Mechanism requirements are taken under considerations, i.e. those submitted to the European Commission in 2011 and 2013. Hence, the analysis addresses four national-based scenarios in total, i.e. the With Existing Measures (WEM) scenario delivered in 2011 and its 2013-updated version as well as the With Additional Measures (WAM) scenario submitted in 2011 and the 2013 version. The following figure shows the nomenclature applied to the national-based scenarios considered in this research.

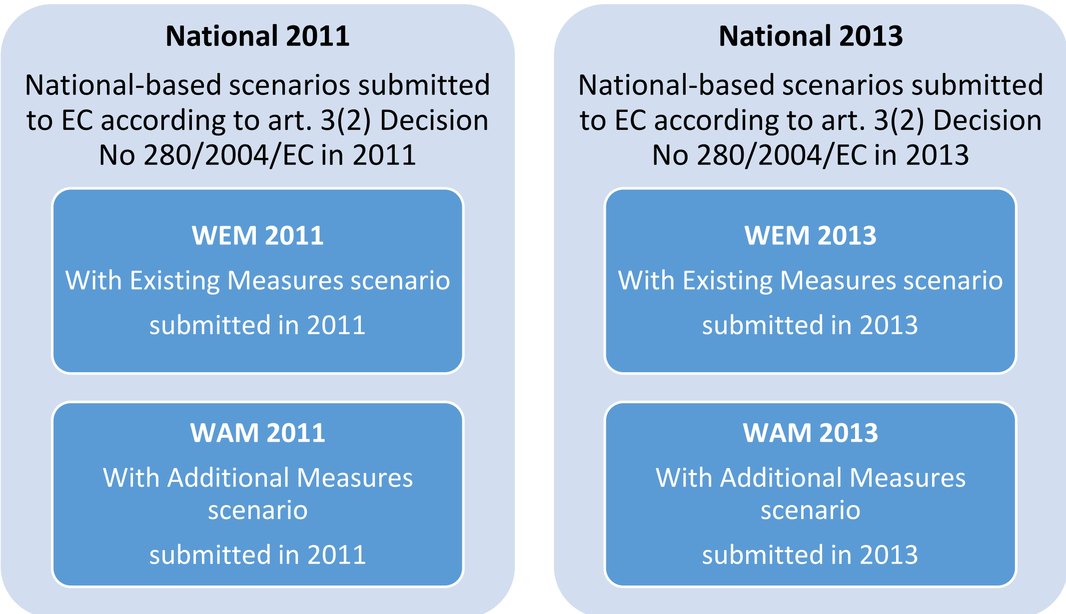


Figure 3 – Nomenclature of the national-based scenarios applied to the analysis

The Italian National-based Model: the MARKAL-Italy Model

The national-based scenarios submitted by Italy in compliance with art. 3(2) of Decision No 280/2004/EC represent the development of the domestic energy system up to 2020 (or 2030) with a 5-years timeframe. These scenarios are developed by the MARKAL-Italy Model, which derived by the implementation from national to local level MARKAL-MACRO Model. The MARKAL-MACRO Model has been developed by combining two models, i.e. the MARKAL Model and the MACRO Model. The former is a partial equilibrium model that provides a technology-rich basis to define the possible development of the energy system over a variable time horizon and for this reason is addressed as “technology model” (Loulou et al., 2004; Gracceva & Contaldi, 2003). The MARKAL Model is the precursor of the more recent and comprehensive TIMES Model. The MACRO is a dynamic general equilibrium model based on neoclassical economic hypotheses, where producers maximize the profit under technological constraints and consumers maximize utility under economic constraints. Both the models simulate the balance between the economic behaviors of producers and consumers defining the corresponding energy demand and supply (Loulou et al., 2004; Gracceva & Contaldi, 2003). The linkage between the two models lays at the level of demand for energy services, which is determined endogenously. The demand for energy services represents the system production stage and results from three productivity factors, namely capital, labor and energy (Loulou et al., 2004; Gracceva & Contaldi, 2003). The model is based on a supply-demand equilibrium, characterized by producers’ maximum profit and consumers’ maximum utility. In this relationship, MARKAL Model defines the most cost-effective technology to meet the demand for energy services, which is determined by the MACRO Model instead. The demand for energy services depends on the economic growth, demand-decoupling factor and energy demand elasticity.

The MARKAL-Italy Model, which performs medium to long term projections (encompassing the period between 1990 and 2030), is aimed at assessing emission reduction costs and potentials as well as the environmental and climate mitigation action costs. This model represents the possible developments of the national energy system (which is modular in its structure) under technological, environmental and economic constraints. It is a technical-economic model assessing the technical potential and the economic feasibility of low carbon technology penetration under perfect market conditions and in relation to energy prices and environmental constraints (Gracceva & Contaldi, 2003).

The Italian National-based Scenarios

As already stated, the set of scenarios considered in this work are run with a 5-years timeframe at least until 2020. The scenarios provide a large number of information and data on the domestic energy system, the main ones can be summarized as follow:

- projections of GHG emissions and removals organized by gas and by sector (according to the reporting template set for the National Inventory Report annually submitted as required by art. 3(1) of Decision No 280/2004/EC) and contribution of ETS and non-ETS sectors on GHG emissions;
- projections of energy consumption and final energy demand divided by sector;

- projections of macro-system and energy-system indicators;
- identification and description of policies and measures, highlighting their status (existing or planned) and the scenario they belong as well as reporting the expected effectiveness in reducing GHG emissions for at least the years 2015 and 2020.

The set of scenarios delivered in 2011 (called from now *National 2011* or - when a distinction between the two scenarios is required - *2011 WEM scenario* and *2011 WAM scenario*) provides projections for the period between 2010 and 2020, while historical data addresses the period from 1990 (sometimes from 2000) to 2005. The projections' reference year is 2009, although preliminary data on 2010 have been also applied. The projections of emissions and removals are based on the data reported in the National Inventory Report (NIR) 2009. Besides, the reference year for the policies included in the set of scenarios is 2010, thus the 2011 WEM scenario includes all the relevant policies and measures implemented and adopted up to the end of 2010, while the 2011 WAM scenario adds also the relevant provisions that were only planned by end 2010.

The set of scenarios delivered in 2013 (named *National 2013* or *2013 WEM scenario* and *2013 WAM scenario* from now on) represents the most updated and complete source addressing the future evolution of the national energy system developed under the monitoring mechanism requirements. The projections address the period between 2015 and 2030, while the data up to 2010 are historical values. The projections' reference year is 2011, but preliminary data on 2012 are also taken under consideration. The NIR 2011 has provided the reference emissions and removals data required to develop the projections. Besides, the reference year for the policies included in the scenarios is formally set in 2012 (ISPRA, 2013a). However, the EU, national and local policies and measures included in the 2013 WEM scenario are the same as included in the WEM scenario reported in the CIPE (Interministerial Committee for Economic Planning) Resolution of 8 March 2013 providing the updated version of the *National GHG Emission Reduction Plan* (CIPE, 2013). Thus, according to Article 2 of CIPE Resolution (CIPE, 2013), the policy assumptions comprise the relevant policies and measures implemented and adopted up to end 2010 except for the provisions addressing the renewables target and the energy efficiency target set within the Climate and Energy Package. The legal framework included into the 2013 WEM scenario is reported in Annex I of the 2013 Climate Policy Progress Report, in Annex I of CIPE Resolution (CIPE, 2013) and in Annex II of the Attachment to the Economic and Financial Document (DEF) prepared by the Ministry of Environment, Land and Sea (MATTM) in 2013 (MATTM, 2013). The 2013 WAM scenario includes the policies and measures addressing the renewables target and the energy efficiency target as well as further relevant provisions which have been planned and reported in official documentation of the Italian Ministry of Environment, Land and See (MATTM) by end 2012. These provisions are included in Annex I of the 2013 Climate Policy Progress Report and in Annex III of the MATTM Report for the Economic and

Financial Document (DEF) (MATTM, 2013). To sum up, for the WAM scenario the policy's reference year is actually 2012, while for the 2013 WEM scenario is 2010.

Data, information and projections referring to the national-based scenarios included in this work derive from the most updated data source (provided as tables) as well as from the related *Italy Climate Policy Progress Report* completing the data tables towards fulfilling the EU and international reporting requirements. The latest tables submitted in 2011 represent the third revision, while only a first revision has been delivered under the 2013 reporting activity at the time the research was carried out. The Climate Policy Progress Report 2011 and 2013 report data and projections included in the corresponding table templates providing also comprehensive explanations. However, the values included in the reports may differ in variable extent to the ones reported in the related table templates submitted to the European Commission by 15 March of the same year and subsequently revised. The data included in the reports generally appears more reliable than those included in the data tables. Thus, the analysis (when possible) prefers the 2011 and 2013 Climate Policy Progress Report to the related data tables as source of data and information.

Finally, the WEM scenarios represent the development of the domestic energy system under business-as-usual trends. The comparison between WEM scenarios delivered in different years provides some clues on change in the national context according to the scenarios' assumptions, although possible variations in data inputs may thwart this analysis. On the other hand, the comparison between scenarios delivered in the same year, which differ only in some additional provisions included only in the WAM scenario, allows to assess the impact (in other words the effectiveness) of the additional measures, i.e. the planned ones on GHG emissions.

2.3 Other Sources

According to the scope of the analyses, further sets of data and extra information belonging to different sources are applied. The additional sources applied to the analyses are the following:

- ISTAT (www.istat.it);
- Eurostat (www.epp.eurostat.ec.europa.eu);
- Commission Decision of 26 March 2013 *on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC* (European Commission, 2013);
- *National CO_2 Reduction Action Plan* adopted through the CIPE Resolution No 17 of 8 March 2013 (CIPE, 23013);

- Attachment to the Economic and Financial Document (DEF) prepared by the Ministry of Environment, Land and Sea (MATTM) delivered the 10 April 2013 (MATTM, 2013);
- Literature and extra legislation.

2.4 Data and Information

The research focuses on the set of EU-wide and national-based scenarios described above. This set is both the main source of data and the object itself of the analyses carried out in this work. The study employs only a part of the bulk of data provided by the scenarios and the related reports (i.e. the *Trends to 2030* for the EU-wide scenarios and the *Italy Climate Policy Progress Report* for the national-based scenarios). More in detail, the work makes use of the following data and information items:

- Macro-system indicators: population, economic activity (GDP), sector activity (transport sector only);
- Macro-system variables: energy import prices;
- GHG emissions: non-ETS data only;
- Policies and measures;
- Energy-system indicators: energy intensity (transport sector only);
- Energy balance: final energy demand (transport sector only).

Annex I concisely defines the scenarios' data set applied to the research. The data items are characterized based on the disaggregation level reported in the sources and the disaggregation level required by the research.

The other sources of data and information provide further information applied to the analysis.

<u>Historical data</u>

By the term "historical data" the study entails the most updated and accurate official data available on the selected items at the time the analysis was carried out. Historical data are applied as benchmark to the scenarios' data in order to verify their reliability and are applied in the assumption analysis as well as in the result analysis.

Historical data on population and GDP

The assumption analysis makes use of the historical data on population and GDP from 1990 to 2012. The former encompasses the most updated data on this issue, which is provided by the Italian Institute of

Statistics (ISTAT); while the latter refers to the most updated data provided by the European Institute of Statistics (Eurostat). All the mentioned data sets are retrievable in the website database of the Italian and EU institutes of statistics.

Historical emission trend

The result analysis employs a set of data on non-ETS GHG emissions for the period from 2005 to 2012 that is derived from the National Inventory Report 2012 (NIR 2012). This set of data includes the most accurate and updated data specifically addressing the non-ETS sectors currently available, albeit they are not the most accurate and updated in absolute terms. In fact, the emission values for 2005, 2008, 2009 and 2010 reported in the NIR 2012 have been checked by a Technical Expert Review Team at EU level in order to support the definition of the annual emission allocations for the years from 2013 to 2020. Although the technical review final report has been made available by the European Commission, no data expressed on non-ETS basis are reported (Capros et al., 2012). For this reason, this work must use the not revised data from the NIR 2012 as historical data. However, the emission data included in the national inventory reports is not directly applicable to this study because of the incompatibility with the required degree of aggregation (i.e. emissions from the non-ETS branch of the only energy system. Consequently, the NIR 2012 data are extracted from other official sources that provide more explicitly data on the non-ETS GHG emission. After several comparisons and literature review, the updated version of the *National CO_2 Reduction Action Plan* adopted through the CIPE Resolution of 8 March 2013 (CIPE, 2013) has been selected as main data source. The 2006 value has been computed as average between the 2005 and the 2007 data reported in the national plan. Finally, the emission data addressing the year 2011 and 2012 refers to the reviewed values reported in the Attachment to the Economic and Financial Document (DEF) prepared by the Ministry of Environment, Land and Sea (MATTM) delivered the 10 April 2013 (MATTM, 2013). It is worth noting that the 2012 data is only a preliminary estimation and this is the reason why the historical emission trend, when depicted, shows a dotted segment between 2011 and 2012.

Reduction path to target achievement

The *Reduction path to target achievement* represents the emission reduction trajectory that Italy should follow in order to meet the binding target set by the Effort Sharing Decision. The trajectory is divided into two parts: the first part encompasses the period from 2005 to 2012; the second part covers the range from 2013 to 2020. The first part is computed as linear reduction path from 2005 to 2013. The 2005 data is the value applied to define the annual emission allocations and it is computed in this study as reported below in this chapter in the section describing the methodology applied to carry out the past trend analysis (section 2.6.3). The 2013 data represents the first annual emission allocation. The second part of the trajectory is made up by the annual emission allocations reported in Annex I of the Commission Decision of 26 March 2013 (European Commission, 2013) and it represents a linear reduction from 2013 to 2020.

2.5 Research Assumptions

Before starting to discuss the methods applied to carry out the research, a last but not least clarification regarding the foundations of the analysis must be made. According to the goals of the research, the economic downturn and the evolution of the legislative framework are investigated in their impact on GHG emission past and future trends, and hence in their impact on the Italian effort towards meeting the non-ETS target. Although the study deeply analyzes the main scenario assumptions, the policy and economic assumptions are assumed as the only causes to explain the change in the scenarios' results and in the subsequent analytical steps of the research. The rationale behind this assumption is the researcher's need to simplify the complexity of the energy system described by the scenarios providing in the meantime meaningful insights. The justification for this choice is explained hereafter.

Demographic trends, fossil fuel prices and technology penetration are the main assumptions founding the scenarios together with domestic economic activity and the policy framework. Firstly, population and GHG emissions are to a large extent decoupled, this has been verifying at the EU level since the earliest nineties (EEA, 2009). Secondly, fossil fuel prices, which are highly relevant drivers in the energy system, feature a tight relationship with GDP dynamics (Tverberg, 2012). Consequently, this driver is incorporated in the economic variables rather than been excluded. Thirdly, technology assumptions are strongly related to the policy assumptions. Policies support technology development and spread by addressing barriers and failures that may slow down or restrain technology penetration and thus, efficiency gains (Sorrell et al., 2000), which are the focus of a large number of policies in this field. Consequently, in this work, technology-related assumptions are implicitly considered in the framework of the policy assumptions.

2.6 Methods

In line with the contents of the previous part, the following section presents, explains and justifies step by step the methods applied to carry out this research. The section starts by presenting the preliminary analysis. The scenario review, which includes the assumption analysis and the results analysis, is then outlined. Next, the methods applied to carry out the gap analysis and its revision are defined. Finally, the decomposition analysis is taken into account.

2.6.1 Preliminary Analysis

The first step of the study consists in a preliminary analysis aimed at providing the entire bulk of data required to carry out the next steps of the research. More in detail, scenarios provide a number of data deriving either from reporting activity or from modelling process. However, data as reported in the sources (i.e. the *Trends to 2030* for the EU-wide scenarios and the *Italy Climate Policy Progress Report* and the reporting tables for the national-based scenarios) are incomplete and sometimes unsuitable for the purpose of the analysis. This inconsistency might be mainly due to the fact that the reported data features a different aggregation level than required by the analyses. In fact, the objective of the preliminary analysis consists in the analysis of the data sources so as to highlight inconsistencies, incongruences and lack of data and to subsequently adjust, adapt and complete the data in order to allow the research to be carried out.

First of all, scenarios provide sets of data on a 5-years timeframe, therefore the linear interpolation is the method applied to fill the data gap, obtaining data year by year for the whole period taken into account by the specific analysis.

Secondly, the data included in the sources are analyzed in order to define where corrections are required. Annex I concisely defines the scenarios’ data set applied to the research and indicates whether the data has been adjusted and adapted in order to fit the research needs beyond the linear interpolation. According to the indications retrievable in Annex I, the preliminary analysis is applied to make fully available the sets of data required to carry out the scenario review (results analysis), and consequently the gap analysis in relation to the EU-wide scenarios. Furthermore, the sets of data from the EU-wide scenarios are corrected to suite the purpose of the decomposition analysis of transport sector. The approach applied by the preliminary analysis is described hereafter.

Scenario review and gap analysis

The analyses require data on GHG emissions for the non-ETS sectors at the aggregate level only. The EU-wide scenarios lack the mentioned data but they provide the total bulk and the GHG emissions under the Emission Trading System. Thus, the non-ETS data is computed by subtracting the ETS load from the total emissions.

Decomposition analysis

This analysis requires data on the non-ETS branch of the transport sector, i.e. all transport modes except for aviation and seaborne transport. Moreover, the analysis focuses on the two branch of the transport sector, namely, freight transport and passenger transport. The two sub-sectors are addressed separately and the decomposition analysis is carried out by applying the related activity and energy use data. The analysis focuses only on the EU-wide scenarios, which provide sets of data both at the aggregate (overall or sub-sectorial) and at the disaggregate (transport modes) level. Table 1 lists the items addressed by transport activity and energy use.

Table 1 - Data items employed in the decomposition analysis

ENERGY USE (ktoe)	**SECTOR ACTIVITY**	
	Passenger transport (Gpkm)	**Freight transport (Gtkm)**
Public road transport	Public road transport	-
Private cars and motorcycles	Private cars and motorcycles	-
Trucks	-	Trucks
Rail	Rail	Rail
Inland navigation	Inland navigation	Inland navigation
Aviation*	Aviation*	-
Total	Total	Total

*Aviation is not covered by Decision No 406/2009/EC

Counting for the sets of data on sub-sectorial activity, in passenger transport the required data is obtained by subtracting the aviation load to the total sub-sectorial bulk. On the other hand, the decomposition analysis applies the total load of freight activity as reported by the scenarios, consequently no corrections are performed on this data.

Furthermore, the EU-wide scenarios provide the aggregate data on energy use as well as split up as reported in Table 1, therefore they do not define the specific energy use of freight and passenger transport. Moreover, both the two sub-sectors include rail transport and inland navigation. Consequently, the preliminary analysis allows the researcher to obtain the required data based on the following steps. First, the aviation load is subtracted from the total bulk in order to define the sectorial energy use from non-ETS modes. Secondly, the relative load of freight transport and of passenger transport in the energy use data addressing rail and inland navigation is computed based on the sectorial activity. At this stage, the energy intensity (energy consumed per unit of activity) of rail is assumed to be equal between the two branches of the transport sector. The same is assumed for inland navigation. The resulting data is the percentage load of the two sub-sectors on the total energy use of the modes taken under consideration. The data is than converted in absolute terms by applying the energy use data reported in the source. Eventually, freight transport is calculated by adding the computed energy use of rail and inland navigation to the reported data on trucks, while energy use in passenger transport is obtained by subtracting the freight data to the non-ETS bulk.

2.6.2 Assumption Analysis

Scenarios are defined as simplified representations of the possible developments of a system or part of it, based on a set of well-defined assumptions. The assumptions (as well as the data) are inputs of the modelling system and represent the scenario's foundations. Hence, as a rule, even small changes in the assumptions might lead to completely different outcomes in the scenario.

The present assumption analysis performs a characterization and a comparative analysis of the main assumptions lying at the roots of the considered scenarios. The main assumptions are population, economic activity, energy import prices, technologies and policies. The analysis is undertaken following two subsequent steps. Firstly, it addresses the non-policy assumptions; secondly, it focuses solely on the policy assumptions. The aim of the analysis is to present and analyze the general features disclosing the differences between the scenarios and the diversities compared to the most updated verified data available. Thus, the objective of this analysis is to gain deeper insights on the foundations of the scenarios in order to better understand the validity of their results.

<u>Non-policy assumptions analysis</u>

Objective of this first part of the analysis is to provide deep understanding on the main assumptions excluding the policy-based ones applied to run the different scenarios. The analysis at this stage addresses the following drivers:

- Population
- GDP and sectorial activity
- Energy import prices
- Technologies

Firstly, the analysis provides background information on the drivers based on official data and reports as well as on literature review. Secondly, the scenarios' assumptions are characterized, described and compared both among each other and with the official verified data. More in detail, the comparative analysis is based on a twofold approach: first, the past data and trends (of population and GDP) are compared with the historical data provided by ISTAT and Eurostat; second, the scenarios are compared each other according to their assumptions. The comparative analysis aims to disclose consistencies or diversities with the most updated verified data and among scenarios. A different approach than above is applied to the technology-related assumptions, for which a general overview is carried out at this stage. While a more detailed review is undertaken in the subsequent policy analysis section due to the tight link between technological development and the policy framework.

Finally, excluding the policy assumptions means that no distinctions are made between the 2009 Baseline scenario and the Reference scenario of PRIMES, which are formally addressed as *PRIMES 2009* in this analysis. The same is also valid for the national based scenarios delivered in 2011 and 2013, which are addressed as *National 2011* and *National 2013* respectively. Consequently, the analysis formally addresses only four scenarios: *PRIMES 2007*, *PRIMES 2009*, *National 2011* and *National 2013.*

Policy assumptions analysis

Among the assumptions lying at the root of the EU-wide and national-based scenarios, the included policies and measures have a relevant role. As a matter of illustration, scenarios' projections are largely used in policy evaluation and policymaking processes. The policy assumptions included into the scenarios attempt to provide the most complete and thorough representation of the legislative framework although dealing with the need of simplifying the complexity of reality. The policy assumptions included in the scenarios encompass the most relevant policies and measures that have been affecting or are expected to affect the energy system under direct relationships of cause-effect. Thus, they address energy supply as well as energy demand. The considered policies and measures may have been implemented, adopted or only planned at the time in which the scenarios were run.

The main objective of the analysis consists in disclosing the policy assumptions addressing the non-ETS sectors that are applied to run the scenarios and the related differences featured by the latter. The analysis aims to provide insights on the evolution and on the current state of the policy framework addressing the non-ETS scope in Italy as well as the diversities between the scenarios. The review presents, characterizes and compares the relevant policies and measures contributing towards the achievement of the emission reduction target set by the Effort Sharing Decision according to the scenarios. The governmental level entitled to carry out such policies goes from EU to local. In fact, the provisions may have been implemented, adopted or planned by the European Community, the Italian Government or by other provincial or local administrative authorities.

The policy assumption analysis is carried out by undertaking the following steps.

First, the policy framework addressing the non-ETS scope is reconstructed and the policies and measures taken under consideration are presents by providing some basic information. The review offers a brief description, for each policy item, of their objective, their main targeted sector, their type of policy instrument and – only for the national based scenarios – their expected effectiveness in term of GHG abatements for 2015 and 2020. In addition, some more detailed descriptions are provided to clarify the concise information presented by the tables reporting the results of the policy characterization. Overall, this part of the analysis is based on information and data provided by Capros et al. (2008, 2010) and by the national reports and the related tables submitted by Italy in 2011 and 2013 (ISPRA, 2011; 2012) as well as on the review of the addressed legal provisions and literature review.

Second, a further review of the information and data provided by the previous step is carried out in order to provide a more complete picture of the policy assumptions characterizing each scenario. Furthermore, a comparative analysis is carried out so as to disclose and provide evidence on the main differences between the scenarios' assumptions. Here, the assumptions are discussed more in depth focusing on the (main) targeted sectors. The comparative analysis addressing the EU-wide scenarios focuses firstly on the main differences between *PRIMES 2007* and *PRIMES 2009*, secondly on the differences between the two scenarios forming *PRIMES 2009*. On the other hand, the comparative analysis on the national-based scenarios addresses the set of scenarios delivered in the same year in a first stage, while it addresses the same type of scenarios (WEM or WAM) delivered in different years in a second stage. Thus, the EU-wide scenarios and the national-based scenarios are addressed separately up to this stage. This detachment has been chosen due to the significant diversity of information provided by the two categories of scenarios.

