UNIVERSIDAD PONTIFICIA COMILLAS

ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)

OFFICIAL MASTER'S DEGREE IN THE ELECTRIC POWER INDUSTRY

Master's Thesis

INFLUENCES OF ENERGY EFFICIENCY MEASURES ON ELECTRICITY DEMAND

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Madrid, July 2015

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Summary

Red Eléctrica España is the TSO of the Spanish electricity system. They are wondering how the energy savings from the Energy Efficiency Directive imposed by the European Union are calculated on a European level and on a Member State level and how these will influence the electricity demand in the system. Therefore, the way these energy saving measures are calculated are extensively described on both levels and subsequently the changes on the electricity demand are calculated with the help of GDP forecasts from the IMF and the electricity demand model of Red Eléctrica España including the possible direct rebound effects. Following an analysis is made of the change in electricity demand caused by the energy saving measures.

Foreword

First and foremost I would like to thank my tower of strength Alicia Gonzalez Alarcon for always being there for me. I would like to thank my parents as well for giving me the opportunity to come to Spain and participate in this master although it wasn't always easy for them. Also I would like to thank my sisters for the mental support as well as the people who gave me an accommodation during all this time.

Contents

Abbreviations

REE	Red Eléctrica España
EU	European Union
TSO	Transmission System Operator
GDP	Gross Domestic Product
EED	Energy Efficiency Directive
ESD	Energy Services Directive
NEEAP	National Energy Efficiency Action Plan
SME	Small and Medium sized Enterprises
SWD	Staff Working Document
ETS	Emission Trading System
EC	European commission
VAT	Value-added tax
CO2	Carbon dioxide
GHG	Greenhouse gasses
BU	Bottom up
IDEA	Instituto para la Diversificación y Ahorro de la Energía

1 Introduction

The dependency of the European Union (EU) on energy imports, particularly of oil and gas, forms the origin for policy concerns relating to the security of energy supplies. The increasing dependency from non-member countries has as a result that in 2012 more than half (53,4 %) of the EU-28's gross inland energy consumption came from imported sources.

As long as 15 years ago European policy makers decided that trying to increase the internal supply in Europe would be much more expensive and worse for the environment than reducing demand. Therefore a long term plan was made to address both the improvement of the environment and the reducing of the demand in the Green Paper of 2000.

Following the Energy Efficiency Directive (EED) of 2012, the EU and the member states are obliged to introduce energy efficiency measures to comply with the 20/20/20 target of the EED. This target obliges the EU as a whole to reduce the greenhouse gas emissions by 20%, have a generation of electricity of renewable energy sources of at least 20% of the total electricity production and to improve their energy efficiency by 20% in 2020 compared to projections. 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. Improving energy efficiency also addresses the key energy challenges of climate change, energy security and competitiveness. Energy efficiency is the ratio of output of performance, service, goods or energy, to input of energy. It is currently the most cost-effective way of reducing energy consumption while maintaining an equivalent level of economic activity.

Climate change was and is still a highly debated topic these days in the entire world. Every government feels that addressing climate change will make the country less competitive and therefore they would like other governments to solve the problem. On 24/06/2015 though, a court ordered the Dutch government to cut the country's greenhouse gas emissions by at least 25 percent by 2020. The court agreed that the government has a legal obligation to protect its people against impending dangers, including the effects of climate change on this country much of which is located below sea level and vulnerable to rising sea levels caused by global warming.

The EED establishes a common framework of measures for the promotion of energy efficiency within the EU in order to ensure the achievement of the Union's 20% 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. Energy efficiency in Europe as a whole will be calculated with the odex indicator based on the Odyssee database.

According to the EED every member state has to improve their energy efficiency every year by an accumulative 1.5%. The EU will analyze if every member state is on the correct path to achieve the required targets of energy efficiency. Therefore, each member state has to prepare a National Energy Efficiency Action Plan (NEEAP) every three years. In this NEEAP the member states state the energy efficiency measures that they will apply in their country to comply with the directive.

REE as the Spanish Transmission System Operator (TSO) is responsible for the technical management of the Spanish electricity system. They have to publish their strategic plan for investments every 5 years to be able to operate the transmission system in a reliable and secure way and to minimize times of non served energy. REE uses a top-down econometric load model, that doesn't incorporate the energy efficiency measures of the NEEAP 2014 yet. The load change related to the eventual investments is the main reason they would like to know the influence of these energy efficiency measures on the future demand.

The bottom-up measures of the NEEAP 2014 and the consecutive ones will have a big influence on the future load demand which are unknown today. Therefore, REE would like to investigate what the possibilities are that these measures can have. As bottom-up measures do not take into account rebound effects, these effects have to be considered as well.

This master thesis will focus on the energy efficiency measures that are documented in the NEEAP 2014 plan of Spain, to investigate what their influence can be on the future of the system, taking into account the possible rebound effects.