Finally, the study carries out a wider comparative analysis addressing all the scenarios. At this stage, the scenarios are compared in their policy assumptions in relation to the (three) main fields of action characterizing the Italian policy effort. The mentioned policy fields of action are outlined by the previous steps of the analysis. The aim of this last part of the analysis is to highlight the differences among the multiple scenarios looking at the issue from the perspective of the identified fields of actions. Moreover, this review allows to complete the previous analysis on the technology-related assumptions.

The policy assumption analysis addresses seven scenarios in total as shown in the following figure.

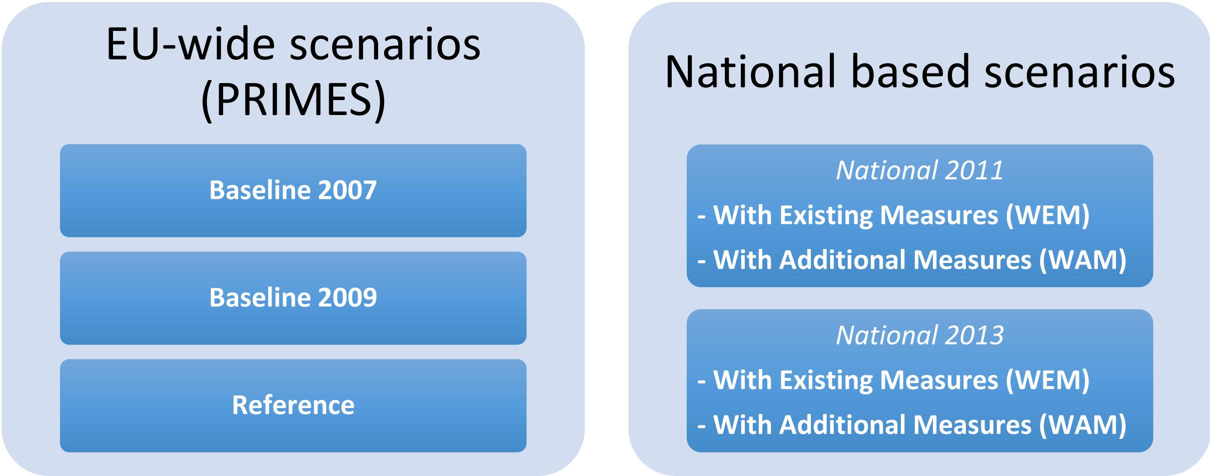


Figure 4 – Scenarios addressed by the policy assumption analysis

2.6.3 Results Analysis

Scenarios include a number of data and information derived either from reporting activity or from the modelling process. The sets of data allow outlining the past and future possible development of energy system's drivers and variables. However, the resulting trends depend on the data quality, which straightly derive by the reporting activity addressing the period before the scenario-specific projections' baseline year. Furthermore, the resulting trends mirror the assumptions applied to develop the scenarios' projections.

The results analysis addresses the data on GHG emissions delivered by the non-ETS sectors in Italy as reported and projected for the period from 2005 to 2020. The analysis is developed into two steps: the first addresses the past trends, i.e. from 2005 to 2012; the second focuses on the projections from 2013 to 2020. The investigation of past trajectories lies at the root of the correct interpretation of the projections, providing insights on the quality and reliability of scenarios' data, assumptions and trends. The analysis of the future trends points out possible evolutions of the non-ETS GHG emissions up to 2020 depending on scenarios' assumptions and allows underlining to what extent the expected progress agrees with the requirements under the Effort Sharing Decision. The results analysis lies at the root of the gap analysis. The study carries out the result analysis by addressing the EU-wide and the national-based scenarios separately. This is due to the structural differences between the two categories of scenarios. The only exception concerns the comparative analysis addressing the year 2005 due to its relevance in the scope of the Effort Sharing Decision and because it is the only data deriving from the monitoring activity in all the scenarios.

Past trend analysis

Objective of the analysis is to outline and analyze the scenarios' GHG emissions data and trends covering the period from 2005 until 2012 in order to assess data's accuracy and trends' preciseness on a qualitative basis. The methodological approach is based on a comparative analysis. Scenarios' data and trends, which may result either from monitoring and reporting activity or from projecting activity, are compared with the historical data. This comparison allows defining the accuracy of the scenarios' data. Furthermore, the scenarios are compared to each other with regard to their data and trends in order to highlight meaningful diversities and similarities.

First, the review addresses the year 2005 due to its pivotal role within the scope of the Effort Sharing Decision. In fact, 2005 represents the baseline year in the definition and assessment of the national effort according to the 13% emission reduction target set for Italy by Decision No 406/2009/EC. Thus, this data should be as accurate as possible because the overestimation or underestimation of the reference value may lead to an overburden or limited incentives respectively towards the national effort in reducing GHG emissions in the non-ETS sectors. At this stage, the historical data and the scenarios' data addressing the year 2005 are compared with the 2005 data derived from the technical review of the National Inventory Report 2012 (NIR 2012) required by the European Commission. The reviewed value, which has been used as a baseline to define the annual emission allocations and is the most accurate data currently existing for 2005, has been computed from the annual emission allocation for 2020 (European Commission, 2013) through the following formula:

$$Dv_{2005} = \frac{AEA_{2020}}{K_r}$$

where:

Dv_{2005}: 2005 reviewed data on GHG emissions

AEA_{2020}: Annual Emission Allocation 2020

K_r: reduction factor set by Decision No 406/2009/EC

K_r Italy = 0.87

The reviewed data is applied as a benchmark to assess the accuracy of the historical data and the scenarios' data for 2005. Assessing the accuracy of the 2005 data is relevant especially in relation to the EU-wide scenarios as it will be highlighted later in the section addressing the gap analysis (section 2.6.4). Finally, the comparison with the historical data underlines how the picture concerning the earliest non-ETS emissions has changed after the technical review. This is particularly relevant because the historical data is still applied as reference value in relevant provisions recently issued such as the *National CO_2 Reduction Action Plan* (CIPE,

2013) and the attachment to the Economic and Financial Document (DEF) prepared by the Ministry of Environment, Land and Sea (MATTM, 2013).

Second, the focus moves to the entire past period from 2005 to 2012. As explained above, the scenarios are characterized and compared in their trends, which may result completely (EU-wide) or partially (national-based) from the projecting activity. The scenarios are compared each other and with the historical data to gain insights on the representativeness of the scenarios, highlighting whether the scenarios may be considered trustable in their future development up to 2020.

Future trends analysis

Objective of the analysis is to identify and explain the scenarios' trends in their projecting path from 2013 to 2020 so as to provide deep understanding on the projections. The analysis discusses and interprets the trends, moreover it draws comparisons between the scenarios' trajectories. The review focusing on the PRIMES scenarios involves the comparison with the annual emissions allocations, which defines the reduction path that Italy should follow to succeed in the scope of the Effort Sharing Decision according to legislative prescriptions. On the other hand, the discussion and comparative analysis carried out on the national-based scenarios is developed by following a stepwise approach. First, the analysis follows a disaggregate approach by focusing on the With Existing Measures scenario and the With Additional Measures scenario developed in the same year. Second, the analysis moves to a higher aggregate level by addressing all the national-based scenarios together so as to provide a clearer picture of projections' evolution.

2.6.4 Gap Analysis

The objective of the analysis is to assess whether the expected progress in reducing GHG emissions delivered in the non-ETS sectors are in line with the requirement set by the Effort Sharing Decision for Italy. As for the result analysis, the study carries out the gap analysis by addressing the EU-wide and the national-based scenarios separately. The assessment follows two distinct approaches depending on the type of scenarios (EU-wide and national-based). On the one hand, the emission gap is assessed on a relative basis in order to highlight the strength of the policy framework (EU-wide scenarios). On the other hand, the analysis assesses in absolute terms whether Italy is expected to meet the binding targets set by law (national-based scenarios). Thus, the different methods lead to distinct results, which allow providing a more complete picture of the national progress (achieved and expected) by looking at the issue from different perspectives.

Scenario-specific assessment (relative approach)

The gap analysis based on a scenario-relative approach addresses the PRIMES scenarios only. The justification for this methods lies on the following items:

- Distance between the most updated verified data and the projected ones
- Obsolete or not fully representative assumptions
- Divergence between the expected trends and the verified trends

The analysis provides meaningful information on the expected effectiveness and strength of the policies and measures considered into the scenarios. Thus, it provides insight on the effort of the Italian government towards a deep restructuration of end-use sectors. Furthermore, it provides a first understanding on the combined effect on the GHG emissions reduction of the economic downturn and of the legal improvements by a qualitative comparison of the scenarios.

The assessment focuses only on the 2020 data, comparing it to the scenario-specific reduction target for 2020, which represents the last value in the reduction path that should be followed assuming the 2005 scenario data as reference level. Thus, the scenario-specific reduction target for 2020 is obtained by multiplying the scenario's 2005 data by the reduction factor set by the Effort Sharing Decision as shown in the following formula:

$$d_{2020} = D_{2005} \cdot k_r$$

where:

D_{2005}: scenario 2005 GHG emission data

d_{2020}: reduction target for 2020

K_r: reduction factor set by Decision No 406/2009/EC

K_r Italy = 0.87

The scenario-specific emission reduction path results as a linear trajectory characterized by a negative growing rate that starts from the reported 2005 data and it ends on the computed 2020 data (i.e. the so called reduction target for 2020). These reduction trends are compared with the emission path to target achievement set by law and made up by the annual emission allocations. This comparative analysis aims to highlight the consistency between the scenario-specific path and the actual reduction trajectory that Italy needs to follow in order to comply with the obligations set by the Effort Sharing Decision and the related legal provisions.

Once computed for each scenario the related reduction target for 2020 and depicted the reduction path, the analysis moves to the emission gap assessment. For each scenario the expected scenario-specific emission gap for 2020 (G_{2020}) is computed by applying the following formula:

$$G_{2020} = D_{2020} - d_{2020}$$

where:

G_{2020}: expected emission gap for 2020

D_{2020}: projected 2020 GHG emission data

d_{2020}: reduction target for 2020

Gap assessment (absolute approach)

Objective of this analysis is to assess whether Italy is expected to meet the non-ETS target set by the Effort Sharing Decision. The assessment addresses only the national-based scenarios because they provide the most updated and hence representative projections about the progress that Italy will take on in the next years up to 2020. In fact, the modelling activity, which results in the national-based scenarios trends, applies recently updated emission data and consistent assumptions as input. Furthermore, the projections' baseline year is fairly close to the present. As obvious, this is especially true for the most updated national-based scenarios, i.e. the so called *National 2013*.

The gap analysis carried out by applying the absolute approach focuses on the period from 2013 to 2020. The assessment lies in comparing the projected emissions with the annual emission allocations, which are defined as "the annual maximum allowed greenhouse gas emissions in the years 2013 to 2020" by Article 2 paragraph 2 of Decision No 406/2009/EC (European Parliament & Council, 2009b). Thus, this analysis sets whether Italy is expected to meet the annual non-ETS targets set by law. Only if the projection for a given year is higher than the annual emission allocation for the same year Italy is expected to fall behind that binding target. In that case, the emission gap reveals the equivalent policy gap, which mirrors the need to trigger further reductions by implementing new policies and measures or strengthening the existing ones. Thus, the presence of the emission gap (and consequently the policy gap) is assessed year by year and the gap is highlighted when the following condition is verified:

$$D > AEA$$

where:

D: projected GHG emission data

AEA: annual emission allocation

The gap analysis addressing the latest national-based scenarios provides the most updated and reliable picture of the Italian progress towards meeting the non-ETS target. The assessment is carried out on the previous version too in order to allow the comparison between the two sets of scenarios. The comparative analysis has a pivotal function towards a clear and correct interpretation of the results and hence to trace the national progress and effort under the non-ETS scope.

2.6.4.1 Gap Analysis Revision

The outcomes of the gap analysis are affected by many sources of uncertainty and variability that may lead to misunderstand the results when analyzed and interpreted. This analysis addresses this issue providing more accurate results in order to allow a more correct interpretation of the gap analysis outcomes. Firstly, the outcomes from the gap analysis are corrected in order to remove sources of distortion between the same category of scenarios. Secondly, the corrected values are analyzed according to the gap analysis methods and they are reviewed through a comparative analysis. Thus, this final step adjusts and completes the outcomes of the previous steps, providing the final (more accurate) results of the gap analysis. Furthermore, it comes up with evidence on the effect of the two main drivers affecting the assessed emission (and hence policy) gap, namely economic assumptions and policy assumptions.

At a first stage, the work performs the correction of the reported data (i.e. until the projections' baseline year) of the less updated scenarios, i.e. *PRIMES 2007* and *National 2011* in order to remove the distortion caused by different data provided by the monitoring activity and included as verified data into the scenarios. The data is corrected based on the most updated scenarios, namely *PRIMES 2009* and *National 2013* respectively. The correction lies in replacing the emission data of the less updated scenarios with the data provided until the projections' baseline year by the updated version and in adjusting the trajectory maintaining the original projected growing rate.

- EU-wide scenarios

  The projections' baseline year is the same in both *PRIMES 2007* and *2009*, i.e. 2005. The 2005 data of the 2007 Baseline scenario is replaced with the PRIMES 2009 data. The emission trend is marked out until 2020 by applying the typical growing rate of the Baseline 2007 to the updated baseline data.
- National-based scenarios

  The projections' baseline year is 2009 in *National 2011* and 2011 in *National 2013*. Consequently, the updated data up to 2011 included into the latest national-based scenarios is applied to *National 2011*. Next, the emission trends of the 2011 WEM and WAM scenarios are rearranged by applying their typical growing rate.

Moreover, the national-based scenarios delivered in 2011 are further corrected in order to enable to distinguish the weight of the economic downturn from the effect of the considered policies and measures in the expected evolution of non-ETS GHG emissions until 2020. On the other hand, this distinction cannot be made at this stage in the EU-wide scenarios. The correction addresses the data about the expected policy effectiveness (expressed in term of $ktCO_2$ eq. avoided per year for the year 2015 and 2020) provided in the assumption analysis. Counting for the With Existing Measures scenario delivered in 2011, the total load of its own policy assumptions is substituted with the one of the updated WEM scenario. The new data of the 2011 WEM scenario is used to correct the With Additional Measures scenario. In fact, the data on the expected effectiveness of the planned policies included into the 2013 WAM scenario is subtracted from the mentioned data.

Next, the gap analysis methodology is applied to the corrected results in order to adjust the previous results and come up with more correct and complete outcomes on the expected emission (and hence policy) gap. Moreover, the study performs a comparative analysis between the most updated scenarios and the corrected version of the previous scenarios in their expected development up to 2020. This analysis provides evidence on the load of the economic and policy assumptions on the gap analysis outcomes. In fact, once performed the data correction, the different development of the scenarios' trends mirrors the different assumptions only. At this stage, the analysis seeks to distinguish the impact of the two variables when possible.

- EU-wide scenarios

  PRIMES 2007 is compared to *PRIMES 2009* in its corrected emission levels. The outcomes define the expected load of the economic downturn and of the policy framework in the evolution of non-ETS GHG emissions up to 2020. However, the assessment provides only an aggregate data.
- National-based scenarios

  The 2011 WEM scenario and the 2011 WAM scenario are compared with the updated versions belonging to *National 2013*. The comparison assesses the impact of the economic assumptions in the projected evolution of GHG emissions up to 2020. Thus, the result represents the impact of the economic constraints resulting from the prolongation of the economic crisis (mirrored by stagnating economic conditions) that are expected to affect the domestic economy until 2015 according to the latest set of national-based scenarios only.

2.6.5 Decomposition Analysis

In line with the previous steps of the research, this part aims to complete the analysis deepening the understanding on the Italian progress towards meeting the non-ETS target in relation to the policy effort and the effect of the severe economic downturn that is still affecting end-use sectors as well as the whole domestic economy. The previous step of the analysis assesses the expected effect of the delay in the economic recovery, which is expected only in the latest national-based scenarios and it covers the period up to 2015. Moreover, it reports the expected effect of the improved policy effort.

This analysis aims to disclose the impact of the economic downturn in its first stage (i.e. until 2010) and of relevant policies and measures implemented before 2010 (mainly at EU level) on the expected development of the energy system up to 2020. In doing so, the study provides evidence at sectorial level, addressing one among the sectors regulated by the Effort Sharing Decision, namely the transport sector. The selection of transport is justified by the relevance and representativeness of this sector that make this analysis topical, comprehensive and hence highly meaningful. The analysis addresses the transport sector at the sub-sector level, hence considering freight transport and passenger transport without performing further structural decompositions. The analysis focuses on the projected development of freight and passenger transport in Italy from 2010 to 2020 according to the 2007 Baseline scenario and the Reference scenario of PRIMES. The two sub-sectors are addressed separately and the assessment is carried out through the decomposition analysis, which aims to define the distinct load of the economic and policy variables in the change of sub-sectorial energy use characterizing the two scenarios for the period between 2010 and 2020. Thus, this analysis moves the focus from GHG emissions to energy use in the domestic energy system and from the non-ETS branch at the aggregated level to a singular sector within it.

The decomposition analysis is a commonly used approach applied to explain structural changes that may occur at sectorial level in the energy system. The decomposition analysis is based on two distinct methods, namely structural decomposition method and index decomposition method (Hoekstra & van der Bergh, 2003). Generally speaking, the aims of both the methods is to define the causes of a verified change in the system in a given timespan (Hoekstra & van der Bergh, 2003). Moreover, these approaches can be employed to assess the impact of the different variables (such as macro-economic as well as technology and policy-related variables) on the given change (IEA, 2007; 2013c). This analysis focuses only on the index decomposition method, which is widely applied to analyze and explain energy, environmental and climate issues as proved by the extensive literature on this field (Palmer, 2003). Furthermore, the results of this kind of analyses are often useful instruments for policymakers (Palmer, 2003). The approach applies only sectorial aggregate information (Hoekstra & van der Bergh, 2003) consequently easing and extending its employment to a vast array of studies covering almost all the features of energy system (Ang & Zhang, 2000; Liu & Ang, 2003). In particular, decomposition analyses on sectorial energy demand and supply usually apply basic decomposition methods although researchers can choose from many approaches to solve the same problem (Ang, 2004).

This study applies the Laspeyres index method in its additive approach (Ang & Zhang, 2000). The aim is to assess the impact of the economic and policy variables in the difference between the projected data on freight and passenger transport energy use for the years 2010, 2015 and 2020 (i.e. the available data from the projecting activity) from the 2007 Baseline scenario and the Reference scenario of PRIMES. Generally speaking, the Laspeyres index method assesses the impact of a specific variable on the change (usually between two historical data) by letting the variable change while maintaining the others constant at the base year value (Ang & Zhang, 2000). The decomposition is performed additively, this means that the decomposition (of energy use in this case) addresses the differential change as showed by the following formula:

$$\Delta E_{TOT} = E_t - E_0$$

Where:

$$E_t = \sum_i A_i S_{i,t} I_{i,t}$$

Applying the previous equations to the present analysis:

E_t: Energy use (of both freight and passenger transport) projected by the Reference scenario

E_0: Energy use (of both freight and passenger transport) projected by the 2007 Baseline scenario

i: sub-sector → freight transport and passenger transport

A: aggregate activity → of freight transport (Gtkm); of passenger transport (Gpkm)

S: sectorial structure → transportation modes (not considered in this analysis)

I: Energy intensity: energy use per unit of activity → of freight transport (toe/Mtkm); of passenger transport (toe/Mpkm)

Thus:

$$\Delta E_{TOT} = E_t - E_0 = \Delta A + \Delta I$$

According to IEA (2013c), the decomposition components in this analysis are:

Activity effect (E_t^A): relative impact on E_t of the sectorial activity change ($A_t - A_0$) maintaining energy intensity fixed (I_0).

Intensity effect (E_t^I): relative impact on E_t of the energy intensity change ($I_t - I_0$) maintaining sectorial activity fixed (A_0).

Based on the description above, the study performs the decomposition analysis for freight transport and passenger transport following two different approaches as consequence of their structural diversity. In fact, freight activity is strongly related to the economic context while passenger transport is roughly decoupled by the domestic economic activity (European Commission, 2011e). Consequently, assuming economic and policy variables as the only drivers of the change according to the research assumptions (section 2.5), the following equation is valid:

$$\Delta E_{TOT} = \Delta E_E + \Delta E_P$$

Where:

ΔE_E: energy use variation resulting from the economic variable

ΔE_P: energy use variation resulting from the policy variable

Based on the definitions and formulae provided above, the decomposition analysis of the two branches of the transport sector is based on the approaches described hereafter.

Freight Transport

The change in energy use is mainly related to variations in the sectorial activity, which in turn is straight dependent to the economic context. Thus, the activity effect is assumed to fully represent the impact of the economic variable, while the policy variable is defined as difference between the total change and the economic impact.

$$\Delta E_{TOT} = (E_t^A - E_0^A) + \Delta E_P$$

Passenger Transport

The change in energy use is mainly related to variations in energy intensity, which in turn is tightly link with the implementation of effective energy and climate policies. Thus, the intensity effect is assumed to fully explain the impact of the policy variable, while the economic variable is derived as difference between the total change and the economic impact.

$$\Delta E_{TOT} = \Delta E_E + (E_t^I - E_0^I)$$

Final Remarks on the Method

The approach characterizes the change between the energy use data of the 2007 Baseline scenario and the corrected data of the Reference scenario. The correction lies in substituting the scenario's data on 2005 with the data reported in the 2007 Baseline scenario and in computing the following values (on 2010, 2015 and 2020) maintaining the original growing rate.

The final results are provided in ktoe and percentage change.

3 RESULTS

The present chapter reports the results of the analysis. It is worth noting that the outcomes of the preliminary analysis, which represents the first stage of the research, are presented after the assumption analysis for the sake of clarity.

3.1 Assumption Analysis

3.1.1 Population

Firstly, based on official data and reports addressing the demographic trends from the nineties up to now the following general features of the Italian population context has been drawn. Italy is the fourth most populous country in the European Union with around 60 million inhabitants (Eurostat, 2012). Total resident population has maintained a rather stable level in the nineties while increasing in the following decade at an average annual growing rate of 0.6% (www3.istat.it). The increasing trend is mainly due to immigration, in fact immigration rate was rather stable between 1990 and 1997 but it started to grow afterwards (www3.istat.it) at a faster and faster pace, making Italy the EU country featuring the second highest migration inflow in 2005 and the highest in 2009 (European Commission, 2012c). Based on *EUROPOP2010* projections of Eurostat, this leading position is expected to be maintained also in the next years keeping on supporting demographic growth.

Secondly, the overview and analysis of the scenarios' assumptions have led to the following understanding. The demographic assumptions included in the PRIMES scenarios are based on Eurostat data and forecasts. *PRIMES 2009* benefits from more updated values compared to *PRIMES 2007* since the assumed values derive from the Eurostat 2008-based population projections (*EUROPOP2008*). PRIMES assumptions are coherent with the verified data provided by Eurostat up to 2005. *PRIMES 2007* assumes a prudent growth between 2005 and 2010, characterized by an annual average growing rate equal to 0.1%, while by a decreasing rate afterward. In fact, demographic trend is assumed to decrease of around 0.1% every year between 2010 and 2020. On the other hand, *PRIMES 2009* assumes a growing dynamic characterized by an average annual growing rate of 0.5% between 2005 and 2010 and of 0.2% between 2010 and 2020. Revised data and different migration assumptions explain the different and diverging demographic assumptions of the two PRIMES version.

The demographic assumptions included in the national-based scenarios derive from the verified data and official population forecasts made by the National Institute of Statistics (ISTAT). The historical data included in *National 2011* have been slightly corrected in the following version (*National 2013*), which includes the most updated data currently available. However, the projected data addressing the years 2015 and 2020 are the same in the two set of scenarios. Beside the past trends that mirror the verified dynamic, the projected values assume a growing trajectory characterized by a yearly average growth of 0.2% between 2015 and 2020, which is also the average growing rate expected for the whole decade (2010-2020).

Table 2 and Figure 5 show the sets of data and the corresponding trends considered in the analysis.

Table 2 – Italian population (Million inhabitants)

Source	Year						
	1990	1995	2000	2005	2010	2015	2020
PRIMES 2007	56.694	56.846	56.929	58.462	58.698	58.630	58.300
PRIMES 2009	56.694	56.846	56.924	58.462	60.017	60.929	61.421
National 2011	56.694	56.846	56.929	58.462	60.464	61.138	61.634
National 2013	56.694	56.844	56.924	58.462	60.340	61.138	61.634
Historical data	56.694	56.844	56.924	58.462	60.340	-	-

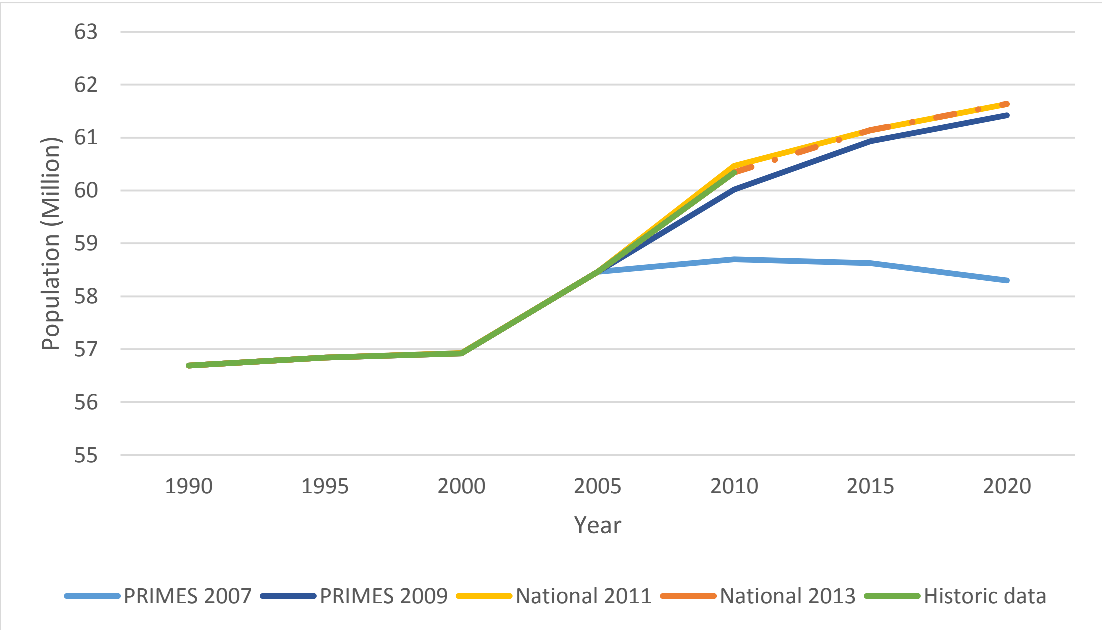


Figure 5 - Italian demographic trends (Million inhabitants)

Finally, the comparative analysis of the data and information regarding population trends within the considered scenarios has led to the results and remarks outlined hereafter. The verified data provided by ISTAT addressing the period between 1990 and 2010 shows a rather stable population in the nineties that steadily increases in the following decade at an average annual growing rate of 0.6%. Despite *National 2013* is the only set of scenarios including the most updated demographic data available, the other scenarios show no or negligible deviations to the verified levels up to 2005. The 2010 data included in the PRIMES scenarios is already a projected value, nevertheless *PRIMES 2009* maintains a rather close trend to the verified one, assuming an annual growing rate of 0.5% for the period 2000-2010. On the other hand, *PRIMES 2007* shows a diverging trend since the 2010 value is more than 1.6 million units lower than the verified data and the average annual growing rate between 2000 and 2010 is equal to 0.3%. Accounting for the projected data addressing the years 2015 and 2020 *PRIMES 2007* keeps on maintaining a divergent trend compared to the other scenarios. In fact, while *PRIMES 2009* and the national-based scenarios assume a consistent annual growing rate of 0.2% between 2010 and 2020, *PRIMES 2007* assumes a decreasing trend (-0.1%). However, the projection data included in the national-based scenarios and in *PRIMES 2009* shows a more prudent estimation compared to the recent ISTAT projections based on 2011 data and run until 2065 (www. demo.istat.it). The mentioned ISTAT projections are divided into three scenarios i.e. reference, high and low, depending on assumptions related to fecundity mortality and migration. Even counting for the low scenario, the projected data in 2015 and 2020 is higher compared to the values assumed by *PRIMES 2009* and the national-based scenarios delivered in 2011 and 2013. However, it is worth to remark that the database of the ISTAT projections, which concern the year 2011, is not updated to the results of the last Census (made by the National Statistical Institute itself), which shows a far lower value for 2011 (around 1 million less). Anyway, not even the projections applied to *National 2013* have been upgraded considering this value.

3.1.2 Economic Context

Firstly, the literature review as well as the analysis of historical data, official documentations and official projections have allowed to depict the Italian economic context as reported hereafter. The Italian economy features an unstable macroeconomic framework mainly characterized by long-lasting inflation, fiscal laxity, high public debt, weak productivity growth (especially in the Southern regions) and problems in making effective and structural reforms (Crafts & Magnani, 2011). Furthermore, Italian economic system is mainly based on small and medium-size firms with a consequent higher rigidity of the system itself, which is barely able to deal with globalization and to cope with economic barriers addressing technological innovation (Rae & Sollie, 2008; Crafts & Magnani, 2011). These factors have been heavily impacting on the national economy, which has been characterized by a moderate growth since the earliest nineties until the recent economic recession. In the first half of the nineties, the GDP grew at an annual average rate of 1.3%, increasing to almost 2% in the second half (www.epp.eurostat.ec.europa.eu). Nevertheless, the yearly growing rate characterizing the period between 1995 and 2000 was still lower than the average of EU-27. Even worse, the domestic growth rate between 1999 and the beginning of the global economic recession (i.e. summer 2007) was half of the EU average (Crafts & Magnani, 2011). Then, the already weak national economy has been deeply hurt by the economic downturn, consequently showing an annual average reduction in GDP of 0.25% between 2005 and 2010 (www.epp.eurostat.ec.europa.eu). In the period between 2000 and 2010 Italy showed the lowest annual average growing rate among the OECD countries (OECD, 2013b). Despite a slight growing trend between 2010 and 2011 (+0.4%) (www.epp.eurostat.ec.europa.eu), GDP has shown a new reduction in 2012 (-2.4%) which is expected to persist in the following year, at a less negative rate though (-1.3%) (www.epp.eurostat.ec.europa.eu; Ministry of Economy and Finance, 2013). Based on the short-term, the projections on the national economy are expected to show positive trends only from 2014 thanks to the structural reforms issued by the national government in 2012 (OECD, 2013b). However, the expected growth is barely predictable also in the short run. In fact, the projected annual growth for 2014 fluctuates from 0.4% based on the OECD data (OECD, 2013b) and 0.7% according to Eurostat to 1.3% when the impact of the structural reforms are partially taken into account (Ministry of Economy and Finance, 2013).

Secondly, the overview and analysis of the scenarios' assumptions addressing the domestic economic activities have led to the following information and insights. The GDP assumptions used to run the PRIMES scenarios are based on the projections made both for the short and the long term by the Directorate-General for the Economic and Financial Affairs (DG ECFIN) with additional contributions from national long-running projections. The short-term forecasts refer to the Spring Economic Forecasts addressing the period 2006-2008 and 2009-2010 in *PRIMES 2007* and *2009* respectively. On the other hand, the long-term projections of the DG ECFIN have been developed in the context of the Annual Ageing Reports. The economic assumptions included in *PRIMES 2007* show a moderate growth over the entire period up to 2020. The economy is assumed to grow at a slow pace in particular between 2000 and 2010, when the annual average growth is one point percentage lower than the EU-27 one (1.2% and 2.2% respectively). This is due to the economic slowdown faced in the first half of the decade (annual average growth of about 0.6%). The context substantially changes counting for the economic assumptions included in *PRIMES 2009* since they address the recent economic downturn. According with the mentioned set of scenarios, the recession was expected to strongly affect the Italian economy as mirrored by the GDP drop between 2005 and 2010 (annual reduction of almost 0.4%). Then, the economic recovery is assumed to take place at a low rate (among the lowest in the European Community), showing an annual average growing rate between 2010 and 2020 of around 1.9%.

The economic assumptions included in the national-based scenarios follow the historic trends, which imply a structural low economic growth, further adding the effect of the economic downturn. The most recent version benefits of the projections included in *The Ageing Report 2012*, on which is based. *National 2011* assumes a great effect of the economic recession on the Italian economy between 2005 and 2010, when the annual average growth is -0.4%. Then, the economic recovery is assumed to take place at a remarkable slow pace, showing a 1.3% annual average growing rate between 2010 and 2020. The assumptions change in some extent in the *National 2013*, the economic downturn maintains deep effects on the national context between 2005 and 2010 but in some extent lower than expected by the previous version (the yearly average growth is around -0.3%). However, the economy is expected to recover after a longer period (compared to *National 2011*) due to the low growing rate, which is expected to characterized the domestic economy until 2020. The annual growing rate is expected to feature the lowest values between 2010 and 2015 (0.4%), while increasing to 1.2% between 2015 and 2020. Consequently, the average yearly GDP rise is expected to amount to of 0.8% between 2010 and 2020.

The following table and the figure show the sets of data and the corresponding trends considered in the analysis.

Table 3 – Italian GDP (000 M€'2005)

Source	Year						
	1990	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
PRIMES 2007	1172.7	1249.2	1372.9	1417.2	1541.5	1704.6	1864.3
PRIMES 2009	1168.7	1244.9	1367.8	1429.5	1403.5	1526.1	1678.7
National 2011	1172.7	1249.2	1372.9	1429.0	1400.9	1489.9	1589.3
National 2013	1166.5	1244.5	1367.8	1436.4	1418.4	1449.3	1538.4
Historical data	1166.5	1244.5	1367.8	1436.4	1418.4	-	-

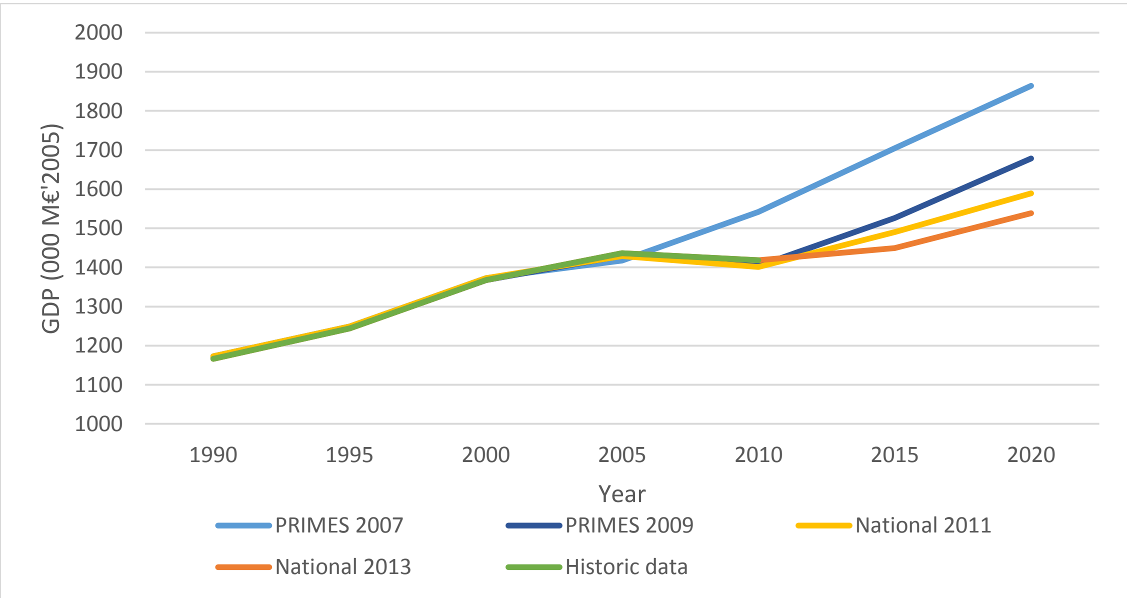


Figure 6 – Italian GDP trend (000 M€'2005)

Finally, the comparative analysis between the previous data and information has led to the following results and remarks. The verified data on the domestic economic activity between 1990 and 2010 show a slow growth in the nineties and in the first half of the following decade while a decreasing trend afterwards up to now (despite a slightly rise in 2011). The same trend is reported in *PRIMES 2009* and in the national-based scenarios, although with some differences in increasing/decreasing rates. On the other hand, the different economic assumptions included in *PRIMES 2007* result in a steady rise of GDP over the entire period, thus starting to diverge from the other scenarios and the verified trend from 2005. After 2010, *PRIMES 2009* and the national-based scenarios develop different representation of the national economic context up to 2020. The 2013 national-based scenarios, which benefit of the most updated data, assume a prudent view expecting a slow economic recovery. On the other hand, *PRIMES 2009* assumes an optimistic view, projecting a steady increase after 2010. *National 2011* stands in between, expecting a constant and moderate increase. In term of growing rate, *PRIMES 2009* assumes a 1.9% average yearly growth between 2010 and 2020, resulting from an average 1.7% and 2.0% growth in the first and second half of the decade respectively. Then, the *National 2011* assumes a constant change of 1.3% over the whole decade. Finally, the *National 2013* includes an overall annual average change of only 0.8% for the period 2010-2020, which results from a projected yearly average growth of about 0.4% between 2010 and 2015 and of 1.2% between 2015 and 2020.

Sectorial Activity

Beside GDP evolution, the economic assumptions include sectorial activity trends, which help to define the role of each sector in the national economy, and hence in the economic growth or slowdown. Furthermore, sectorial activity provides information on structural changes that may characterize end-use sectors and may affect the entire economic system. For the sake of completeness, the sectorial activity indicators included in the set of scenarios addressed by the research are listed below.

PRIMES scenarios address sectorial activity data by using energy intensity indicators.

- Industry: energy on value added
- Residential: energy on private income
- Tertiary: energy on value added
- Transport:
  Passenger transport activity: billion passenger per kilometer (Gpkm);
  Energy intensity of passenger transport: toe on million passenger per kilometer (toe/Mpkm)
  Freight transport activity: billion tonne per kilometer (Gtkm);
  Energy intensity of freight transport: toe on million tonne per kilometer (toe/Mtkm)

On the other hand, in the national-based scenarios, sectorial activity is mainly defined by its economic-related parameters, which are listed hereafter:

- Industry: gross value added of total industry
- Tertiary: gross value added
- Transport: passenger transport activity (Gpkm) and freight transport activity (Gtkm)

None specific parameter has been developed for the residential sector in the national-based scenarios. In fact, its load on the system is mainly based on population trends as well as on number of household.

3.1.3 Energy Import Prices

Firstly, the review of official data and sources has produced the following brief outlook of fossil fuel prices' development from the nineties up to now. World's fossil fuel prices are relevant parameters that contribute to shape global and national energy systems. Oil prices have been characterized by fluctuating trends during nineties, while showing a steady increase between 1998 and 2008, falling afterward in 2009. After 2009, price levels start growing again up to the present day. Natural gas prices show roughly the same path of oil prices but maintain lower levels. Finally, coal prices have been characterized by lower variability and levels in the last two decades, although showing a slight increase between 2000 and 2008 (EIA, 2013; Shafiee & Topal, 2010). Fossil fuels prices depend on a large number of factors that are also difficult to predict such as resource availability, global economic context, energy demand and supply. Counting for the supply side, prices influence and at the same time are influenced, by fossil fuel production and this is particularly true for oil and natural gas, while the production-price relationship is weaker for coal (Shafiee & Topal, 2010). Consequently, the evolution of world fossil fuel prices is barely predictable.

Secondly, the overview and analysis of the fossil fuels prices used as assumptions to run the scenarios, which are summarized in Table 4, have led to the following characterizations. First, world fossil fuel prices included in PRIMES scenarios are based on the Prometheus stochastic world energy model, which provides different scenarios of prices depending on the global energy demand and resources availability. PRIMES scenarios are based on the median scenario run by the Prometheus model, which assumes that oil and gas resources are enough to allow for a smooth evolution of prices even though they maintain high levels due to supply constraints. Furthermore, oil and gas prices are considered tightly linked and natural gas is expected to meet part of energy demand previously covered by oil, increasing its market share. On the other hand, coal prices are expected to increase at a slower pace despite the increasing demand because the main consumers are also the main producers. World fossil fuel prices are projected to grow over time in both *PRIMES 2007* and *PRIMES 2009* but the latter assumes an oil price context characterized by higher prices.

On the other hand, world fossil fuel prices included in national-based scenarios are supplied by Commission official papers. The values have been further reviewed considering actual values reported by national operators in order to provide a more reliable estimation based on the domestic environment but at the same time maintaining its accordance with EU data and projections.

Finally, the table below shows the global fossil fuel prices applied as assumptions in the PRIMES and the national-based scenarios. As can be observed, the data feature different units making hard to draw comparisons. Anyhow, fuel prices, which are assumed to increase over the entire projected period in all the scenarios, are increasingly higher passing from *PRIMES 2007* to *National 2013*.

Table 4 – Energy import prices according to the scenarios

Fossil Fuel	Scenario	Unit	Year			
			2005	2010	2015	2020
Oil	PRIMES 2007	€'2005/boe	43.60	43.60	46.32	48.88
	PRIMES 2009	€'2008/bbl	-	59.65	-	73.37
	National 2011	€'2005/bbl	48.32	76.00	77.60	87.40
	National 2013	€'2006/toe	335.30	357.80	481.10	541.50
Natural Gas	PRIMES 2007	€'2005/boe	27.68	33.20	34.72	36.80
	PRIMES 2009	€'2008/boe	-	36.66	-	51.54
	National 2011	€'2005/GJ	4.88	8.15	8.38	9.61
	National 2013	€'2006/toe	189.30	251.50	310.10	352.80
Coal	PRIMES 2007	€'2005/boe	11.84	10.96	11.44	11.76
	PRIMES 2009	€'2008/boe	-	14.29	-	21.42
	National 2011	€'2005/GJ	2.02	4.30	4.50	5.30
	National 2013	€'2006/toe	78.50	126.00	126.00	149.00

3.1.4 Technology-related Assumptions

Technology-related assumptions concern energy efficiency improvements, renewables' spread and new technologies penetration in the market and changes in the energy mix. Technology maturity, market forces (e.g. energy prices and costs dynamics) and public policies drive technology uptake (Sorrell et al., 2000; IPCC, 2011; IEA, 2013b). Policies and measures can boost energy efficiency in end-use sectors, renewable sources development and widespread diffusion of new low carbon technologies in the market by addressing barriers and failures through a number of possible instruments. The policy instruments, which include for instance binding targets and standards, financial support, informative campaigns and R&D support, can act on market drivers supporting learning-by-doing progress and economy of scale development. These dynamics speed up technologies' maturity achievements, which is essential for the spreading adoption of new technologies. Thus, technology assumptions reflect self-drive as well as policy-determined technological improvements recently achieved and envisaged for the future. The tight link between technology success and the related legislative framework makes the technological options included in the scenarios often implicitly defined within the policy assumptions. The technologies affecting end-use sectors that are included in the scenarios can be distinguished into three main branches, concerning renewable sources developments, energy efficiency improvements in the civil sector and technical improvements in road transport.

Renewables development in non-ETS sectors is mainly related to increasing use of energy renewable sources in the built environment and of biofuels and other renewable fuels in transport sector. Energy efficiency improvements can be largely achieved in all end-use sectors, however the technology assumptions focus on the civil sector and transport, which are the sectors featuring the highest cost-effective saving potentials (Fraunhofer ISI, 2012). Counting for the civil sector, energy efficiency gains can be achieved by enhancing building envelope, heating and cooling systems, lighting, electric appliances (e.g. boilers, televisions and refrigerators) and other energy related products that do not use energy but affect energy consumption (e.g. insulation materials, windows, taps). Finally, technical improvements in road transport allow to achieve energy savings while controlling and reducing emissions by enhancing components' efficiency and by setting emission standards for vehicles to favor fleet update.

Besides the above concise description, a more detailed overview of the main technology-related assumptions is provided at the end of the next section.

3.1.5 Policy Assumption Analysis

This section provides the results of the overview carried out on scenarios' policy assumptions addressing the scope of the Effort Sharing Decision, i.e. affecting the non-ETS sectors. The characterization and overview of the policy assumptions as well as the results of the comparative analyses are provided hereafter. The results are reported through a set of dedicated tables and descriptions that focus on the EU-wide scenarios in a first stage and on the national-based scenarios afterwards. Lastly, the results of the wider comparative analysis focusing on the main fields of action featured by the policy assumptions are reported.

EU-wide scenarios

The 2007 Baseline scenario includes the main EU provisions addressing or influencing the energy system and the related GHG emissions implemented up to end 2006. *PRIMES 2009* updates the EU legislative framework included in *PRIMES 2007*, albeit in different extent considering the baseline and the reference scenario. In fact, policy assumptions represent the main divergent point between the 2009 Baseline scenario and the Reference scenario. The former includes the relevant EU policies and measures and the most relevant national ones implemented by April 2009. Moreover, it includes the relevant legislative provisions adopted by April 2009 for which there was almost no uncertainty on their future implementation at the time the scenarios were run. While, the latter includes the same policies of the baseline scenario adding some additional legal provisions which consists of the relevant policies and measures addressing the climate and energy field adopted between April 2009 and December 2009. Moreover, the Reference scenario includes the provisions addressing the emission target and the renewables target for 2020, which are assumed to be met in the Reference scenario. The policies and measures addressing the non-ETS sectors are presented in the tables below (Tables 5, 6 and 7). Firstly, Table 5 lists the policies and measures included in *PRIMES 2007*, which are also considered in the updated PRIMES version. Secondly, Table 6 shows the additional provisions included in the 2009 PRIMES scenarios that they have been implemented or adopted between January 2007 and April 2009. Finally, Table 7 lists the provisions included only in the Reference scenario. The tables provide some basic information, including a concise description of the objective, the main addressed sector and the nature of the policy instruments.