1.1 Energy intensity

Energy intensity is a measure of the energy efficiency of a nation's economy. The ratio of energy use to GDP is called "energy intensity". The ratio of energy use to GDP indicates the total energy being used to support economic and social activity. It represents an aggregate of energy consumption resulting from a range of production and consumption activities. The energy intensity of a process (energy consumed per unit of output) is the inverse of the "energy efficiency" of the process (output per unit energy consumed). (United Nations, 2005) The ratio of energy use is measured as the gross inland consumption, it is calculated as the sum of the gross inland consumption of the five sources of energy: solid fuels, oil, gas, nuclear and renewable sources. ((EEA), 2014)

To analyze energy efficiency and as a proxy energy intensity in end-use sectors it is necessary to decompose the energy consumption.

There are 3 main purposes of decomposition of energy consumption

- To quantify contributions of each sector to the change in energy consumption
- To track down the origin of energy consumption variations
- To measure the effectiveness of energy policies and technologies

Energy consumption change can be decomposed into three categories (Ang, 2012) :

1. The activity effect (which means The change in the aggregate associated with a change in the overall level of the activity)
2. The structure effect (which means The change in the aggregate associated with a change in the mix of the activity by sub-category)
3. The intensity effect (which means The change in the aggregate associated with changes in the sub-category energy intensities)
4. The residual

Because energy intensities are calculated based on the sectors' economic output (i.e., value added in millions of chained year-2005 dollars), an increase or decrease in energy intensity does not necessarily show the actual change in the energy efficiency of the sector. This is one of the main limitations when energy intensity is calculated based on the economic output of industrial sectors rather than physical output. On the other hand, a physical indicator at this level of aggregation (subsectors) can also be a misleading indicator of energy efficiency. (de la Rue du Can, et al., sd)

2 Proposed Method

As said before, the main objectives of the thesis are to estimate the influence of the energy efficiency measures in the NEEAP 2014 on the future load demand and to get an idea of how the energy saving measures are calculated on a European level and on a MS level. Therefore, the following will be analyzed and studied in this thesis:

The EED will be studied into detail to have a clear understanding of what the exact obligations of the member states are and to serve the establishment of the future plan on how the EU needs to calculate the improvement of energy efficiency as a whole.

The analysis of the 2014 NEEAP will help to get a better view on what Spain is planning to do to be able to comply with the European obligations.

The energy efficiency measures that are to be, or have already been, implemented in Spain, will be studied together with their possible rebound effects. As it is well known that rebound effects depend on the price or income elasticity of electricity it is worth to focus on the concepts of price and income elasticity as well. The electricity savings from the measures will be discounted from the total demand calculated with the model of REE, with updated gdp forecasts to see their impact on the future Spanish electricity demand.

Thanks to the fact that the model of REE is a top-down model and the energy efficiency measures applied in the NEEAP 2014 of Spain were calculated in a bottom up way, the difference between bottom-up and top-down methods for calculating energy efficiency will be explained.

Following this, the change in electricity demand that the energy measures have caused will be analyzed, and a concise explanation on how to deal with the influence of energy efficiency measures on the load in the future, will be given.

3 Energy efficiency in Europe

3.1 Legislation

3.1.1 History

3.1.1.1 Green Paper

The importance of energy efficiency was first mentioned in the Green Paper of 29 November 2000 "Towards a European strategy for the security of energy supply". In this Green Paper the EC mentioned its concerns for the constantly increasing external energy dependency of the EU. At that time 50% of the energy used in the EU was imported and it was estimated that this would increase to 70% in 20 to 30 years if no actions would be taken. It is logical that depending on energy imports increases economic, social and ecological risks for the EU. Energy imports account for a total of 6% of the total imports into the EU.

At that time 45% of the oil imports came from the Middle East and 40 % of the natural gas imports came from Russia.

The Green Paper tackled the issues by creating a strategy for energy security so as to reduce the risks linked to depending on energy imports.

New challenges

The two main challenges mentioned in the Green Paper were:

- Environmental concerns influencing energy choices, most significantly efforts to combat climate change
- The development of the internal market, which has given a new place and a new role to energy demand and could lead to political tensions, e.g. falling prices could undermine efforts to combat climate change. It is up to our societies to find satisfactory compromises

The European Economic Community (EEC) didn´t have as much power as needed to handle these energy issues, and there wasn´t a consensus regarding the energy policy decisions to be made amongst the Member States. Therefore, it was decided not to propose a complete strategy for security of supply, but rather to launch **a debate** on the pending issues.

A long-term energy strategy

The main objective of an energy strategy would be to increase the security of supply of energy products on the market at an affordable price for every consumers At the same time sustainable development and environmental concerns have to be dealt with to improve the well-being of the citizens and to improve the functioning of the market.