Table 5 – Policy assumptions of 2007 Baseline scenario (also included in *PRIMES 2009*)

Policies and measures identification and description			
Policy or measure	**Description**	**(Main) Target**	**Type of instrument**
RTD support (7th framework program-theme 6)	Provision establishing financial support to R&D in the period 2007-2013. The provision boosts innovative technologies, including CCS, RES, nuclear and new technologies aimed at improving energy efficiency.	Cross sectoral	Economic
Cohesion Policy – ERDF, ESF and Cohesion Fund	Provision establishing a financing framework for the period 2007-2013 to support national policies on energy efficiency and renewables in order to strengthen Community economic and social cohesion.	Energy efficiency (Cross sectoral)	Economic
Eco-design Framework Directive 2005/32/EC	Provision establishing a framework for setting Community ecodesign requirements for energy-using products excluding any means of transport.	Energy Efficiency (Cross sectoral)	Regulatory
Labelling Directive 2003/66/EC	Provision addressing energy labelling of household electric refrigerators, freezers and their combinations.	Energy Efficiency (Civil)	Regulatory
Buildings Directive 2002/91/EC	Provision promoting the enhancement of the energy performance of new and existing buildings establishing minimum and binding requirements.	Energy Efficiency (Civil)	Regulatory
Energy Star Program Council Decision 2006/1005/EC	Agreement jointly adopted with the United States promoting the production of energy-efficient office equipment.	Energy Efficiency (Civil)	Regulatory
Biofuels Directive 2003/30/EC	Directive promoting the use of biofuels and other renewable fuels for transport in order to reach a 5.75% share of renewable energy in the transport sector in the Community by 2010.	Transport	Regulatory
Landfill Directive 99/31/EC	Provision defining stringent technical requirements for waste and landfills in order to prevent negative effects on the environment due to waste disposal.	Waste	Regulatory

Table 6 – Policy assumptions included in 2009 Baseline and Reference scenarios

Policies and measures identification and description			
Policy or measure	**Description**	**(Main) Target**	**Type of instrument**
State aid Guidelines for Environmental Protection and 2008 Block Exemption Regulation	Provision establishing financial support to nearly all sectors of the economy, including energy supply as well as end-use sectors boosting R&D and the improvement of new technologies such as CCS, RES, nuclear and new technologies aimed at improving energy efficiency.	Cross sectoral	Economic
Directive 2006/32/EC on end-use energy efficiency and energy services	Directive aimed to increase the cost-effective improvement of end-use energy efficiency through implementing a framework encompassing several actions such as the definition of indicative targets and the inclusion of incentives and measures addressing both energy demand and supply.	Energy Efficiency (Cross sectoral)	Regulatory
Stand-by Regulation 2008/1275/EC	Regulation implementing the Directive N. 2005/32/EC establishing ecodesign requirements for stand-by and off mode electric power consumption related to electrical and electronic household and office equipment.	Energy Efficiency (Civil)	Regulatory
Simple Set-to boxes Regulation 2009/107/EC	Regulation implementing Directive 2005/32/EC establishing ecodesign requirements for simple set-top boxes.	Energy Efficiency (Civil)	Regulatory
Office/street lighting Regulation 2009/245/EC	Regulation implementing Directive 2005/32/EC establishing ecodesign requirements for office and public street lighting, including indicative benchmarks for products applied to this field.	Energy Efficiency (Civil)	Regulatory
Household lighting Regulation 2009/244/EC	Regulation implementing Directive 2005/32/EC establishing ecodesign requirements related to non-directional household lamps and information requirements for special purpose lamps.	Energy Efficiency (Civil)	Regulatory
External power supplies Regulation 2009/278/EC	Regulation implementing Directive 2005/32/EC establishing ecodesign requirements for electric power consumption in no-load condition and average active efficiency of external power supplies.	Energy Efficiency (Civil)	Regulatory
Regulation EURO 5 and 6 2007/715/EC	Regulation defining minimum technical requirements for new passenger cars and light commercial vehicles and their pollution control devices in order to reduce and control their emissions.	Transport	Regulatory
Fuel Quality Directive 2009/30/EC	Provision introducing sustainability criteria for fuel in order to decrease negative effects on human health and the environment through the reduction of GHG intensity and the exploitation of biofuels.	Transport	Regulatory
Regulation on CO_2 from cars 2009/443/EC	Regulation establishing emission performance standards for new passenger cars to reduce related CO_2 emissions.	Transport	Regulatory

Table 7 – Policy assumptions included only in the Reference scenario

Policies and measures identification and description			
Policy or measure	**Description**	**(Main) Target**	**Type of instrument**
Electric motors Regulation 2009/640/EC	Regulation establishing ecodesign requirements for electric motors (including when integrated in other products).	Energy Efficiency (Industry)	Regulatory
TVs (+labelling) Regulation 2009/642/EC	Regulation establishing ecodesign requirements for televisions.	Energy Efficiency (Civil)	Regulatory
Circulators Regulation 2009/641/EC	Regulation establishing ecodesign requirements for glandless circulators (including when integrated in other products).	Energy Efficiency (Civil)	Regulatory
Freezers/ refrigerators (+labelling) Regulation 2009/643/EC	Regulation establishing ecodesign requirements for household refrigerating appliances.	Energy Efficiency (Civil)	Regulatory
Recast of the EPBD 2010/31/EU	Directive recasting the requirements of the energy performance of new and existing buildings.	Energy Efficiency (Civil)	Regulatory
Labelling Regulation for tyres 2009/1222/EC	Regulation establishing an informative framework for tyres through labelling.	Energy Efficiency (Transport)	Regulatory
Regulation Euro 6 for heavy duty vehicles 2009/595/EC	Regulation defining minimum technical requirements for new heavy duty vehicles and their pollution control devices in order to reduce and control their emissions.	Transport	Regulatory
EU binding legislations part of the Climate and Energy Package:			
RES Directive 2009/28/EC: Provision establishing national binding targets to deliver an overall 20% share of energy from renewable sources and a 10% share of renewable energy in the transport sector by 2020.			
Effort Sharing Decision No 406/2009/EC: Provision establishing national binding targets for non-ETS sectors to deliver an overall 10% reduction in GHG emissions compared to 2005 levels by 2020.			

The policy assumptions mainly mirror the EU policy context, which represents only to a limited extent the national-specific legal framework addressing the domestic energy system. Although some relevant national provisions are included in the scenarios, these are mostly related to the supply side of the energy system. On the other hand, Italy has implemented a large number of policies and measures addressing energy efficiency in end-use sectors by transposing EU provisions into the national legislation. This consideration is particularly relevant since a large number of policies and measures included in the scenarios addresses energy efficiency. Most of the provisions on energy efficiency address the civil sector (residential and tertiary) mainly by setting minimum and binding requirements for the built environment (Directive 2002/91/EC) and standards for energy-using appliances (Directive 2003/66/EC, Directive 2005/32/EC and related EU Regulations). Despite the above mentioned EU Directives are all included in the PRIMES 2007 assumptions, a large number of provisions related to the Eco-design Directive (Dir. 2005/32/EC) such as the regulations on civil lighting, the so called "stand-by regulation" and other measures on household appliances were issued after 2006, thus are included only in the 2009 PRIMES scenarios. In addition, the 2007 Baseline Scenario does not include the first Energy Efficiency Directive (Dir. 2006/32/EC) of 5 April 2006, which is included in the 2009 PRIMES scenarios indeed. Besides, transport is addressed by the PRIMES policy assumptions through a different approach, which is also due to the delay of the European Union in dealing with it compared to the built environment. In fact, only one main legislative measure is included in *PRIMES 2007*, i.e. the Biofuels Directive (Dir. 2003/30/EC). In addition, the 2007 Baseline scenario assumes a voluntary agreement between the European Commission and the European Automobile Manufacturers Association (ACEA), which anticipates Regulation 2009/443/EC setting CO_2 emission limits for new passenger cars, which is included in the 2009 PRIMES scenarios.

The differences between the 2007 Baseline scenario and the updated set of scenarios mirror the abundance of relevant policies and measures issued in the field of climate and energy by the European Union between the beginning of 2007 and April 2009. However, a further distinction should be made in relation to the 2009 PRIMES scenarios only. As already stressed, the Reference scenario proposes a more updated policy context at EU level compared to the 2009 Baseline scenario. In fact, the Reference scenario includes the relevant provisions issued by the European Commission between April and December 2009, among which Directive 2009/28/EC *on the promotion of the use of energy from renewable sources* and Decision n. 406/2009/EC *on the effort of Member States to reduce their greenhouse gas emissions*. Consequently, it assumes the achievement of the targets set by these provisions for 2020. Then, the Reference scenario upgrades the assumed legislative framework of the related Baseline by including new energy efficiency policies and measures, which again are mostly focused on the civil sector but they also address industry outside the ETS and transport. Counting for the civil sector, the Reference includes the repealed Directive on energy performance of buildings (Dir. 2010/31/EU) and other regulations addressing ecodesign standards for appliances. Moreover, legislative measures on further efficiency and technical improvements in transport are covered in the Reference scenario through regulations on tyres labelling and minimum technical requirements for heavy duty vehicles.

National-based scenarios

The policies and measures included in the national-based scenarios can be divided into two main categories: sector-specific and cross-cutting provisions. The former specifically entails one of the sectors outside the Emission Trading System (ETS) while the latter affects more than one end-use sector and may partially cover also the ETS branch, making more likely double counting when considering policy effectiveness. Annex II reports a brief overview of the main cross-sectoral policies included into the scenarios.

The policy assumptions of the national-based scenarios addressing the non-ETS sector are listed in the set of tables provided below. The provisions are split up based on the targeted sector. Counting for the cross-cutting policies, they are ascribed to the sector affected most. For every provision is offered a concise description of the objective and the type of instrument applied according to the distinction used in the last revision of the reporting tables submitted to the European Commission. Finally, data on the policy effectiveness is reported in terms of estimated emission reductions (ktCO_2 eq. per year) for the year 2015 and 2020. Table 8 lists the policies and measures included in the 2011 With Existing Measures scenario and Table 9 shows the additional measures included in the 2011 With Additional Measures scenario. The related information and data derives from the *2011 Climate Policy Progress Report* and the third reviewed version of excel tables submitted to the European Commission in 2011. Afterwards, Table 10 lists the policies and measures included in the 2013 With Existing Measures scenario and eventually, Table 11 reports the further (planned) measures assumed in the 2013 With Additional Measures scenario. The related information and data derives from the *2013 Climate Policy Progress Report* and the first table template revision.

Table 8 - Policy assumptions included in the 2011 With Existing Measures scenario (continuing)

Policies and measures identification and description			**Policy effectiveness (ktCO_2 eq. per year)**	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Civil sector				
Building Regulation (Legislative decrees 192/05 and 311/06)	Minimum mandatory standards on new and existing buildings (Energy efficiency)	Regulatory	1.107	2.311
Building Regulation (Legislative decrees 192/05 and 311/06)	Minimum mandatory standards on new and existing buildings (RES)	Regulatory	123	257
Budget law 2007 and budget law 2008	Supporting energy saving in existing buildings through tax deduction of 55%	Fiscal	611	611
Budget law 2009	Supporting energy saving in existing buildings through tax deduction of 55%	Fiscal	436	436

Policies and measures identification and description			Policy effectiveness ($ktCO_2$ eq. per year)	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Civil sector				
White certificates - decree december 2007	Supporting energy saving 2008-2012 (Energy efficiency)	Regulatory	3.301	3.120
White certificates - decree december 2007	Supporting of energy saving 2008-2012 (RES)	Regulatory	367	347
Legislative decree 201/07 (transposition of Dir. 2005/32/EC-first regulations)	First regulation on mandatory energy efficiency standards for energy-using products	Regulatory	866	2.599
National Strategic Framework 2007-2013 ERDF (Dir. 2006/32/EC)	Supporting energy savings through POR and POIN	Regulatory	363	423
NEEAP 2007 (White certificates 2012 - 2016)	Supporting energy savings (Energy efficiency)	Regulatory	3.228	3.893
NEEAP 2007 (White certificates 2012 - 2016)	Supporting energy savings (RES)	Regulatory	359	433
Transport				
Legislative decree 128/05 (transposition of Dir. 2003/30/EC)	Mandatory use of biofuels (target 4.5% to 2012)	Regulatory	1.204	1.204
Infrastructural measures (including Marco Polo program on freight transport)	Completion of High Capacity and High Speed networks and tuning of regional networks for commuting and goods. Completion of mass rapid transport networks.	Regulatory	3.750	5.700
Emission standard for new car (Regulation No 443/2009)	Fleet update 130 g CO_2/km	Regulatory	5.400	10.200
Directive 2009/28/EC	Supporting use of biofuels (target 10 %)	Regulatory	592	1.578
National Strategic Framework 2007-2013 - FESR	Intermodal infrastructure projects: metropolitan railways	Regulatory	320	1.278
Industry				
Nitric acid (transposition of Dir. 96/61/EC and Dir. 2008/1/EC)	Reduction of N_2O emissions in nitric acid production plants	Other	690	740
Agriculture				
Nitrogen fertilizer (CAP Reform 2006/144/EC)	Rationalization in the use of nitrogen fertilizer	Other	470	790
Animal storage (CAP Reform 2006/144/EC)	Recovery of biogas from animal storage system	Other	300	400

Policies and measures identification and description			Policy effectiveness ($ktCO_2$ eq. per year)	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Waste				
Separate collection (transposition Directive 1999/31/EC)	Compliance with separate collection targets and reduction of biodegradable waste disposed into landfills	Other	2.700	3.700

Table 9 - Policy assumptions included in the 2011 With Additional Measures scenario

Policies and measures Identification and description			Policy effectiveness ($ktCO_2$ eq. per year)	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Civil sector				
National Action Plan for Renewable Energy 2010 (NAP-RES 2010) - Further measures	Measures to achieve the target of Thermal RES	Regulatory	6.842	16.272
Further incentive (White certificates 2016-2020 – Dir. 2009/28/EC)	Measures supporting energy savings (NAP-RES 2010)	Regulatory	0	5.113
Additional incentives	Economic incentives to support new equipment introduction (also in compliance with the NAP - RES 2010)	Fiscal	0	1.568
Legislative decree 201/07 (transposition of Dir. 2005/32/EC - further regulations)	Eco-design and mandatory energy efficiency standards for machinery (appliances, boilers, etc.) (NAP-RES 2010)	Regulatory	0	1.568
New standards of efficiency in buildings (Dir. 2010/31/EC)	Further energy saving and promotion of renewable energy in buildings	Regulatory	371	5.114
Transport				
Measures related to demand and behaviors	Measures promoting technological, behavioral and legislative aspects (NAP-RES 2010)	Research	0	2.900
Intermodal measures to be funded	Promotion of infrastructure, intermodal and public mobility with electrical transport (NAP-RES 2010)	Regulatory	1.167	3.500
Measures, incentives and new CO_2 targets more stringent than in Regulation No 443/2009	Measures supporting introduction of electric cars, saving of fuels and faster fleet update of cars and light duty vehicles with new ones (NAP-RES 2010)	Regulatory	0	9.865

- Civil sector

  The legislative framework included in the WEM scenario is mainly based on regulatory provisions with the only exception of financial instruments provided by budget law 2007, 2008 and 2009. The policy assumptions address energy efficiency improvements attained by implementing the Building regulation, the first regulations under the ecodesign Directive and the White Certificates scheme. Further energy savings are achieved through developing projects and programs within the National Strategic Framework. The bulk of measures addressing the civil sector are expected to lead to GHG emission reductions for about 10.8 Mtoe CO_2 eq. in 2015 and 14.4 Mtoe CO_2 eq. in 2020.

  The WAM scenario includes further measures related (or partially related) to the National Action Plan for Renewable Energy 2010 promoting thermal energy from RES and energy efficiency improvements. In addition, new legislative provisions under the ecodesign Directive and new standards of efficiency in buildings as prescribed by Directive 2010/31/EC are included. Again, even in this case, policies and measures are mainly based on regulatory instruments, while economic instruments play a secondary role. The additional reductions in GHG emissions due to the expected policy effectiveness amount to 7.2 Mtoe CO_2 eq. in 2015 and 29.6 Mtoe CO_2 eq. in 2020. The measure aimed at improving thermal RES is the main contributor in 2015 with 6.8 Mtoe CO_2 eq. and it accounts for more than half of the expected reductions in 2020 with 16.3 Mtoe CO_2 eq..

- Transport:

  The WEM scenario includes provisions supporting the use of biofuels (Legislative decree 128/05 and Dir. 2009/28/EC), policy instruments aimed at boosting fleet update through emission standards for new cars and measures enhancing transport networks. As also mentioned above, the policies and measures taken into account are based on regulatory instruments only. The total effectiveness of the provisions is about 11.3 Mtoe CO_2 eq. in 2015 and 20 Mtoe CO_2 eq. in 2020, where half of the expected reductions must be ascribed to Regulation No 443/2009/EC supporting car fleet update.

  The additional measures included in the WAM scenario can be all attributed to the National Renewable Energy Action Plan issued in 2010 (NAP-RES 2010). The measures encompass several fields within the transport sector from behavioral changes to technical and technological improvements, including the promotion of electric transport. The main policy instruments planned to be adopted in order to implement the listed measures are based on the regulatory approach. However, the further measures addressing demand and behavior changes are based on research instruments according to the description provided in the third reviewed table template submitted to the European Commission. Within this Plan, also research instruments are introduced, which must be considered belonging to the information category of different types of policy instruments as proposed by Vedung (1998). The additional sectorial emission reductions expected by the implementation of the policies and measures included in the WAM scenario is about 1.2 Mtoe CO_2 eq. in 2015 and 16.3 Mtoe CO_2 eq. in 2020. The far higher value in 2020 is related to a large extent (60% of the total bulk) to the implementation of more stringent standards for new cars.

- Industry, Agriculture and Waste:
  These end-use sectors, which contribute to a lower extent on non-ETS GHG emissions, are addressed only in the WEM scenario, moreover only a very limited number of policies and measures are reported. Finally, policy effectiveness of each policy and measure is expected to stay constant between 2015 and 2020.
  The policy assumption addressing the non-ETS branch of industry consists of policies and measures aimed at reducing N_2O emissions released in nitric acid production, although no clear explanations on the applied policy instruments are provided. The expected emissions reduction is about 0.7 Mtoe CO_2 eq. both in 2015 and 2020.
  Agriculture includes two regulatory provisions, one addresses the rationalization in the use of fertilizers to reduce and control soil emissions from fields, the other focuses on biogas recovery from animal storage system. The contribution towards GHG emissions reduction is estimated to be around 0.8 Mtoe CO_2 eq. for the former and around 0.4 Mtoe CO_2 eq. for the latter between 2015 and 2020.
  Waste sector counts only one policy item as assumption which focuses on west management improvement towards separate collection enhancement and reduction of biodegradable waste flows into landfills. The provision, which is based on regulatory instruments, is expected to reduce GHG emissions of about 3.7 Mtoe CO_2 eq..

Table 10 - Policy assumptions included in the 2013 With Existing Measures scenario (continuing)

Policies and measures identification and description			**Policy effectiveness (ktCO$_2$ eq. per year)**	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Civil sector				
Building Regulation (Legislative decrees 192/05 and 311/06)	Minimum mandatory standards on new and existing buildings (Energy efficiency)	Regulatory	2.180	3.610
Budget law 2007 and budget law 2008	Supporting energy saving in existing buildings through tax deduction of 55%	Fiscal	610	610
Budget law 2009	Supporting of energy saving in existing buildings through tax deduction of 55%	Fiscal	440	440

Policies and measures identification and description			Policy effectiveness ($ktCO_2$ eq. per year)	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Civil sector				
White certificates - decree december 2007	Supporting energy saving 2008-2012 (Energy efficiency)	Economic	3.120	3.120
Legislative decree 201/07 (transposition of Dir. 2005/32/EC- first regulations)	First regulation on mandatory energy efficiency standards for energy-using products	Regulatory	870	2.600
National Strategic Framework 2007-2013 - ERDF (Dir. 2006/32/EC)	Supporting energy savings through POR and POIN	Economic	420	420
Transport				
Infrastructural measures (including Marco Polo program on freight transport)	Completion of High Capacity and High Speed networks and tuning of regional networks for commuting and goods. Completion of mass-rapid transport networks.	Planning	3.750	5.700
Legislative decree 128/05 (transposition of Dir. 2003/30/EC)	Mandatory use biofuels (target 4.5% to 2012)	Regulatory	1.490	1.490
Emission standard for new car (Regulation No 443/2009)	Fleet update at 120 g CO_2/km in 2015 and 95 g CO_2/km in 2020	Regulatory	5.400*	10.200*
Legislative decree 28/2011 (transposition of Dir. 2009/28/EC)	Supporting use of biofuels (target 10%)	Regulatory	590	1.580
National Strategic Framework 2007-2013 - FESR	Intermodal infrastructure projects: metropolitan railways	Planning	320*	1.280*
Industry				
Nitric acid (transposition of Dir. 96/61/EC and Dir. 2008/1/EC)	Reduction of N_2O emissions in nitric acid production plants	Other	740	740
Agriculture				
Nitrogen fertilizer (CAP Reform 2006/144/EC)	Rationalization in the use of nitrogen fertilizer	Regulatory	790	790
Animal storage (CAP Reform 2006/144/EC)	Recovery of biogas from animal storage system	Regulatory	400	400
Waste				
Separate collection (transposition Dir. 1999/31/EC)	Compliance with separate collection targets and reduction of biodegradable waste disposed into landfills	Regulatory	3.700	3.700

*Note: In the *2013 Climate Policy Progress Report* the values on the effectiveness of the item “Emission standard for new car (Regulation No 443/2009)” have been confused with the values addressing “National Strategic Framework 2007-2013 - FESR”. This mistake does not affect the last table template.

Table 11 – Policy assumptions included in the 2013 With Additional Measures scenario (continuing)

Policies and measures identification and description			Policy effectiveness ($ktCO_2$ eq. per year)	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Civil sector				
NAP-RES 2010, NEEAP 2011 and Legislative decree 28/2011 (Art. 28)*	Measures promoting thermal RES and related small-scale interventions	Economic	0	10.600
NEEAP 2011, Law 05/09/2011 (White certificates 2012-2016) and Kyoto fund	Measures promoting cogeneration and trigeneration in tertiary sector	Other	460	1.490
Legislative decree 28/2011	Measures promoting energy saving in civil sector	Economic	1.760	4.690
National Action Plan for Energy Efficiency 2011 (NEEAP 2011) -White certificates 2012 - 2016	Measures promoting energy saving	Other	800	1.230
NAP-RES 2010 and NEEAP 2011 - White certificates 2012 - 2016	Measures promoting energy saving	Other	0	2.530
New energy efficiency standards for buildings (Dir. 2010/31/EC)	Measures supporting energy savings in buildings, promoting RES and incentive mechanisms based on tax deduction	Fiscal	0	4.000
Budget law 2009	Measures supporting energy saving in buildings extending tax deduction of 55% from 2013 to 2020	Fiscal	340	1.150
Reformulation of energy taxation	Measures promoting the use of low carbon products and services also through measures of information	Economic	0	1.000
Transport				
Intermodal measures to be funded	Measures promoting infrastructure, intermodal and public mobility with electrical transport (NAP-RES 2010)	Planning	1.170	3.500
Measures to improve fleets update (Regulation (EC) N. 443/2009)	Measures to reduce the average emissions	Regulatory	0	1.800
Reformulation of energy taxation	Measures promoting use of low carbon products and services also through measures of information	Economic	0	500

Policies and measures identification and description			Policy effectiveness (ktCO2eq. per year)	
Policy or measure	**Description**	**Type of instrument**	**2015**	**2020**
Industry				
Legislative decree 28/2011	Measures promoting energy saving	Economic	610	1.640
Reformulation of energy taxation	Measures promoting the use of low carbon products and services also through measures of information	Information	0	1.500

*Note: The policy item is attributed to the supply sector (renewables) in the *Climate Policy Progress Report 2013* while in end-use industry sector by the last reporting tables. However, based on prescriptions included in the Legislative decree 28/2011 it is more likely belonging to civil sector.

- Civil sector:

  The policy assumptions included in the WEM scenario are focused on enhancing energy efficiency and this is done by using many policy instruments. Regulatory instruments are applied through the implementation of the Building regulation and the first regulations under the ecodesign Directive. Economic instruments are employed under the White Certificates scheme and the regional programs developed within the National Strategic Framework. Among the economic instruments, budget law 2007 and the two following ones make use of fiscal instruments. These measures are expected to lead to GHG emission reductions for about 7.6 Mtoe CO_2 eq. in 2015 and 10.8 Mtoe CO_2 eq. in 2020, where the highest contribution derives from the Building regulation and the use of White Certificates.

  Counting for the WAM scenario, most of the policy assumptions are policies and measures planned or envisaged by the National Action Plan for Renewable Energy 2010 and the National Energy Efficiency Action Plan 2011. The other measures are related to the implementation of the Building Directive, the extension of fiscal instruments provided up to 2020 by budget law 2009 and to energy taxation reformulation. These policy instruments related to the policy assumptions are various but not always well specified and it can be summed up that they generally belong to Vedun's (1998) category of economic instrument. The expected additional GHG reductions linked with the mentioned policy assumptions amount to 3.4 Mtoe CO_2 eq. in 2015 and to 26.7 Mtoe CO_2 eq. in 2020. The sharp growth in expected emission reductions between 2015 and 2020 is mainly due to the implementation of measures promoting thermal renewables and related to small-scale interventions, which are expected to lead to GHG emission reductions for 10.6 Mtoe CO_2 eq. in 2020. However, other policies and measures are expected to start showing their effectiveness after 2015 contributing to a relevant extent on the overall reductions in 2020.

- Transport:

  The WEM scenario includes regulatory measures aimed at supporting and boosting biofuels use (Legislative decree 128/05 and Dir. 2009/28/EC) and cars fleet update (Regulation No 443/2009) as well as planning measures on infrastructures' development and enhancement. The total effectiveness of the regulatory provisions is estimated about 7.5 Mtoe CO_2 eq. in 2015 and 13.3 Mtoe CO_2 eq. in 2020, while planning measures are expected to reduce GHG emissions of 4.1 Mtoe CO_2 eq. in 2015 and of 7 Mtoe CO_2 eq. in 2020. The resulting overall GHG emissions reduction is 1.2 Mtoe CO_2 eq. in 2015 and 20.3 Mtoe CO_2 eq. in 2020.

  The scope of the additional measures included in the WAM scenario is to further reduce cars emissions by applying economic instruments and to promote the use of low carbon products and services through reformulating energy taxation (economic instrument). Furthermore, other policies and measures, which are envisaged in the National Action Plan for Renewable Energy 2010, are focused on supporting electrical transport development and widespread by applying planning instruments. The overall sectorial emissions reduction is expected to be 1.2 Mtoe CO_2 eq. in 2015 (only due to planning measures on electric transport) and 5.8 Mtoe CO_2 eq. in 2020 (thanks to the measures on electric transport which still contribute to the largest extent).
- Industry, Agriculture and Waste:

  The policy assumptions included in the 2013 WEM scenario are the same as the ones included in the 2011 version. The only exception concerns industry, in fact some planned provisions focused on the non-ETS branch of industry are included in the WAM scenario. The objective of these policies and measures is to promote energy savings (Legislative decree 28/2011) and the use of low carbon products and services (reformulation of energy taxation). The former is based on economic instruments allowing to reduce GHG emissions of around 0.6 and 1.6 Mtoe CO_2 eq. in 2015 and 2020 respectively. The latter is expected to bring about a reduction in GHG emissions of about 1.5 Mtoe CO_2 eq. for 2020 also through information campaigns.

Besides the comparison between the national-based scenarios delivered in the same year, the comparative analysis has addressed the same type of scenarios (With Existing Measures scenarios on one hand and With Additional Measures scenarios on the other) delivered in different years. The following part provides firstly the results of the analysis addressing the With Existing Measures category of scenarios, while the results for the With Additional Measures category of scenarios is reported afterwards.

The With Existing Measures scenarios delivered in 2013 are highly consistent with the previous version except for some additional provisions addressing the civil sector included in the latter (see Tables 8 and 10). The further measures included in the 2011 WEM scenario concern renewable energy in the built environment as set by the Building Regulation and as addressed by the White Certificates scheme on the one hand and energy efficiency measures based on the first National Energy Efficiency Action Plan (NEEAP) on the other. The difference in expected GHG emission reductions in the civil sector is equal to 3.2 and 3.6 Mtoe CO_2 eq. in 2015 and 2020, respectively. The higher values in the 2011 WEM scenario are due to the additional measures here included, although the policy effectiveness of the energy efficiency measures linked with the Building Regulation are expected to be higher in the 2013 WEM scenario, allowing the reduction of the gap between the two scenarios. Considering the transport sector, the policy assumptions are the same and also the policy effectiveness is roughly the same (although slightly higher emission reductions are expected in the last version).

The comparative analysis addressing the With Additional Measures scenarios delivered in 2011 and 2013 (see Tables 9 and 11) highlights the highly remarkable differences in relation to both the policy items and the assessed policy effectiveness. The diversity is particularly evident for the civil sector, where the 2011 WAM scenario is mostly based on policies and measures related to the National Action Plan for Renewable Energy 2010, while the policy assumptions of the 2013 WAM scenario mirror the sectorial policy evolution in the last years, characterized by the implementation of relevant provisions. More specifically, many policies and measures are related to the National Energy Efficiency Action Plan 2011 and the Legislative Decree 28/2011, which have been clearly not included in the previous reporting documentation. Furthermore, the type of approach differs between the scenarios in relation to the policy instruments taken under consideration. The 2011 WAM scenario relies almost completely on regulatory instruments, while the 2013 WAM scenario is mostly based on economic and financial instruments. Finally, the expected reductions in GHG emissions result lower in the latest version, where the 2015 value is less than half of the 2011 WAM scenario's and the 2020 value is around 3 Mtoe CO_2 eq. lower.

Counting for the transport sector, the policy assumptions are partially consistent, although the assessed emissions reductions for 2020 strongly differ between the two scenarios, being equal to 16.3 Mtoe CO_2 eq. in the 2011 version and to 5.8 Mtoe CO_2 eq. in the second one. This remarkable difference is mainly due to the expected effectiveness of further policies and measures promoting car fleet updates and light duty vehicles that amounts to around 9.9 Mtoe CO_2 eq. in the 2011 WAM scenario and 1.8 Mtoe CO_2 eq. in the following version. The far higher value in the 2011 WAM scenario is due to the fact that more measures, which support electric cars spread and fossil fuels savings, are included.

Finally, only the latest With Additional Measures scenario includes additional measures addressing industry. These provisions are expected to lead to a further reduction in GHG emissions of more than 3 Mtoe CO_2 eq..

Policy assumptions: the three main lines of actions

The scenarios' policy assumptions aim to provide a representative picture of the policy context characterizing the domestic energy system development. The policies and measures addressing climate and energy–related issues focus on a wide range of actions belonging to a vast array of fields. However, the review and analysis of the scenarios' policy assumptions has outlined the core objectives of the legislative effort addressing the Effort Sharing Decision scope. The policy effort in the non-ETS branch can be mainly attributed to three wide objectives: development of renewable sources, energy efficiency improvements and enhancements in the transport sector.

The development of renewable sources

The spread of renewable sources in non-ETS sectors mainly concerns the increasing use of renewables in the built environment and of biofuels and other renewable fuels in transport sector.

Counting for the former, all scenarios include Directive 2002/91/EC on the energy performance and their transposition in the national legal framework through Legislative decree 192/05 and the amending Legislative decree 311/06. Besides, PRIMES scenarios include financial instruments delivered by the European Union (e.g. through the Cohesion fund which has been effective between 2007 and 2013) and only the most relevant provisions issued by Italy in this field. The Reference scenario of PRIMES adds Directive 2010/31/EU recasting the previous Building Directive. The national-based scenarios include Directive 2002/91/EC as well as the transpositional provisions and the recasting Directive. In addition, the 2011 national-based scenarios include supporting instruments in the form of White certificates, provided by the Ministerial Decree of December 2007 and by the National Energy Efficiency Action Plan 2007. Moreover, the WAM scenarios add further foreseen measures and incentives in relation to Directive 2009/28/EC and the National Renewable Energy Action Plan 2010. On the other hand, the 2013 national-based scenarios include less provisions on renewables in the built environment, although the WAM scenario expects new measures aimed at promoting their further development.

Concerning the increasing use of biofuels and other renewable fuels in transport sector, the driving provisions are Directive 2003/30/EC and Directive 2009/28/EC. The former sets the target of 5.75% share of renewable energy in the transport sector in the European Community by 2010, the latter requires Member States to reach a minimum 10% share of energy from renewables in 2020. Furthermore, Directive 2009/30/EC introduces sustainability standards for fuel to reduce carbon intensity and support renewable fuels and biofuels use in transport sector. The above mentioned directives are included in all scenarios with some exception. In fact, *PRIMES 2007* and the 2009 Baseline scenario of PRIMES assume only Directive 2003/30/EC.

Energy efficiency improvements

All end-use sectors can achieve remarkable energy efficiency improvements addressing their energy saving potentials. Enhancing energy efficiency is a key objective for the European Union which has established a legislative framework to support energy saving gains based on Directive 2006/32/EC and, then, on Directive 2012/27/EU. At the national level, this framework encompasses a large number of policies and measures mainly developed within the National Energy Efficiency Action Plan (NEEAP) 2007 and the 2011 updated version, but others have been adopted independently from the National Plan. *PRIMES 2007*, albeit considering the development and spread of more efficient technologies among the technology assumptions, does include neither the first Energy Efficiency Directive, which is indeed included in *PRIMES 2009*. The 2011 national-based scenarios include measures implemented within the NEEAP 2007, while the 2011 national-based scenarios assume only planned policies (hence included in the With Additional Measures scenario) developed within the NEEAP 2011. In addition to the measures proposed by the National Energy Efficiency Action Plan in its first and updated version, some other economic policy instruments aiming to support energy efficiency improvements are considered in the national-based scenarios. These policies and measures include Budget law 2007, 2008 and 2009, the Ministerial decree of December 2007 on the White Certificate mechanism and the National Strategic Framework. Moreover, the 2011 WAM scenario includes further incentives related to the White Certificate which are planned according to the National Renewable Energy Action Plan 2010, while the WAM 2013 adds further measures that will be supported by extending the Budget law 2009 from 2013 to 2020.

Some more specific policies and measures addressing energy efficiency in the civil sector are included in the scenarios. Energy efficiency improvements in the built environment can be obtained by enhancing buildings' envelope, heating and cooling systems, lighting and electric appliances as well as energy-related products. Energy performance of new and existing buildings is mainly regulated through minimum mandatory standards set by Directive 2002/91/EC and its upgraded version, namely Directive 2010/31/EU. As already highlighted, considering the development of renewables in the built environment, all scenarios include the former, while the latter is considered only by the PRIMES Reference scenario and by the national-based scenarios. Moreover, both the WAM scenarios add planned measures to enhance the existing standards. Concerning energy-using and energy-related products, besides the Labelling Directive 2003/66/EC and the Energy Star Program addressing respectively household and office appliances, the Ecodesign Directive (Dir. 2005/32/EC) is the main provision triggering the adoption of technological advanced energy-using and energy-related products. Directive 2005/32/EC, which establishes a framework for setting ecodesign requirements, is included in all scenarios, although *PRIMES 2007* does not include the related provisions. However, *PRIMES 2007 includes* Directive 2003/66/EC and the Energy Star Program (Council Decision 2006/1005/EC). Moreover, *PRIMES 2009* and the national-based scenarios take into account a number of EU regulations belonging to the Ecodesign framework. For instance, the 2009 Baseline scenario takes under consideration the ecodesign regulations on household and office lighting, external power supplies, set-to boxes and on appliance stand-by mode. The Reference scenario adds the regulations addressing televisions, circulators and freezers/refrigerators, whereas the national-based scenarios include the first regulations, still, further regulations are only taken into consideration in the 2011 WAM scenario. However, further measures aimed at supporting energy efficiency in this field are included in both the 2011 and 2013 With Additional Measures scenarios.

Enhancements in the transport sector

Enhancements in the transport sector are mainly related to components and fleet technical improvements in road transport and infrastructure development.

Among the regulations addressing components technical improvements, Regulation 2009/1222/EC on tyres labelling has a strong relevance. This provision is considered in the Reference scenario of PRIMES as well as in the national-based scenarios. But the latter also encompasses the fleet update measures. The fleet technical improvements, which consist in passenger cars as well as light and heavy duty vehicles update, are based on a set of regulations defining emission performance standards for new vehicles. Besides EURO 5 and 6 Regulation (2007/715/EC) on new passenger cars and light commercial vehicles (included in *PRIMES 2009*), the main provision addressing passenger cars is the Regulation 2009/443/EC. This legislation sets mandatory emissions reduction targets for new cars, i.e. fleet average emissions of 130 g CO_2/km by 2015 and of 95 g CO_2/km by 2020. Both *PRIMES 2009* and the national-based scenarios include the mentioned regulation although, as already said, the latter assembles this provision with others addressing components enhancement. In addition, both the national-based WAM scenarios include further measures to upgrade emissions reduction standards for cars. Finally, Regulation 2009/595/EC, which sets minimum technical requirements for heavy commercial vehicles, is mentioned only by *PRIMES 2009*. Overall, looking through the above mentioned provisions, it can be highlighted that they were all adopted after 2006 and for this reason none of them are included in *PRIMES 2007*.

Concerning the policies and measures addressing infrastructure enhancement, the principal objectives concern the completion of high capacity, high speed and mass-rapid networks, the adaptation of regional networks to commuting and freight transport needs and the development of intermodal infrastructures. Some of the provisions addressing these fields of action are part of EU and national projects and programs such as the Marco Polo Program on freight transport (developed at EU level) and some intermodal projects that are part of the National Strategic Framework 2007-2013. The national-based scenarios include many policies and measures addressing infrastructure development and enhancement. Furthermore, some planned provisions are included in the With Additional Measures scenarios supporting the development of public electric transport by building up the required infrastructure. On the other hand, PRIMES scenarios do not give particular attention to this side of transport sector, although *PRIMES 2009* includes some assumptions addressing the development of electric transport, which are excluded in *PRIMES 2007* though.

3.2 Preliminary Analysis

The preliminary analysis has allowed to obtain the required data to carry out the following result analysis and gap analysis. The bulk of data on non-ETS GHG emissions applied to the following analyses is reported in Annex III. The mentioned sets of data have been applied to develop the graphs reported hereafter that represent the core of the results and gap analyses. The graphs depict the scenarios' trends year by year. Every graph includes the historical data and the emission trajectory towards the achievement of the non-ETS reduction target for 2020. The former is depicted as a green line in the following graphs and the dotted segment in the last part of the line is due to the fact that the 2012 data is provisional. The latter is drawn by a grey line, which distinguishes the computed part (dotted segment between 2005 and 2013) from the part defined by the annual emission allocations (solid segment from 2013 to 2020).

Figure 7 shows the non-ETS GHG emission trends as projected by the 2007 Baseline scenario (yellow line), the 2009 Baseline scenario (blue line) and the Reference scenario (orange line) developed by the PRIMES modelling system. The set of data applied to develop Figure 7 are reported in Annex III.

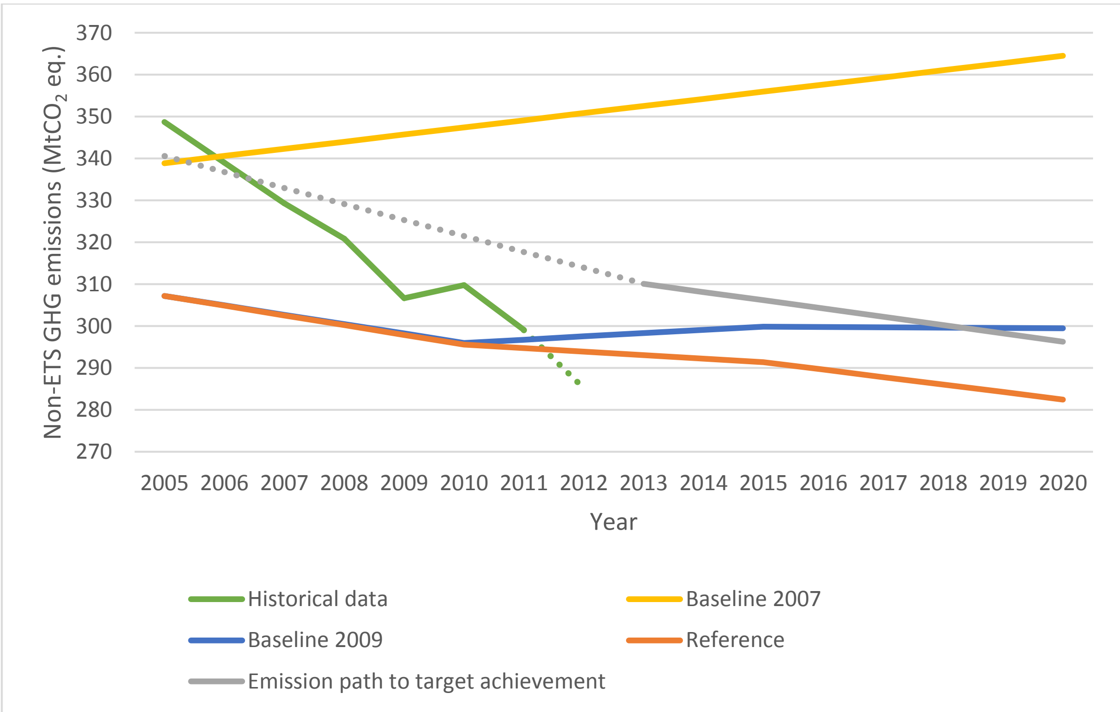


Figure 7 – Italian non-ETS GHG emission trends projected by PRIMES scenarios

Figure 8 and Figure 9 depict the GHG emission trends as reported and projected by the national-based scenarios submitted to the European Commission in 2011 and 2013, respectively. The sets of data applied to develop Figure 8 and 9 are derived from the *Italian Climate Policy Progress Report* delivered in 2011 and 2013, respectively. The reference data is reported in Annex III of this work.

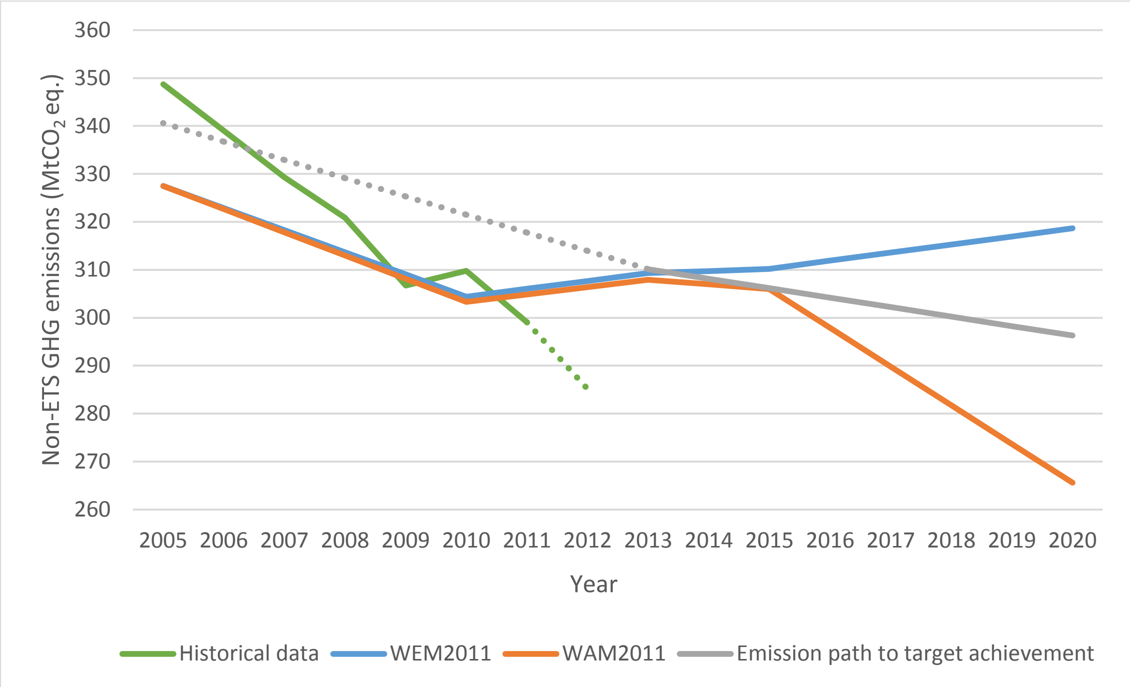


Figure 8 – Italian non-ETS GHG emission trends projected by *National 2011*

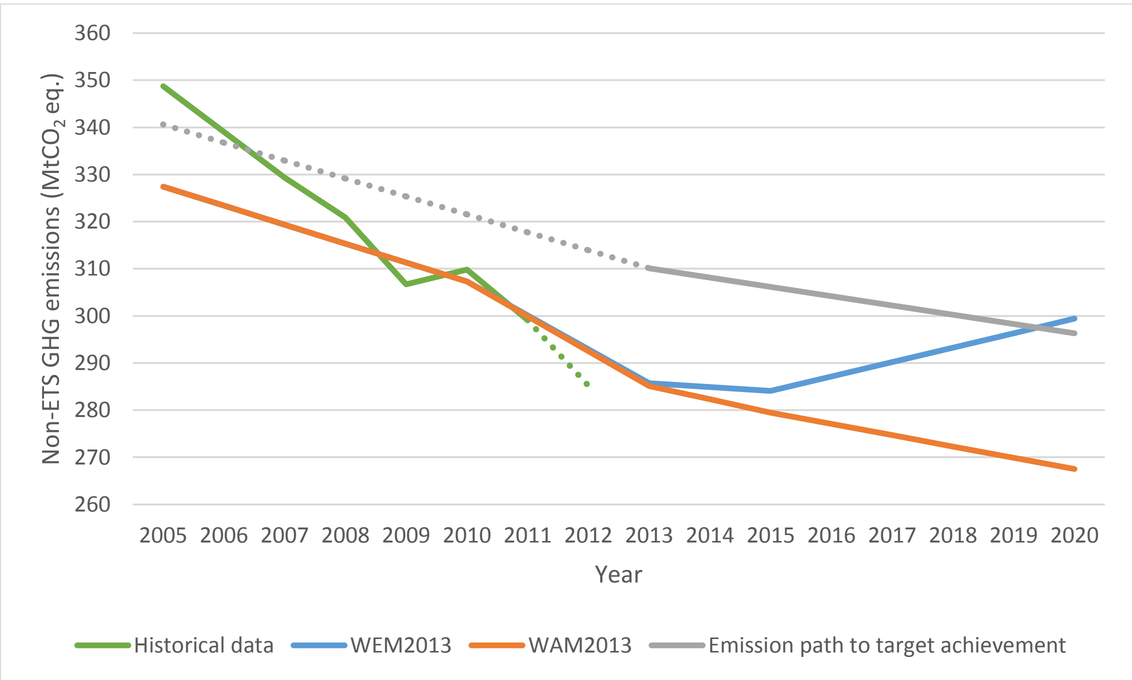


Figure 9 – Italian non-ETS GHG emission trends projected by *National 2013*

The preliminary analysis has revealed incongruities between the data reported in the Climate Policy Progress reports and the related tables submitted to the European Commission by 15 March of the same year and subsequently revised. The latest tables submitted in 2011 represent the third revision, while one revision was delivered under the 2013 reporting activity at the time the research was carried out. The difference affects the data sources in various extent. However, the data reported in the Climate Policy Progress Reports appears more reliable since it does not show the peculiar trend characterizing the emission levels reported in the most updated reporting tables. In fact, according to the most updated reporting tables, the With Additional Measures (WAM) scenarios show higher emission levels than the With Existing Measures (WEM) ones for part of the projected period. These outcomes are absolutely unexpected because, as a rule, the With Additional Measures scenario adds the planned measures to the existing ones (included in the WEM scenario). This figure is particularly evident in the 2011 case, where the WAM values exceed the WEM ones between 2010 and 2015. The difference peaks in 2015 with the WAM exceeding the WEM data by around 7.5 $MtCO_2$ eq.. Considering the 2013 case, the projections under the With Additional Measures scenario exceed the WEM values too, but to a limited extent. The exceeding values concern the period between 2012 and 2015 and the maximum difference, which characterized the year 2015, reaches around 1.5 $MtCO_2$ eq.. Annex IV provides more detailed information on this issue supporting what stated above through data tables and graphs.

3.3 Results Analysis

3.3.1 Analysis of Year 2005

The non-ETS GHG emission data for 2005 is crucial in the scope of the Effort Sharing Decision because it is the baseline year in the definition and assessment of the national effort according to the national reduction target for 2020.

The most accurate data currently existing on the Italian non-ETS GHG emissions for the year 2005 amounts to 340.6 $MtCO_2$ eq.. This value derives from the technical review of the data reported by the Italian National Inventory Report 2012. Table 12 reports the 2005 data from the National Inventory Report 2012 as well as from the scenarios. It is worth noting that none of the scenarios' data derives from projecting activity. Moreover, the table provides the results of the comparison of the data with the most accurate one.

Table 12 – Italian non-ETS GHG emissions for the year 2005 ($MtCO_2$ eq.)

	Historical data	**PRIMES 2007**	**PRIMES 2009**	**National 2011**	**National 2013**
2005 Non-ETS GHG Emissions	348.7	338.9	307.2	327.5	327.4
Distance from the most accurate value	8.1	-1.7	-33.4	-13.1	-13.2

The data addressing the year 2005 derives from the most updated verified data available at the time the scenarios were run. The 2005 data represents the projections' baseline year in the EU-wide scenarios (PRIMES). *PRIMES 2007* and *PRIMES 2009* strongly differ in their starting values (Figure 7). Despite ex-post revisions generally lead to more accurate and reliable data, the 2005 emission level included in *PRIMES 2007* is closer to the most accurate data (Table 12). On the other hand, the National Inventory Report 2009 and 2011, which are the data source of *National 2011* and *National 2013* respectively, agree in the 2005 data. Nevertheless, the same consistency is not featured neither with the most accurate data nor with the not reviewed data from the National Inventory Report 2012.

3.3.2 Analysis of Past Trends

The analysis of past trends has addressed the scenarios' trends from 2005 to 2012. The scenarios have been compared each other and with the historical data, which was applied as benchmark in order to provide insight on the accuracy of the data and the reliability of the scenarios. The EU-wide scenarios and the national-based scenarios have been analyzed separately.

EU-wide scenarios

As can be observed from Figure 7, starting from the highly different values for 2005, *PRIMES 2007* and *PRIMES 2009* show divergent trajectories up to 2010, with the former increasing and the latter decreasing. On the other hand, the 2009 Baseline scenario and the Reference scenario are consistent in their trajectories until 2010, but they start developing divergent paths afterwards. The Reference scenario maintains a decreasing trend, characterized by a slower pace than before though, while the 2009 Baseline scenario shows a slightly increasing trend. However, the difference in total non-ETS GHG emissions in 2012 between the two scenarios is less than 4 $MtCO_2$ eq., therefore still little. Anyway, both the 2007 and 2009 PRIMES scenarios are far to represent the verified emission trend. On the one hand, the 2007 Baseline scenario, despite being characterized by a rather consistent value for 2005, is based on assumptions that are not valid anymore and that distance the forecasted trajectory to the verified trend up to 2012. Consequently, the 2007 Baseline scenario cannot be considered representative of the current trend and, therefore, it can neither provide trustable information on how the emission trend may change up to 2020. On the other hand, the 2009 Baseline and the Reference scenarios benefit of more updated and accurate data on non-ETS emissions for the period after 2005-2007 (i.e. after the first phase of the emission trading scheme) as well as of more correct and updated assumptions. Consequently, despite the initial remarkably higher gap compared to the most update value, the distance becomes narrower after 2008, when the verified emissions drop mainly as consequence of the economic downturn. Despite a slight growth between 2009 and 2010, the decreasing trend characterizing the historical data allow the scenarios projections to get close to the last verified data (i.e. 2011). Anyhow, if the provisional data reported for the year 2012 would be confirmed by the forthcoming final data, the resulting trajectory would distance it from the 2009 PRIMES projections again.

National-based scenarios

As shown in Figure 8 and Figure 9, the emission levels in the national-based scenarios are consistent between 2005 and 2010, featuring decreasing trends and only slightly different values. Then, the two sets of scenarios (i.e. *National 2011* and *National 2013*) show diverging paths after 2010, since the trajectory of *National 2011* starts to rise while *National 2013* keeps on decreasing at a higher pace than before. The comparative analysis between the scenarios' trends and the historical data shows that the trajectories disagree especially up to 2008. However, the faster decreasing rate characterizing the historical data after 2008 allows to narrow the gap. Nevertheless, *National 2011* shows opposite trends compared to the historical trajectory as soon as the data results from the projecting activity, i.e. after 2009. On the other hand, *National 2013* features consistency with the verified data addressing the years 2010 and 2011 (i.e. the projections' baseline year). Furthermore, *National 2013* keeps on developing on the same direction as foreseen by the provisional data addressing the year 2012.

3.3.3 Future Trends Analysis

The analysis of future trends has addressed the scenarios' projections from 2013 to 2020. The scenario review provide deep understanding on the scenarios' projections. The EU-wide scenarios and the national-based scenarios have been analyzed by applying different approaches and the results are discussed separately in this section.

EU-wide scenarios

The 2007 Baseline scenario forecasts an emission value for 2020 that is extremely higher than the 2009 Baseline (65 $MtCO_2$ eq. higher) and than the Reference scenario (82 $MtCO_2$ eq. higher). The trajectory followed by the 2007 Baseline scenario (see Figure 7) provides evidence itself of the unreliability of this scenario, which does not include the effect of the recent economic downturn and any policies and measures implemented from 2007. On the other hand, the 2009 Baseline and the Reference scenarios simulate possible future trends that are more likely to be consistent with the actual one. However, the two scenarios of PRIMES 2009 project a different evolution of non-ETS emissions in the next period due to the effect of policies and measures included as assumptions in the Reference but not in the Baseline. The divergence in the trends starts in 2010 but it becomes more remarkable from 2015, with the Baseline scenario forecasting rather stable emissions while the Reference scenario projecting a faster pace in reducing GHG emissions compared to the previous period (see Figure 7). This difference reaches 17 $MtCO_2$ eq. in 2020 and it represents the emission reduction contribution of relevant policies and measures implemented between April and December 2009 (including the legal provisions under the Climate and Energy Package). Moreover, the comparison between the emission path towards the 2020 target achievement (as defined by the annual emission allocations) and the scenarios' trends leads to different outcomes depending on the scenario. The 2007 Baseline scenario is characterized by a remarkable divergent and higher trend compared to the reduction path. The 2009 Baseline scenario, instead, would overtake the annual emission allocation trajectory after 2018, due to the increasing trend after 2010. Thus, the exceeding values would characterize only the year 2019 and 2020. On the other hand, the Reference scenario maintains lower values compared to the emission path defined by the annual emission allocations over the entire period, although the trajectory becomes in some extent closer after the lower decreasing pace characterizing the projections between 2010 and 2015.

<u>National-based scenarios</u>

The 2011 WEM and WAM scenarios (Figure 8) report non-ETS GHG emission levels of 327.4 $MtCO_2$ eq. in 2005 and they show a very slight divergence until 2013, which is so limited that may be considered negligible. After 2013, the two emission paths begin to diverge, first at a low rate (up to 2015) and then at a faster pace (from 2016 to 2020). More in detail, the With Existing Measures scenario forecasts that GHG emissions from non-ETS sectors increase of around 6 $MtCO_2$ eq. between 2010 and 2015, while the With Additional Measures scenario expects emissions to grow almost of 3 $MtCO_2$ eq. in the same period. As a result, the difference between the projected emissions in 2015 amounts to some 4 $MtCO_2$ eq.. The divergence between the scenario trajectories becomes more remarkable after the year 2015, almost reaching 14 $MtCO_2$ eq. in the following year and overtaking 50 $MtCO_2$ eq. in 2020.

The 2013 WEM and WAM scenarios (Figure 9) show the same values for the period between 2005 and 2010 and they maintain very close emission levels up to 2013 (when the difference is still negligible). Then, the two scenarios develop diverging trends up to 2020 but the difference in magnitude is limited up to 2015 (equal to 4.6 $MtCO_2$ eq.) because both the scenarios are characterized by decreasing paths, although the reduction pace in WAM projections is faster than in WEM ones. However, the divergence becomes more remarkable afterwards. In fact, the gap between the projected trends amounts to around 10 $MtCO_2$ eq. in 2015 and it grows afterwards, consequently the difference between the data reaches almost 32 $MtCO_2$ eq. in 2020.

The comparative analysis between the two sets of national-based scenarios in their future trends up to 2020 shows that the trajectories belonging to the same scenario category (i.e. WEM or WAM) feature roughly the same development. Starting from 2013, the WEM and WAM scenarios included both in the 2011 version and in the following one are characterized by diverging trends. The difference between the WEM and WAM scenarios is limited between 2013 and 2015, when only the 2011 WEM scenario is characterized by a growing trend. Afterwards, starting from 2015 the difference becomes more remarkable both in *National 2011* and in *National 2013* since both the WEM scenarios show growing trends as well as both the WAM scenarios are characterized by decreasing trajectories. However, the difference forecasted for the year 2020 is around 20 $MtCO_2$ eq. higher in *National 2011* than in *National 2013* mainly because of the drop in emissions forecasted by the 2011 WAM scenario for the period 2015-2020. Consequently, the 2020 emission levels in the WAM scenarios are extremely close, in fact the 2011 WAM data is around 2 $MtCO_2$ eq. lower than the 2013 WAM one. On the other hand, the WEM scenarios maintain divergent values with the 2011 WEM data being about

19 $MtCO_2$ eq. higher than the value projected in the 2013 version. This is possible although the 2013 WEM scenario features a faster growing pace than the 2011 WEM scenario, because the 2015 data, which represents the starting point of the faster growing pace in the 2013 WEM scenario, is about 26 $MtCO_2$ eq. lower in the 2013 version compared to the previous one.

3.4 Gap Analysis

The objective of the analysis is to assess whether the expected progress in reducing non-ETS GHG emissions in Italy according to scenario projections agrees with the requirement set by the Effort Sharing Decision. The analysis has been carried out following two distinct methods: a relative approach has been applied to the EU-wide scenarios; an absolute approach has been applied to the national-based scenarios. The former allows to gain useful understanding on the load of the economic downturn and of relevant policies and measures in the experienced and expected reductions of GHG emissions from the sectors outside the Emission Trading System. The latter assesses whether Italy is expected to meet the reduction targets set by law through the annual emission allocations for the period from 2013 to 2020.

<u>Scenario-specific assessment (relative approach)</u>

The gap analysis addresses only the 2020 data projected by the EU-wide scenarios. The data of each scenario is compared to the reduction target for 2020 computed by applying the national reduction factor set by the Effort Sharing Decision (0.87 for Italy) to the scenario's 2005 data. Thus, the linear path between the 2005 data and the computed reduction target for 2020 represents the reduction path that should be followed assuming the scenario's 2005 data being the reference level for the national effort set by Decision No 406/2009/EC.

The scenario-specific reduction target for 2020 and the related reduction path are depicted in the figure below as dotted lines. Moreover, Figure 10 includes the reduction path towards meeting the reduction target as currently set by law (for the period 2013-2020) in order to highlight to which extent the reduction trajectories based on the scenarios' data differ from the final reduction trajectory set by law.

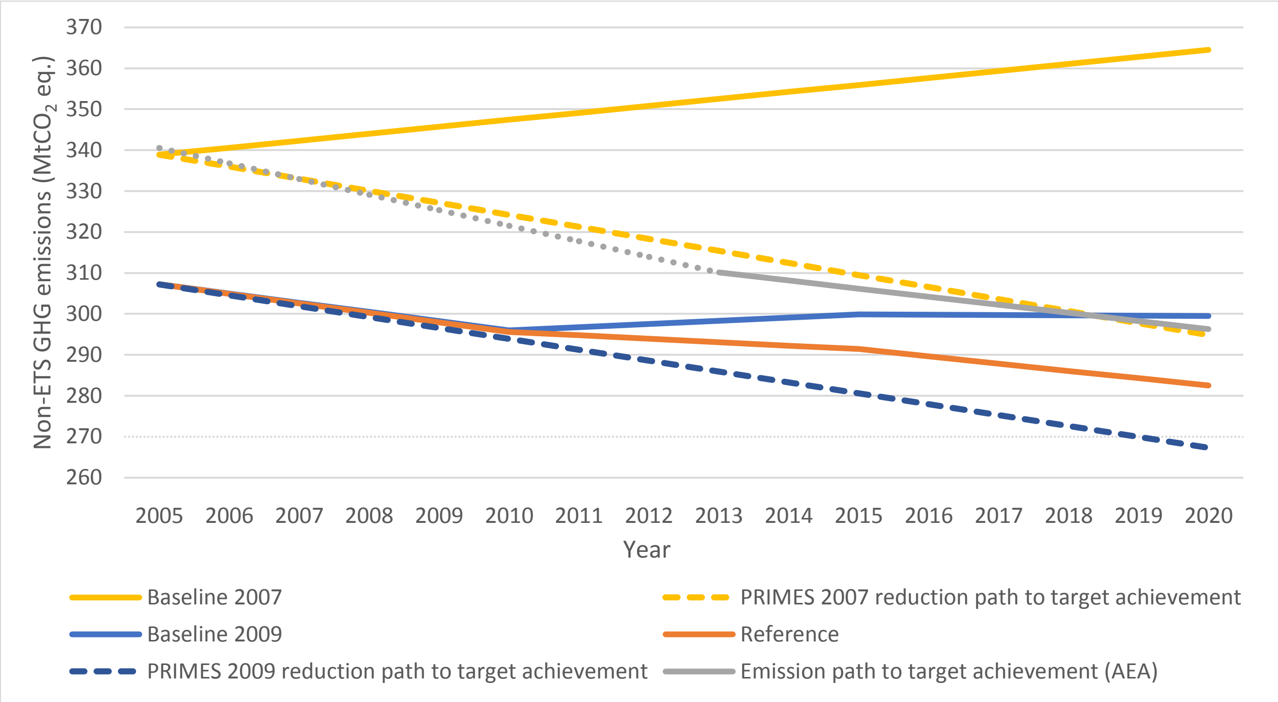


Figure 10 – Italian non-ETS GHG emissions from PRIMES and scenario-specific reduction path ($MtCO_2$ eq.)

As can be observed from Figure 10, the 2005 data is the same in the 2009 Baseline scenario and in the Reference scenario, consequently also the reduction target for 2020 and the reduction path between 2005 and 2020 is the same. Moreover, the 2005 emission level included in the 2009 PRIMES scenarios is lower than the one applied to the 2007 Baseline scenario and this is consequently reflected on the reduction target for 2020, which is lower in the updated PRIMES scenarios (see Table 13).

As can be seen from Figure 10, the reduction path set for the 2007 Baseline scenario is highly consistent with the binding reduction trajectory set through the annual emission allocations. On the other hand, the reduction path referring to the 2009 PRIMES scenarios is far lower than the currently binding trajectory (around 24 $MtCO_2$ eq. lower than the annual emission allocation set for 2013 and 29 $MtCO_2$ eq. lower than the one set for 2020).

Besides this comparison, the main aim of this analysis is to highlight whether Italy is expected to face an emission gap (and consequently a policy gap) in 2020 according to the scenarios' projections for 2020 and the related targets. Figure 10 displays that all the scenarios expect Italy to face a gap in meeting the 13% reduction target compared to their 2005 emission levels. The distance from the 2020 reduction target is remarkable for every scenario, but it is dramatically high especially for the two baseline scenarios. Table 13 reports for each scenario the difference between the projected GHG emission levels in 2020 and the scenario-specific 2020 reduction target. This difference represents the expected emission gap.

Tab. 13 – PRIMES' emission levels, reduction targets and expected gap for the year 2020 ($MtCO_2$ eq.)

	Baseline 2007	Baseline 2009	Reference
Emission level	364.5	299.5	282.5
Reduction target	294.8	267.3	267.3
Expected gap	69.7	32.2	15.2

The table above shows the magnitude of the expected gap for the year 2020. The Reference scenario shows a relevant emission gap, amounting to 15.2 $MtCO_2$ eq., although the expected gap in the 2009 Baseline scenario is around twice and in the 2007 Baseline is even more than four times higher than the Reference one. The diversity in the expected gap between the 2007 and 2009 Baseline scenarios mirrors the application of different assumptions and baseline data (i.e. 2005 data) to run the scenarios. On the other hand, the Reference scenario and the 2009 Baseline scenario have been run starting from the same assumptions except for some additional policies and measures (including the provisions within the Climate and Energy Package), which have been applied only to the Reference scenario. Thus, these additional provisions are expected to contribute in reducing non-ETS GHG emissions in Italy for 17 $MtCO_2$ eq..

<u>Gap assessment (absolute approach)</u>

Objective of this analysis is to assess whether Italy is expected to meet the non-ETS target set by the Effort Sharing Decision and the related provisions. The assessment lies in comparing the projected emissions with the annual emission allocations, which are the maximum allowed emissions for the period 2013-2020 set for Italy by the European Commission. Thus, the emission gap (and consequently the policy gap) assessment covers the period from 2013 to 2020.

Figure 8 and Figure 9 provide visual evidence of the expected emission (and policy) gap. Counting for the With Existing Measures scenario delivered in 2011 (WEM 2011), the GHG emissions are expected to fall behind the emission reduction trajectory after 2013 without recovering by 2020. Thus, based on the expected effect of the policies and measures adopted and implemented by the end of 2010, Italy is expected to meet only the first annual binding limitation during the whole period from 2013 to 2020. The gap is remarkable especially after 2015 (when the gap is still limited and equal to 4 $MtCO_2$ eq.), in fact the increasing trend projected under the WEM scenario results in an emission gap reaching 22.4 $MtCO_2$ eq. in 2020. The picture changes completely considering the forecasted GHG emissions under the 2011 WAM scenario since the non-

ETS GHG emissions are expected to never exceed the annual emission allocations during the entire period from 2013 to 2020.

The reduction path towards the achievement of the Effort Sharing Decision target is generally far higher than both the national-based scenarios delivered in 2013 (see Figure 9). The annual emission allocation set for 2013 is 25 MtCO_2 eq. higher than the projected data. On the other hand, the WEM scenario projects a growing trend after 2015, which is expected to fall behind only the last annual emission allocation. This figure is extremely different compared to the expectations under the WEM scenario delivered in 2011. The total emission gap, which affects only the binding limit set for 2020, is equal to 3.1 MtCO_2 eq.. Consequently, Italy is expected to face a narrow policy gap based on the policy assumptions of the 2013 WEM scenario. The results of the gap analysis are provided in the next section (Table 15).

3.4.1 Gap Analysis Revision

The gap analysis has provided evidence on the expected effort and progress of Italy in dealing with the reduction target set by the Effort Sharing Decision and the related provisions. However, the results are affected by the uncertainty and variability characterizing the scenarios' data and assumptions. Consequently, this analysis supplies more accurate results by correcting the data and adjusting the emission trends. In doing so, the analysis completes and improves the outcomes of the previous gap analysis. Moreover, it points out the effect of the main assumptions (i.e. economic and policy assumptions) in determining the future expected evolution of GHG emissions in the sectors outside the Emission Trading System.

EU-wide scenarios

The correction performed on the EU-wide scenarios uniforms the projections' baseline year (i.e. 2005) among the scenarios, by applying the PRIMES 2009 data to the previous PRIMES version (i.e. 2007 Baseline scenario). The growing trend of the 2007 Baseline scenario is maintained, albeit adjusted to the new 2005 data. In addition, the correction uniforms the reduction path to target achievement set on the basis of the 2005 data and used to assess the scenario-specific emission gap. Figure 11 depicts the new trend of the 2007 Baseline scenario after the correction and combines it with the PRIMES 2009 trends, the scenarios' reduction path to target achievement and the emission path set by law for Italy.

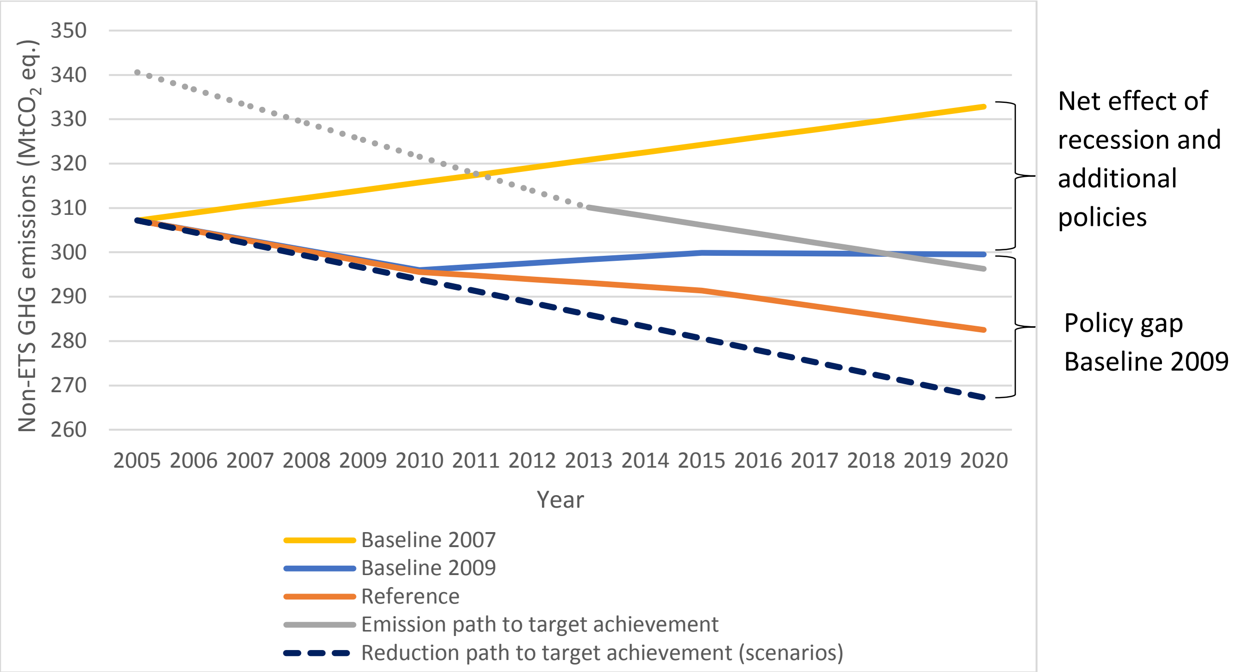


Figure 11 – Italian non-ETS GHG emissions from PRIMES and scenario-specific reduction path - corrected ($MtCO_2$ eq.)

The results of this analysis correct and complete the outcomes of the gap analysis carried out on the EU-wide scenarios that have been presented in the previous section (section 3.4). The correction has lowered the 2020 data of the 2007 Baseline scenario from 364.5 $MtCO_2$ eq. to 332.8 $MtCO_2$ eq., consequently reducing the distance from the other scenarios as well as from the reduction target for 2020. Nevertheless, the corrected trend still distances the other trajectories to a remarkable extent due to its steady growing pace (see Figure 11). In fact, the corrected trend still exceeds every annual emission allocation (grey solid line) and maintains far higher levels than the updated PRIMES version. Moreover, the new emission gap is only 4.2 $MtCO_2$ eq. lower than before the data correction. Table 14 reports the emission gap featured for 2020 by the corrected data of the 2007 Baseline scenario in relation to the other PRIMES scenarios (included the not corrected version) as well as in relation to the reduction target set in relative terms (scenario-specific) and in absolute terms (i.e. the annual emission allocation for 2020).

Table 14 – Distance from the corrected 2020 data of the 2007 Baseline scenario ($MtCO_2$ eq.)

	Baseline 2007	**Baseline 2009**	**Reference**	**Reduction target**	**AEA[1]**
Distance from the corrected data	31.7	-33.3	-50.3	-65.5	-36.5

[1] AEA: Annual Emission Allocation

The results provided by the table above highlight the expected effect of the updated assumptions solely in boosting non-ETS GHG emission reductions in Italy for 2020. Thus, having assumed that the economic and policy-related forces drive the difference, the combined effect of the economic downturn and of relevant policies and measures implemented between January 2007 and April 2009 are expected to lower non-ETS GHG emissions in Italy of around 33 $MtCO_2$ eq. in 2020. The reduction is more remarkable when considering the effect of the additional policies and measures included in the Reference scenario.

National-based scenarios

The correction performed on the set of scenarios included in *National 2011* allows to remove the effect of the diversity in the verified data and in the policy assumptions compared to the updated set of scenarios (i.e. *National 2013*). In fact, the data and trends of the 2011 WEM scenario and of the 2011 WAM scenario have been corrected and adjusted by including the verified data until 2011 as well as the policy assumptions characterizing the equivalent updated scenarios. Figure 12 shows the corrected trajectories of the national-based scenarios delivered in 2011, combining them with the trends of *National 2013* and with the emission path set by law. In addition, the following table provides the assessed policy gap according to the expected development of the non-ETS GHG emissions projections of the With Existing Measures scenarios delivered in 2011 (both original and corrected version) and of the 2013 version.

Table 15 - Expected emission gap –absolute terms ($MtCO_2$ eq.)

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
WEM 2011	-	1.6	4.0	7.7	11.4	15.1	18.7	22.4
WEM 2011 Corrected	-	-	-	3.5	7.5	11.6	15.6	19.8
WEM 2013	-	-	-	-	-	-	-	3.1

Expected emission gap between the non-ETS GHG emission projections of With Existing Measures scenarios –2011 (original and corrected version) and 2013 – and the annual emission allocations set for Italy in Annex I to the Commission Decision of 26 March 2013 ($MtCO_2$ eq.)

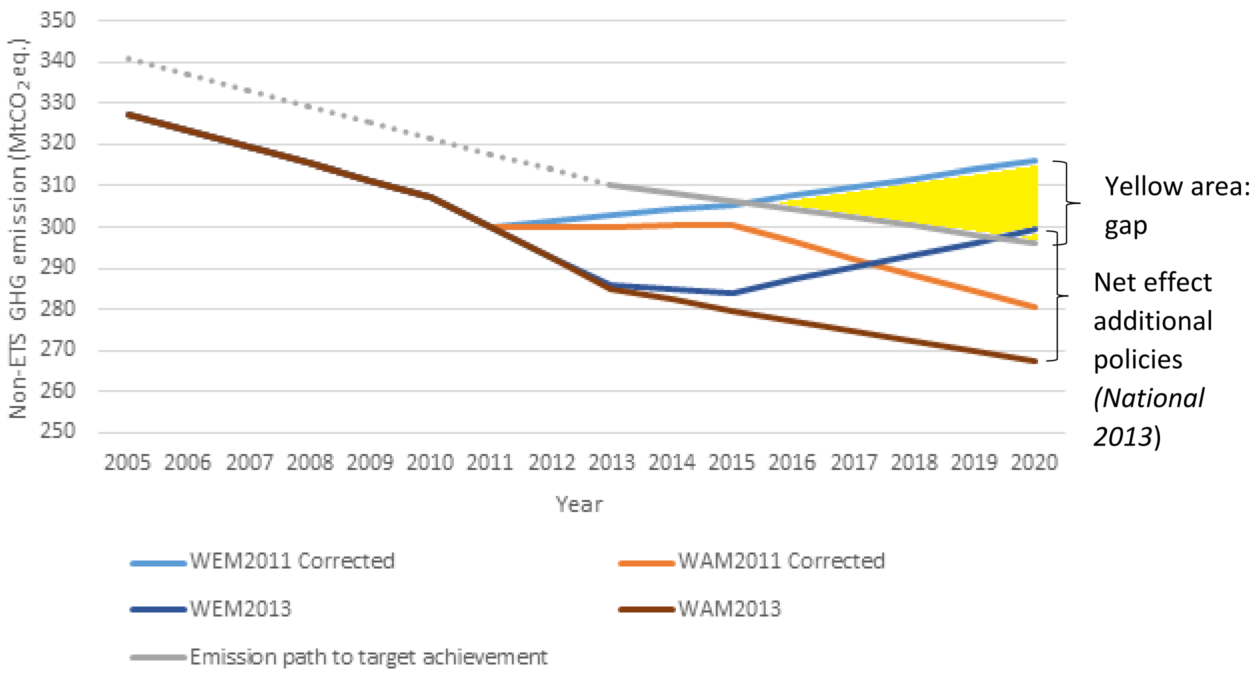


Figure 12 – Italian non-ETS GHG emissions from *National 2011* (corrected version) and *National 2013* ($MtCO_2$ eq.)

As can be observed from the figure above, the corrected 2011 WAM scenario still does not exceed any annual emission allocation. The trend diverges from the updated one between 2011 and 2015, while the gap is narrowed afterwards due to the effect of the policies assumptions included into the 2013 WAM scenario. It is worth noting that the corrected 2011 WAM scenario would have overtaken the WAM 2013 data for 2020 if its own policy assumptions had been maintained. In fact, as disclosed in the policy assumption analysis, the policy assumptions of the original 2011 WAM scenario expect higher reductions in non-ETS GHG emissions compared to the updated version. Counting for the corrected 2011 With Existing Measures scenario, the trend still falls behind some of the annual emission allocations (see Table 15). In the original version, the emission trend is expected to lag behind all the annual maximum allowed emissions set by law except for the first one (i.e. 2013), while the corrected version is expected to face a gap only after 2015. On the other hand, the 2013 WEM scenario is expected to lag behind only the last annual emission allocation (i.e. 2020). These outcomes are explained by the comparative analysis addressing the corrected 2011 WEM scenario and its updated version that shows the two trends diverging between 2011 and 2015, with the former increasing and the latter maintaining a negative growing rate up to 2015. The opposite trends mirror the different economic assumptions of the two scenarios, i.e. more optimistic in the former and prudent in the latter (for more information see section 3.1.2). The emission gap between the two scenarios reaches 21.5 $MtCO_2$ eq. in 2015 and 16.6 $MtCO_2$ eq. in 2020. Finally, these outcomes outline the effect of the different economic assumptions in defining and assessing the expected progress and effort within the scope of the Effort Sharing Decision in the next years up to 2020. The diversity in the economic assumptions of the two national-based scenario versions lies in the expectations related to the recovery from the strong economic crisis.

3.5 Decomposition Analysis

The decomposition analysis completes the previous steps of the research by providing evidence of the deep impact of the economic downturn and the strong effect of policies and measures at sectorial level by addressing the most representative (due to its dual nature) among the non-ETS sectors namely transport. The analysis of the energy system moves from the investigation of GHG emission evolution from the whole non-ETS branch to the examination of the energy use change in a single non-ETS sector. Thus, the analysis goes a step further by applying the decomposition analysis index so as to assess the impact of the economic downturn in its first stage and of relevant legal provisions within the Effort Sharing Decision scope to freight transport and passenger transport. The analysis addresses the two sub-sectors separately in their expected evolution up to 2020 as projected by the 2007 Baseline scenario and the Reference scenario of PRIMES.

Freight transport

Haulage is strongly coupled with domestic economic growth, consequently the sectorial activity and the related energy use (as well as the related GHG emissions) have been strongly affected by the economic downturn. The Reference scenario of PRIMES includes the effect of the economic downturn in its assumptions, and hence the dramatic fall of freight activity and energy demand between 2005 and 2010. In fact, according to the projected data of the Reference scenario, freight activity was expected to decrease of 2% and energy use of 2.5% every year up to 2010, starting to recover afterwards. On the other hand, the 2007 Baseline scenario does not include the effect of the economic recovery, moreover the policy assumptions are remarkably less abundant than in the Reference scenario. Consequently, the Baseline maintains positive trends over the entire projecting period and especially between 2005 and 2010. Despite the Reference scenario expects freight transport to recover after 2010 featuring around the same growing rate characterizing the Baseline projections, the difference in energy use between the two scenarios is remarkable even after the correction of Reference data on 2005 with the Baseline's. The table below presents the results of the comparison between the data included in the two scenarios. It is worth noting that the table shows the corrected data on energy use of the Reference scenario, moreover the energy intensity data has been computed from the reported activity and the energy data.

Table 16 – Freight transport data from PRIMES 2007 and Reference scenario (corrected)

		Year				Annual % growing rate		
		2005	**2010**	**2015**	**2020**	**2005-2010**	**2010-2015**	**2015-2020**
Energy use (ktoe)	**Baseline 2007**	14.039	15.555	16.974	17.837	2,2	1,8	1,0
	Reference	14.039	12.267	13.375	13.884	-2,5	1,8	0,8
	Difference	-	**3.288**	**3.599**	**3.953**			
Freight activity (Gtkm)	**Baseline 2007**	260	282	302	315	1,7	1,4	0,8
	Reference	263	236	256	271	-2,0	1,7	1,2
	Difference	-3	47	46	43			
Energy intensity (toe/Mtkm)	**Baseline 2007**	54,0	55,1	56,2	56,7	0,4	0,4	0,2
	Reference	53,5	52,0	52,2	51,2	-0,5	0,1	-0,4
	Difference	0,5	3,1	4,0	5,5			

The difference in the projected energy use from the two scenarios is highly remarkable and it increases over time, representing always more than one fourth of the Baselines' data load. The diversity in freight activity is roughly stable after 2010, albeit being relevant in magnitude. Consequently, also the resulting energy intensity changes over time. The table shows that the Reference projects lower values than the Baseline, however the higher growing rate of sectorial activity after 2010 mirrors the expected recovery.

The data reported in Table 16 are applied to the decomposition analysis, which assesses the impact of the economic downturn and of the additional policies and measures included in the Reference on the highlighted difference in energy use projected by the two scenarios. Table 17 reports the results of the decomposition analysis, which allows to characterize the assessed change in energy use in terms of the driven force at its basis. The results are provided in absolute terms (ktoe) and in relative terms (percentage) and they are discussed in detail in the next chapter.

Table 17 – Decomposition analysis results for freight transport

IMPACT (ktoe)	2010	2015	2020
Policies	726	1.034	1.493
Economic crisis	2.562	2.565	2.460
TOTAL	3.288	3.599	3.953

IMPACT (%)	2010	2015	2020
Policies	22%	29%	38%
Economic crisis	78%	71%	62%
TOTAL	100%	100%	100%

Passenger transport

Passenger transport strongly differs from freight transport in its features. In particular, passenger transport is characterized by a weak link with the economic activity (generally expressed in term of GDP growth), which is the main driver in freight activity indeed. This feature has a straight effect on the sectorial projections provided by the scenarios. In fact, the Reference scenario, albeit including the effect of the economic crisis, projects only a slightly decrease of energy use between 2005 and 2010 amounting to 0.1% every year, while sectorial activity maintains positive trends over the entire projecting period. Moreover, the sector is expected to constantly reduce its energy intensity over time (see Table 18). On the other hand, the Baseline scenario mirrors the positive expectations characterizing the pre-crisis period with sectorial energy consumption and activity increasing over time. As consequence, also the resulting energy intensity increases over time, mirroring the lack of energy and climate measures aimed to trigger energy efficiency improvements. Despite the positive expectations, sectorial activity is lower in the Baseline than in the Reference scenario, demonstrating that the sector is expected to be barely affected by the economic crisis. Counting for the projected energy use, the Baseline scenario expects a steady increase while the Reference projects a slightly decrease due to the economic downturn and positive and stable trends during the economic recovery thanks to the energy efficiency improvements. Consequently, the two scenarios show different energy use up to 2020, although the difference is far lower than expected for freight transport. The table below presents the results of the comparison between the data included in the two scenarios. As for Table 17, the table reports the corrected data of the Reference scenario and the calculated data on energy intensity.

Table 18 – Passenger transport data from PRIMES 2007 and Reference scenario (corrected)

		Year				Annual % growing rate		
		2005	**2010**	**2015**	**2020**	**2005-2010**	**2010-2015**	**2015-2020**
Energy use (ktoe)	**Baseline 2007**	25.702	26.548	27.550	28.700	0,7	0,8	0,8
	Reference	25.702	25.601	26.200	26.251	-0,1	0,5	0,0
	Difference	0	947	1.350	2.449			
Passenger activity (Gpkm)	**Baseline 2007**	937,4	951,2	975,1	1.004,1	0,3	0,5	0,6
	Reference	925,4	952,4	998,4	1.030,3	0,6	1,0	0,6
	Difference	12	-1	-23	-26			
Energy intensity (toe/Mpkm)	**Baseline 2007**	27,4	27,9	28,3	28,6	0,4	0,2	0,2
	Reference	27,8	26,9	26,2	25,5	-0,6	-0,5	-0,6
	Difference	-0,4	1,0	2,0	3,1			

As shown in the table above, the diversity in the projected energy use between the two scenarios steady increases over time, even though it maintains a moderate magnitude. This diversity is mainly related to change in energy intensity, which is expected to steady decrease in the Reference while it increases in the Baseline. The data reported in Table 18 are applied to carry out the decomposition analysis, which assesses the impact of the enriched policy framework and of the economic constraints characterizing the Reference scenario by calculating the intensity effect. The results are reported in Table 19 in terms of contribution to the overall change in energy use expressed both in ktoe and in percentage. The results are peculiar due to the negative values characterizing the economic impact on the energy use. The following chapter discusses and explains these results.

Table 19 – Decomposition analysis results for passenger transport

IMPACT (ktoe)	2010	2015	2020
Policies	981	1962	3116
Economic crisis	-34	-612	-667
TOTAL	947	1.350	2.449

IMPACT (%)	2010	2015	2020
Policies	104%	145%	127%
Economic crisis	-4%	-45%	-27%
TOTAL	100%	100%	100%

4 DISCUSSION

This chapter provides a comprehensive picture of the issues investigated and outlined in this work, identifying the strengths and weakness, and hence the relevance of the research. First, the results of the study presented in the previous chapter are discussed comprehensively and coherently in order to fully explain evidence and insights resulting from the study. Secondly, barriers and their implications in the research are addressed and explained. Finally, the relevance of the research, the possible applications and future developments are discussed.

4.1 PRIMES 2007

The in-depth review of the scenarios' main assumptions and the comparative analysis between scenarios and historical data on macroeconomic drivers provided by the Italian and the European Institute of Statistics (ISTAT and Eurostat respectively) have stressed the obsoleteness of the 2007 Baseline scenario.

Firstly, the scenario's assumptions on macroeconomic variables (i.e. population and GDP growth) dramatically diverge from the verified data and the assumptions included in the other scenarios starting from the beginning of the projected period (i.e. after 2005). Counting for the demographic dynamics, the 2007 Baseline is the only scenario assuming a stable population after 2005. Moreover, it is the only scenario taking into account a steady growth of the domestic economy since the economic crisis is not taken under consideration. Despite the expected GDP growth applied to the projecting activity was considered moderate at the time the scenario was run (Capros et al., 2008), it is still higher than any expectation of economic growth after the recovery so far. To provide a clue of the highly dramatic effect of the economic downturn on the Italian economy, the expected GDP level assumed for 2020 in the most updated scenario currently available on the Italian context (i.e. *National 2013*) is lower than the value expected for 2010 included into the 2007 Baseline.

Secondly, the 2007 Baseline scenario assumes a legislative framework in the field of climate and energy that is extremely poor compared to the current legislation, which is partially included in the updated EU-wide scenarios (*PRIMES 2009*) while it is almost fully represented in the national-based scenarios. Such diversity of the 2007 Baseline scenario mirrors the robust legislative effort of the European Union and Member States on the issue from 2007.

Thus, the inconsistency with the current Italian context characterizing the assumptions lying at the basis of the projecting activity in the 2007 Baseline scenario is highlighted by the results of the GHG emission projections themselves and by the gap analysis carried out in this work. In fact, the scenario's trend on GHG emissions features a steady growth over the entire projected period distancing both the projected data included in the updated PRIMES scenarios and the (verified and projected) data included into the national-based scenarios.

Finally, the 2007 Baseline scenario features an unexpected accuracy on the data addressing the projections' baseline year (i.e. 2005) due to the high consistency with the most updated verified data on non-ETS GHG emissions currently available (i.e. the data from the technical review carried out for the European Commission). Nevertheless, the wrong and incomplete assumptions founding the projecting activity result in incorrect projections that cannot be considered trustable anymore. However, the diversity of the assumptions allows to gain meaningful understanding on the impact of the additional and correct assumptions founding the updated version once carrying out a comparative analysis, therefore this fact justifies the employment of the 2007 Baseline scenario in this research.

4.2 PRIMES 2009 and National-based Scenarios

The in-depth review of the scenarios' assumptions shows higher, albeit variable, consistency of the updated EU-wide scenarios (i.e. *PRIMES 2009*) with the current trends as well as with the national-based scenarios compared to the previous version of PRIMES. This section discusses the results addressing more specifically the 2009 PRIMES scenarios (i.e. Baseline and Reference) and both the national-based scenarios (i.e. *National 2011* and *National 2013*).

The demographic assumptions are consistent among scenarios, featuring a steady increase (due to migration inflow), which is slightly lower in *PRIMES 2009*. Moreover, they agree with the current trends and the EU forecasts while they are more prudent than the latest forecasts made by the National Institute of Statistics (ISTAT). Positive trends concern also fossil fuels prices, which feature increasing values passing from PRIMES scenarios to national-based scenarios. Lastly, the technology assumptions reflect self-driven as well as policy-determined technological improvements recently achieved and envisaged. In this work, the characterization of the technology assumptions has been mainly derived from the policy assumptions review since policies and measures implicitly or explicitly include the technology assumptions. The scenarios' technology assumptions mainly concern renewable sources in the built environment and in the transport sector (mainly in relation to biofuels and other renewable fuels), technologies aimed at improving energy efficiency in the built environment and technical innovations in road transport fleet and their components. The scenarios are more rich in their technology assumptions moving from the 2009 Baseline scenario to the Reference scenario of PRIMES and from the EU-wide scenarios to the national-based ones.

The aforementioned assumptions contribute in shaping the energy system, and hence in determining GHG emissions derived by energy use in non-ETS sectors. However, they are minor contributors compared to the economic and policy assumptions, which are assumed in this work as the only drivers explaining the scenarios' results. This is justified by the increasingly weak link between demographic levels and GHG emissions (EEA, 2009), the strong relationship between fossil fuel prices and the economic growth (Tverberg, 2012) and the tight link between technology assumptions and policy assumptions (Sorrell et al., 2000). Consequently, the outcomes of the in-depth review of the policy assumptions and of the assumed GDP trends included in the scenario are discussed more in detail hereafter.

The legislation aimed at combating climate change by acting on end-use sectors has been enriching over time thanks to a vigorous effort primarily at EU level. The policy effort has been improved over time as result of an increasing concern on the detrimental effect of climate change and of an unsustainable energy use on the European economy and society. Many legislative provisions addressing this issue have been adopted by the European Commission and implemented by Member States. Decision No 406/2009/EC is a cornerstone in this topic, together with the other provisions overarched by the Climate and Energy Package. The review of the policy assumptions addressing the non-ETS sectors included into the scenarios traces out the legislative progress at EU and Italian level in the scope of the Effort Sharing Decision.

The PRIMES scenarios mainly mirror the EU legislative effort, which represents only to a certain extent the Italian legislation in the field, albeit Italy strongly relies on the European law especially in the overarching topic of energy efficiency. First, the increasing legislative effort at EU level between January 2007 and April 2009 is proven by the remarkable difference in the policy assumptions included in the two Baseline of PRIMES. Second, the year 2009 has represented a milestone in the EU effort in fighting climate change due to the adoption of the Climate and Energy Package and of relevant provisions such as the Effort Sharing Decision and the so called *Renewables* Directive (Dir. 2009/28/EC). Moreover, a number of secondary laws addressing energy efficiency improvements in end-use sectors (especially in the civil sector) were implemented in 2009. Finally, the extraordinary EU policy effort characterizing the year 2009 is proven by the additional assumptions included in the Reference scenario of PRIMES and consequently by the diverging trends in GHG emissions up to 2020 projected by the mentioned scenario compared to the Baseline.

The national-based scenarios move one step further providing more updated, complete and accurate information especially at national level on the sector-specific and cross-cutting legislative provisions addressing the sectors covered by the Effort Sharing Decision. The scenarios include the relevant policies and measures in place (both With Existing Measures scenario and With Additional Measures scenario) and the planned ones (With Additional Measures scenario only).

First of all, the high consistency of the With Existing Measures scenario delivered in 2013 with the previous version (delivered in 2011) highlights that no significant improvements were made in the Italian legislation addressing the Effort Sharing Decision scope in the last two years. This fact raised concerns on the effectiveness of the Italian effort especially on topical sectors such as transport. In fact, while the European Union is calling for increasing national legislative efforts to curb energy use and GHG emissions from the transport sector, the Italian legislation addressing this sector totally relies on the European laws. In fact, the sectorial policy package is made up by EU regulatory measures aimed at supporting biofuels (under Directive 2009/28/EC - implemented by Legislative decree 128/05) and cars fleet update (according to Regulation No 443/2009). Moreover, it includes planning measures on infrastructures' development and enhancement based on the National Strategic Reference Framework (NSRF) developed by the European Commission. Besides, some planned policies are under discussion at national level but the expected benefits would still not meet EU requirements. On the other hand, the national policymaking effort addressing the civil sector has improved over time thanks to the EU leverage and relevant national measures such as the White Certificates scheme. The policy package addressing the civil sector is made up by regulatory instruments (Building Regulation and Ecodesign Directive and the related Regulations) as well as by economic instruments (White Certificate scheme and provisions under the budget laws). Moreover, many policies and measures based on a balanced mix of policy instruments are planned or envisaged. These provisions mainly address energy efficiency enhancements and are supported by the National Renewable Energy Action Plan 2010 (NAP-RES 2010) and the National Energy Efficiency Action Plan 2011 (NEEAP 2011).

On the other hand, the agreement between the assumptions of the With Existing Measures scenarios delivered in 2011 and 2013 is no longer observed when looking at the additional (planned) provisions included in the With Additional Measures scenarios. The diversity is related to both the policy items and the assessed policy effectiveness and affects the civil sector as well as the transport sector. The resulting difference in term of expected GHG emission abatements for 2020 amounts to 10.3 $MtCO_2$ eq., which is equal to more than one third of the expected abatements for the same year considered in the With Existing Measures scenario delivered in 2013. Unexpectedly, the lowest value in the difference belongs to the 2013 WAM scenario, proving that the further GHG emission abatements for 2020 based on the measures not yet in place is barely predictable. This is due to the uncertainty on the strength of the legislative effort that Italy will undertake in the next years. Furthermore, the assessment of the expected effectiveness of policies for 2015 and 2020 is affected by high uncertainty, especially when considering measures not yet implemented. Consequently, these values (provided by the *Italian Climate Policy Progress Report* submitted to the Commission) have mainly an indicative purport. However, the planned measures included in the With Additional Measures scenarios provide useful insight on the potential abatements deriving by the implementation of additional measures already planned. According to both the With Additional Measures scenarios, the additional measures would allow Italy to double the expected reductions deriving by the existing measures in 2020.

Finally, the European Union has undertaken an impressive legislative effort towards curbing energy use and the related GHG emissions in end-use sectors. The year 2009 has represented a milestone in this effort with the implementation of the Effort Sharing Decision and of other highly relevant provisions. However, the Italian legislative effort under the Effort Sharing Decision scope has been oriented more to implement EU provisions rather than develop own strategies tailored on the Italian context and needs. As a consequence, the Italian package is weak and imbalanced, lacking provisions especially in topical sectors such as transport and tertiary. Furthermore, the future development of the national effort is barely predictable although there is a need for further provisions to overcome the current overall weakness and the sectorial imbalance. Moreover, the implementation of further measures is essential to ensure the achievement of the emission reduction target set by Decision No 406/2009/EC by keeping up the annual emissions allocations laid down in the Commission Decision of 26 March 2013 for the period from 2013 to 2020. In fact, the legislative effort has a pivotal role towards the success in complying with the EU emission reduction obligations in the short to medium term as well as to set the domestic economy on track to meet the long-term EU objective of becoming a resource-efficient and low-carbon economy by addressing the typical system inertia soon.

The legislative effort has a pivotal role in triggering GHG emission reductions by implementing sector-specific and cross-cutting policies aimed at reducing energy intensity and carbon intensity of non-ETS sectors. However, the recent economic downturn, especially in the dramatic form experienced by Italy, enlightened the major role played by the economic activity in the progress towards meeting the emission reduction target set by the Effort Sharing Decision.

The economic downturn has deeply hurt the domestic economic activity having detrimental effects on every sector of the economy (although with some limited exception, e.g. passenger transport). This, in turn, has led to the abrupt reduction in final energy demand, and hence in the related GHG emissions in all end-use sectors. The economic assumptions applied to the scenarios are roughly close up to 2010 and they are consistent with the verified trend, which features a steady decrease starting from 2005. However, the economic assumptions start to diverge after 2010 due to different expectations on the recovery time. *PRIMES 2009* and *National 2011* assume that the economic recovery would have started from 2010, albeit the former takes on an optimistic view while the latter a more prudent one. However, it is worth noticing that according to Capros et al. (2010) the economic growth assumed in *PRIMES 2009* for Italy during the economic recovery is among the lowest of the whole EU-27. This is a further clue of the deep effect of the economic downturn on the Italian economy, deeper than expected in the first stage. On the other hand, the 2013 national-based scenarios, which benefit of the most updated data, assume a more prudent view where economic recovery will take place more slowly. In fact, domestic economy is expected to be affected by stagnating conditions until 2015 and by moderate growth afterwards. These assumptions are consistent with the general trends of the most recent economic forecasts made at national, EU and international level. Finally, the prolonged effect of the economic crisis on the Italian economy will affect for long time all end-use sectors, contributing in curbing final energy demand and the related GHG emissions in the short to medium term. Consequently, the economic crisis is playing and will likely play a relevant role in the effort towards meeting the binding target set by the Effort Sharing Decision for the whole lifespan of the commitment although decreasing over time. On the other hand, it is worth mentioning that the detrimental effects on public and private finance of the economic recession would likely affect the reduction progress the other way round in the longer term. In fact, once the economic recovery will take place energy use and the related GHG emissions would feature a steeper increase if no overhauls in the end-use sectors took place in the meantime.

The diversity in the policy assumptions and in the expected effect and lifespan of the economic downturn result in different projections of GHG emissions trends passing from the EU-wide scenarios to the national-based scenarios and from the second to last to the last set of national-based scenarios.

Counting for PRIMES 2009 projections, the Baseline scenario shows a negative trend only until 2010, i.e. as far as the GDP is expected to decrease, while it starts to grow afterwards. On the other hand, the Reference scenario maintains a negative trajectory also after the expected economic recovery. The diverging trends result from the expected effect of the additional measures included in the Reference only, which are expected to lead to further emission abatements amounting to 17 $MtCO_2$ eq. in 2020 (i.e. the emission gap between the two 2009 PRIMES scenarios). Moreover, the Baseline trend grows at a slower pace while the Reference trend decreases at a faster pace after 2015 due to the increasing effect over time of the policies and measures included in the scenarios. The increasing effectiveness over time is explained by the fact that legal provisions have to address barriers and system inertia before becoming fully effective. In spite of the roughly stable trend featured by the Baseline and the decreasing trend of the Reference, the gap assessment has demonstrated that the policies and measures included in both scenarios are still too weak to lead to a 13% reduction in GHG emissions in the non-ETS sectors for 2020 compared to the baseline year levels (i.e. 2005 data). In other words, the legislation addressing the Effort Sharing Decision scope as it was in April (Baseline) and December (Reference) 2009 needed a further policy effort to meet the non-ETS target, even though the Reference scenario assumes the achievement of the Renewable target and of the non-ETS target.

Moving from the latest set of EU-wide scenarios available at the time the research was carried out to the national-based scenarios delivered by Italy in compliance with the monitoring and reporting obligations, the analysis assesses in absolute terms the expected progress of Italy towards meeting the national target set by the Effort Sharing Decision. The 2013 With Existing Measures scenario provides the most updated and reliable information on the current and expected effort of Italy based on the legislation currently in place. According to the gap assessment carried out on the mentioned scenario, Italy is expected to lag behind only the last annual emission allocation, i.e. the one addressing the year 2020. Thus, the combined effect of the economic downturn and of the policy and measures currently in place are expected to keep Italy almost completely on track towards meeting the Effort Sharing Decision obligations. The expected emission gap amount to 3.2 $MtCO_2$ eq.. The gap could be closed by making use of the flexibility instruments provided by Article 3 (paragraph 3, 4 and 5) of the Effort Sharing Decision and by implementing further policies and measures, and hence by closing the policy gap.

Looking at the With Existing Measures scenario delivered in 2011 the outcomes of the gap assessment change, even though the trend has been corrected including the most updated verified data reported in the latest version (i.e. verified data up to 2011). In fact, Italy is expected to exceed all the annual emissions allocations from 2016 to 2020, reaching an emission gap of almost 20 $MtCO_2$ eq. in 2020. Once again, the outcomes derive from the combined effect of the economic assumptions and of the expected effectiveness of the policies and measures in place at the time the scenario was run. However, the policy assumption analysis has shown that the two versions of With Existing Measures scenario agree in the policies and measures taken into account, in fact the diversity in the expected emissions abatement amount to 3.3 $MtCO_2$ eq. in 2020. Consequently, the disagreement between the outcomes of the gap analysis addressing the two scenarios can be explained by the different expectations on the economic recovery. In fact, *National 2011* assumes that the economic recovery would have taken place from 2010 and Italian GDP would have featured a roughly stable growing rate up to 2020 (annual average growing rate of 1.3%). On the other hand, *National 2013* expects Italy to face economic stagnation with an annual average growth rate of 0.4% until 2015. The economic recovery will occur only afterwards with an annual average growth rate of 1.2% between 2015 and 2020. By smoothing out the difference in the policy assumptions of the two WEM scenario (gap analysis revision) the analysis has assessed that the expected impact of the delay in the economic recovery is equal to 21.5 $MtCO_2$ eq. in 2015, decreasing to 16.6 $MtCO_2$ eq. in 2020.

On the other hand, both the With Additional Measures scenarios do not exceed any annual emission allocation. Moreover, they show overall decreasing trends up to 2020, demonstrating that the additional measures included in these scenarios would curb GHG emissions effectively in the long term, contributing towards the restructuration of the end-use sectors and moving towards a more sustainable and consequently less energy and carbon intensive domestic economy.

Finally, the outcomes of the gap analysis and of the comparative analysis between the national-based scenarios delivered in 2011 and 2013 demonstrate that the economic downturn and its prolonged effects are determinant in the Italian effort towards meeting the non-ETS target. Moreover, the With Additional Measures scenarios demonstrates that the current policy effort of Italy is still too weak and further policies are required to be implemented in order to ensure the compliance with the Effort Sharing Decision obligations as well as to move towards a low carbon economy.

4.3 Decomposition Analysis

Further understanding on the role of the policy variable on one hand, and of the economic variable on the other hand has been obtained from the decomposition analysis on energy use in transport sector. The study has allowed to assess, based on a topical and highly representative sector, the impact of the first stage of the economic downturn, i.e. up to 2010, and of the policies implemented up to late 2009. The analysis, which has addressed the Reference scenario of PRIMES comparing it with the 2007 Baseline scenario, has assessed the expected impact of the economic and policy variable in the change of energy use in both freight and passenger transport up to 2020. Based on the results reported in the previous chapter some remarks can be made.

Freight transport and passenger transport are structurally different since the former is tightly linked with the economic context, while the latter is not. This is demonstrated by the past sectorial activity of the two branches of transport. In fact, freight transport has been experiencing a dramatic reduction since the economic crisis arrival, while passenger transport has not shown any evident reduction due to the economic downturn. This structural difference between haulage and passenger transport is also well depicted in the Reference scenario since the former is assumed to recover from the drop in the sectorial activity experienced during the economic downturn only between 2015 and 2020, while passenger activity is assumed to never decrease over time. Consequently, energy use in freight transport is projected to fall between 2005 and 2010, starting to recover afterwards, albeit achieving the pre-crisis level not even in 2020. On the other hand, energy use in passenger transport is expected to only slightly decrease between 2005 and 2010 but rapidly recovering afterwards. The highly different trends characterizing freight transport and passenger transport lead to highly different outcomes from the decomposition analysis, as explained hereafter.

Firstly, the reduction in energy use projected for freight transport by the Reference scenario is mainly due to the effect of the economic downturn and only to a limited extent from policies and measures addressing the sector. Despite the impact of the economic downturn is expected to decrease over time, it accounts for more than 60% of the difference between the energy use as projected by the Reference scenario and the 2007 Baseline scenario, which does not include the effect of the economic downturn. On the other hand, the curbing effect of policies increases over time, enhancing energy efficiency and reducing energy intensity. The policy effect is expected to become relevant from 2015, as demonstrated by the expected reduction in energy intensity between 2015 and 2020.

Secondly, the decomposition analysis of passenger transport shows peculiar results that can be explained as follow. As for freight transport, the decomposition analysis aims to assess the impact of the economic and policy variable in their reciprocal relationship where the former decreases and the latter increases over time. The impact is assessed on the difference between the final energy demand projections of the Reference scenario and of the 2007 Baseline scenario over the period 2010-2020. The difference between the data of the two scenarios, which is lower than the one characterizing the previous case, is explained again by the effect of the policy variable on one hand and of the economic variable on the other. The former represents the relevant legal provisions issued before 2008 in this field such as Regulation 2009/443/EC (establishing emission performance standards for new passenger cars), which has led to relevant reductions in energy and carbon intensity in passenger transport. The latter is not expected to lead to energy use reductions, on the contrary it is likely to increase energy consumptions. Thus, the difference in the energy use data between the two scenarios up to 2020 is totally explained by the curbing effect of the legislation in place, although part of these reductions are hidden by the demand for passenger transport that is dominated by road and private transport. Consequently, the increasing sectorial activity partially offsets energy efficiency gains, which are expected to be relevant over the entire projecting period, leading to increasing energy demand.

Finally, the decomposition analysis has highlighted the difference in the expected impact on the two branches of transport sector of the evolution of the legislative framework and of the economic downturn. The mentioned difference is explained by the different relationship between the domestic economic activity and the sectorial activity. In freight transport, where this relationship is tight, the dominating variable in driving energy use change is the economic one. On the other hand, the weak link between passenger activity and GDP makes the policy variable the major cause of the expected energy change over time. Thus, energy use and the related GHG emissions from end-use sectors strongly rely on the degree to which sectorial activity and domestic economic activity (i.e. GDP) are decoupled.

4.4 Final Considerations and Further Developments

The IPCC defines the *scenario* as “a plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships” (IPCC 2007, p. 951). Bearing this definition in mind, the research has investigated the role of the economic and policy variables in driving the change in the expected progress of Italy towards meeting the emission target. However, the study has struggled with errors and variability affecting emission data not resulting by projecting activity, i.e. the reported data up to the projections' baseline year. Consequently, the scenarios' results, and hence the outcomes presented above are affected by variable but still relevant data uncertainty. Evidence has come up during the research, moreover the issue has been directly addressed in some analyses. The main issues addressing data uncertainty that have been revealed by the study are reported hereafter.

First, the preliminary analysis has disclosed the inconsistency between the reference sources of the national-based scenarios delivered in the same period (i.e. the reporting tables and the *Italian Climate Policy Progress Report*). Moreover, it has found peculiar trends between the scenarios when looking at the reporting tables submitted to the European Commission, especially counting for the final ones delivered in 2011. These trends are more likely affected by mistakes than by error because some of the projected values of the With Additional Measures scenarios exceed the data included in the With Existing Measures scenario of the same year. This cannot be accepted because, by definition, the former derives by adding further reduction measures to the latter and consequently the *Italian Climate Policy Progress Report* has been used as main data source of both *National 2011* and *National 2013*.

Second, the study has disclosed the variability and the uncertainty of the past data and trends included in the scenarios but not resulting from the projecting activity. This data represents the most updated value available at the time each scenario was run. Consequently, the comparison between the scenarios and the further comparison with the most updated data currently available (called "historical data" in the analysis) has allowed to outlined that the variability decreases over time, especially after 2008. This can be explained by improvements in the monitoring and reporting activity (required at EU and international level) also in relation to the transition from phase one to phase two of the EU Emission Trading System (ETS). On the other hand, the data before 2008 is characterized by high uncertainty, especially the 2005 data. This outcome is particular relevant since 2005 represents the baseline year for the definition of the national reduction effort under the Effort Sharing Decision and hence of the annual emission allocations. At this stage, the comparative analysis has addressed all the scenarios as well as the *historical data* and the data applied to define the annual emission allocations that is the most accurate data currently available. Thus, the addressed sets of data represent the data for the year 2005 as reported in *PRIMES 2007* and PRIMES 2009 and as officially reported by Italy in 2009 (as reported in *National 2011*) and in 2011 (as reported in *National 2013*). Furthermore, the historical data represents the data reported in the National Inventory Report 2012 (NIR 2012), while the most accurate data derives from the technical review of the NIR 2012 data. The outcomes of the comparison show that the distance from the most accurate data is remarkable, albeit decreasing over time. The 2007 PRIMES scenario represents the only exception, in fact the reported value is extremely close to the recently reviewed one. However, also this result may be attributed to error and uncertainty affecting the monitoring activity.

Finally, this research has faced and has addressed a topical issue of the monitoring and reporting activity, which aims to assess national and community effort in meeting the emission reduction commitments. The mentioned issue lies in the data error, which affects the reporting data on non-ETS GHG emissions, consequently affecting the evaluation of progress and efforts made towards meeting the emission target.

The complexity of the system, the interrelationship with the ETS sectors, which also implies the risk of sectorial carbon leakage, and instances of attribution in the monitoring and reporting activity itself contribute to the intrinsic error of the verified data. This in turn affects the scenarios' results, which depend on the assumptions as well as on the data input used to the modelling process. In fact, the application of barely accurate data, although considering correct assumptions affects the results of the projecting activity. Consequently, the evaluation of progress and efforts made in reducing GHG emissions to meet the national target based on the scenario analysis is also affected by error. Moreover, when the assessment addresses more than one scenario developed in different years, such as in this research, the error may result in higher data variability. As consequence, the analyses made in this research try to explain the effect of one source of variability of scenarios' data namely the assumptions founding the scenarios. On the other hand, it addresses the data variability resulting from the uncertainty of the monitoring activity and the intrinsic error of this kind of data by increasing the preciseness of the data. In detail, the less updated scenarios, which are assumed less accurate in their verified data (i.e. the data before the projections' baseline year), have been corrected by including the most updated verified data reported in the latest set of scenarios (i.e. *PRIMES 2009* for the EU-wide scenarios and *National 2013* for the national-based ones). Consequently, the research has overcome, when possible, the variability of the reported data included in the same category of scenarios allowing meaningful and more precise evaluation of the other source of data variability, which affect the projected data instead, i.e. the scenarios' assumptions.

Concluding, the research addresses and is affected by data variability at the same time. In fact, data variability represents the core of the analysis to the extent to which it concerns the scenarios' projections, and hence implicitly the scenarios' assumptions. On the other hand, it affects the results of the study when looking at the data in absolute terms in order to assess the progress made and expected in the future to comply with the binding emission targets set by law in terms of annual emissions allocations. However, also in this instance the employment of two set of scenarios, i.e. the latest one (*National 2013*) and the previous one (*National 2011*) has allowed to enrich the assessment with meaningful outcomes and insights resulting from comparative analyses. These considerations hold the research's strength, which contributes in deepening the understanding on the Italian effort in the Effort Sharing Decision scope beyond the intrinsic uncertainty. The uncertainty has been in part overcome by employing a considerable number of scenarios (seven in total), which represent the most relevant scenarios applied at EU and national level to support policymaking activity.

The scenarios have been deeply reviewed and relationships between the scenarios' data and with other data (i.e. the most updated data available and the annual emission allocations) have been traced. The resulting outcomes provide a complete, rational and meaningful representation and evaluation of the Italian progress in relation to the main drivers affecting GHG emissions from the short to the long period. Lastly, the outcomes of the stepwise methodology tailored on the specific framework and purpose addressed by the research has been supported by a well-known method (i.e. decomposition analysis), although shaped on the specific needs of the analysis.

The research reported in this work can be considered the cornerstone of a number of further studies focused on the Italian effort towards meeting the national reduction target. In addition, other more specific analyses not directly addressing the national effort may benefit of the current work as a detailed source of information and evidence on the topic. Finally, this work could be viewed as a useful instrument supporting policymaking activity at national level. To sum up, the employment of the outcomes can be relevant for many purposes. However, this research has been developed in view of a future more specific analysis addressing the Italian transport sector, which is widely considered the weakest among the end-use sectors in supporting the national effort to meet the emission reduction target. The analysis would define to what extent the transport system may contribute towards GHG emissions reduction for 2020 and afterwards also in relation to the EU endorsement of moving beyond the current 20% emission reduction target under the right conditions (i.e. under an international agreement on climate change). The study would be likely developed through a first sectorial scenario analysis, of which the decomposition analysis carried out in this work would be a completing part. Then, the study would investigate the untapped energy saving potentials and the policies and measures implemented and planned by Italy in this sector. These analyses would define the expected contribution of the transport sector towards meeting the national emission target under the Effort Sharing Decision according to the outcomes of the current study, opening to a number of further research developments.

5 CONCLUSION

The present work outlines the current effort and the expected progress of Italy in complying with the national emission target for 2020 set by the Effort Sharing Decision. The study has investigated the impact of the national policy framework and of the deep and prolonged economic crisis on the past achievement of the Italian effort and its likely future progress up to 2020. The analysis has employed the most relevant scenarios available at EU and national level describing the likely development of the Italian energy system.

The research demonstrates that the current Italian policy effort is inadequate to fully meet the national target. In fact, based on the latest projections, Italy is likely to exceed the last annual emission allocation (i.e. the annual binding limit set for the year 2020). However, the current package of planned policies affecting the end-use sectors covered by the Decision shows that there is room for improvements. The implementation of the planned policies would lead to relevant emission reductions in the mid-term, making Italy on track to meet the target. Moreover, it would pave the way for supporting the long-term goal of the European Union to become a low-carbon economy.

Furthermore, the research proves the tight link between the national progress in reducing GHG emissions and the effect of the recent economic crisis. The work shows that the prolonged detrimental effects of the economic downturn are playing a crucial role in curbing GHG emissions and such effect is expected to last until the economic recovery will occur. Consequently, it is demonstrated that the economic downturn is the major driver supporting the Italian effort towards meeting the national emission target. This effect compensates to large extent the lack of a comprehensive and effective national policy package. In fact, the mentioned policy gap would have caused Italy to largely fail to meet the national target if the economic crisis had not occurred. In addition, the research has verified that economic constraints affect the end-use sectors to different extents depending on the degree to which sectorial activity is decoupled from economic growth. This evidence has been found by investigating the expected effect of the economic downturn in its first stage on energy use in transport. The transport sector is made up by freight transport and passenger transport, where the former is tightly linked with GDP dynamics, while the latter is not. The study verifies that the economic downturn is expected to deeply affect energy use (and hence GHG emissions) in freight transport over a long period (i.e. 2020 and beyond). On the other hand, passenger transport is expected to not be affected by the economic crisis. Thus, the study outlines that the lower the decoupling between sectorial activity and GDP the higher the curbing effect of the economic downturn on sectorial energy use, and hence on the related GHG emissions. Besides, the passenger transport case has allowed to verify that in absence of economic constraints (i.e. from sectorial decoupling or economic recovery) only a robust policy effort aimed at the reduction of energy and of the carbon intensity of end-use sectors could support effective GHG emission reductions over time.

Finally, the research has verified that the current and expected progress of Italy in reducing GHG emissions in view of the national emission target is more related to the effect of the economic crisis rather than to an effective policy effort at national level. Despite the effect of the economic recession making the target closer, the outcomes of this study show that a policy gap is still expected. Consequently, the work proves and stresses the need for a more robust effort that Italian policymakers should take on in order to enable the country to meet the national emission target for the whole period from 2013 to 2020. Thus, the implementation of a coherent policy package addressing this issue would ensure the compliance with the mid-term target beyond the intrinsic uncertainty affecting the reported data. Furthermore, it would trigger the change towards a more sustainable, low-carbon economy.

Lastly, this work may represent the basis for a number of further studies focusing on the Italian effort under the Effort Sharing Decision. In addition, other more specific analyses, not directly addressing the national effort, may benefit of the current work as a detailed source of information and evidence on the topic. Last but not least, this study may represents a useful tool for policymakers providing a basic understanding on the topic.

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7 ANNEXES

Annex I

Scenarios' data items used in the study with disaggregation degree as reported in the scenarios and as required to carry out the research

DATA ITEMS SCENARIOS (applied to the research)	UNITS	DISAGGREGATION DEGREE			CORRECTION	
		REPORTED		REQUIRED	EU-wide	National-based
		EU-wide	National-based			
Population	Million	National	National	National		
Economic activity (GDP)	000M€'05	National	National	National		
Energy prices	*	National	National	National		
Sector activity	**	Sector Sub-sector (transport): • freight • passengers (Tot.) Modes (transport)	-	Sub-sector transport (Non-ETS):*** • freight • passengers	x	
Energy use	ktoe	Total Sector Modes (transport)	-	Sub-sector transport (Non-ETS):*** • freight • passengers	x	
GHG emissions	$MtCO_2$ eq.	Total ETS Sector	Total ETS Non-ETS	Non-ETS	x	

Annex II

Overview of the main cross-sectorial policies included in the national-based scenarios.

Directive 2009/28/EC, Legislative decree 28/2011 and National Action Plan for Renewable Energy (PAN-RES) 2010

The Directive "establishes a common framework for the promotion of energy from renewable sources. It sets mandatory national targets for the overall share of energy from renewable sources in gross final consumption of energy and for the share of energy from renewable sources in transport" (European Parliament & Council 2009c, Art. 1). According to the national target set in Annex I of the Directive, Italy has to reach a 17% share of energy from renewable sources in gross final consumption by 2020. The binding target on the share of renewable energy in transport is the same for every Member State, i.e. a minimum 10% quota by 2020 (Art. 3 paragraph 4). Article 4 of the Directive requires the adoption of a national renewable energy action plan by every Member State. The action plan sets the national framework to achieve the binding targets considering effective measures to implement. Furthermore, it assesses the expected effect on final energy consumption of measures addressing energy efficiency improvements. Directive 2009/28/EC has been transposed on national legislation by Legislative decree n. 28 of 3 March 2011.

Energy Efficiency Directive (Dir. 2006/32/EC and Dir. 2012/27/EU) and National Efficiency Action Plan (NEEAP) 2007 and 2011

Directive 2012/27/EU (repealing Directive 2006/32/EC) "establishes a common framework of measures for the promotion of energy efficiency within the Union in order to ensure the achievement of the Union's 2020 20% headline target on energy efficiency and to pave the way for further energy efficiency improvements beyond that date. It lays down rules designed to remove barriers in the energy market and overcome market failures that impede efficiency in the supply and use of energy, and provides for the establishment of indicative national energy efficiency targets for 2020" (European Parliament & Council 2012, Art. 1). Member States shall set and notify to the European Commission their indicative national energy efficiency target (Art. 3 of Directive 2012/27/EU). Furthermore, they shall submit national energy efficiency action plans according to the schedule provided by article 14 of Directive 2006/32/EC defining the roadmap of how they expect to meet the commitment (Art. 4 and 14 of Directive 2006/32/EC).

White Certificate System

The With Certificate system establishes energy saving obligations coupled with tradable white certificates (Energy Efficiency Titles - EET) which are imposed on distribution network operators. The scheme aims to support energy efficiency improvements mainly in end-use sectors by requiring suppliers to implement adequate projects. Eligible measures can address end-use sectors and small-scale supply systems applied to end-use sectors (photovoltaic installations, solar water heaters and micro-cogeneration) as well as grid-connected cogeneration and new district heating (generation plant and network) (Bertoldi & Rezessy, 2009). The system, which has been introduced in 2005, was revised by Decree of the Ministry of Economic Development of 21 December 2007.

National Strategic Reference Framework (NSRF) 2007-2013

The National Strategic Reference Framework (NSRF) 2007-2013, which was approved by the European Commission and consequently implemented by CIPE Resolution 166/2007, has been developed in the framework of the European Regional Development Fund (ERDF). According to Article 2 of Regulation No 1080/2006/EC (European Parliament & Council, 2006), the European Regional Development Fund focuses on "the need to strengthen competitiveness and innovation, create and safeguard sustainable jobs, and ensure sustainable development" by redressing the main regional imbalances. The National Strategic Framework (2007-2013) defines strategies and operational programs representing the bases of a coherent regional development policy framework, which focus on the ERDF objectives.

Kyoto fund

The Kyoto Fund is a financial instrument established by the Italian Ministry of Environment, Land and Sea based on a total capital of € 600 million that is aimed at promoting public and private investments on energy efficiency. The eligible projects should address energy efficiency improvements in the civil sector and in industry, small high-efficiency power plants spread, the use of renewable sources in small-size plants and the development of innovative technologies in the energy sector (www.minambiente.it).

Budget law

The so called "Budget law" is an ordinary law providing the reference financial framework by approving the annual budget and the legislated long-term budget by 30 September of each year. The 2011 and 2013 national based scenarios include the budget law for the years 2007, 2008 and 2009, namely law 296/2006, 244/2007 and 203/2008 respectively. These provisions introduce restrictions and minimum requirements, support schemes, tax credits and fiscal incentives in several sectors both covered by ETS and non-ETS. For instance, budget law 2007 sets annual minimum quota on biofuel consumption in transport sector and, together with budget law 2008, has modify in some extent the rules of the Green Certificates scheme, which supports electric production from renewables. Furthermore, budget law 2007 and 2008 support energy efficiency in industry by supplying tax credits for high efficiency electric engines and inverters. Finally, the budget laws have been providing for fiscal incentives supporting energy efficiency improvements in the civil sector since 2007.

Reformulation of energy taxation

Planned measures recasting the current taxation on energy products used in the civil sector, in transport and industry. The aim is to promote consumption of low carbon fuels and supporting energy efficiency.