The main strategy was to reduce the risks concerning the dependence of energy imports rather than maximizing energy self-sufficiency or minimizing dependence. One of the problems that should be addressed was that the EU relies too heavily on fossil fuels.

Action areas

The Green Paper outlined a long-term energy strategy in which the EU was to take action in the following areas:

- Rebalancing its supply policy by taking clear action in favor of a demand policy.

  There are more possibilities to reducing the demand than to increase the internal energy supply. Therefore, the growth of demand should be controlled by using taxation to change the consumers' behavior. With regard to supply, global warming issues should be prioritized as to for example promoting renewable energy supplies using profitable energies to finance their development.

- Assessing the contribution to be made by nuclear energy in the medium term

  If no action will be taken, the contribution of nuclear energy will decrease more in the future. While assessing the future contribution of nuclear energy, the debate should look at issues such as global warming, security of supply and sustainable development as well. Whatever conclusions will be drawn, research in the area of safe management of nuclear waste must be prioritized.

- Providing a stronger mechanism to build up strategic stocks and to secure new import routes for increasing amounts of oil and gas.

The Green Paper opened a wide debate within the EU on security of supply. Most of the stakeholders who gave their opinion on the proposals in the Green Paper (e.g. Member States and NGOs) were in favor of the strategy proposed, namely the emphasis on controlling demand by, for example, promoting greater energy efficiency.

Given that there was almost unanimous agreement on this approach, the EU has took action by adopting:
- Directive 2001/77/EC on electricity production from renewable sources;
- Directive 2002/91/EC on energy saving in buildings;
- Directive 2003/30/EC on promoting biofuels;
- The White Paper to improve management of the transport sector, which accounts for 32% of energy consumption and 28% of total CO2 emissions.

Oil dependency
Regarding oil stocks, the EU is, dependent on oil resources imported from Non-EU Member Countries. The Commission considered it necessary to increase dialogue between the EU and the countries exporting the energy in order to improve market transparency and conclude satisfactory supply agreements. The Commission is looking at a new approach that would guarantee greater stability of oil stocks among the EU's Member States. The need for strategic gas stocks should also be considered.

Advantages of nuclear
Nuclear energy is an essential part of the debate on security of supply, as the greenhouse gas savings from nuclear energy are equivalent to the emissions from half of the cars on the EU's roads. Opinions still differ on this form of energy, but the nuclear energy possibility remained open. The processing and transportation of radioactive waste was and still is one of the main concerns about nuclear. The EU responded by making nuclear safety a very important issue in negotiations on the access of candidate countries and, in the long term, it was planning to introduce new measures for the EU as a whole.

Harmonization need of Taxes
Harmonization of taxes on energy were deemed necessary at that time. The harmonized taxes were designed primarily to avoid competitive distortions in the energy sector within the Internal Market. The Energy Taxation Directive sets out common rules on what should be taxed, when and which exemptions are allowed. Minimum tax rates, were mainly based on the volume of energy consumed. Above these minimum rates, Member States are free to set their own national rates as they see fit.

Internal energy market
The internal energy market plays an important role in security of supply, as the legislation establishing it seeks not only to achieve more competitive prices but also to impose public service obligations to ensure that there is no breakdown in energy supply. However, there is a need for a more open market and increased intra-Community trade.

The Commission stressed the fact that progress has been made with regard to security of supply but believes that consideration must be given to a global concept of security of supply covering:

- long-term preventive action
- market surveillance mechanisms
- policy instruments
- strengthening relations with Non-EU Member Countries

3.1.1.2 ESD

Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC is also known as the ESD. Its purpose was to make the end use of energy more economic and efficient by:

- Establishing indicative targets, incentives and the institutional, financial and legal frameworks needed to eliminate market barriers and imperfections which prevent efficient end use of energy

- Creating the conditions for the development and promotion of a market for energy services and for the delivery of energy-saving programs and other measures aimed at improving end-use energy efficiency.

The ESD was created because of concerns about CO2 and other greenhouse gases and the human activities associated with the energy sector that are responsible for no less than 78 % of Union greenhouse gas emissions.

General targets for saving energy

Member States needed to adopt and achieve an indicative energy saving target of 9 % by 2016 and they create or appoint one or more independent authorities as to ensure the overall monitoring of the process to achieve the targets which are published in the National Energy Efficiency Action Plan (NEEAP).

Public sector purchasing policy

Member States must ensure that the public sector adopts measures to improve energy efficiency, inform the public and businesses of the measures adopted and promote the exchange of good practice. Member States must appoint one or more new or existing organizations to carry out administrative, management and implementation duties in order to meet their obligations.

Promotion of energy end-use efficiency and energy services

Member States must ensure that energy distributors, distribution system operators and energy retail businesses that sell electricity, natural gas, heating oil and district heating:

- Refrain from any activity which could hamper the supply of energy services, programs to improve energy efficiency and other measures aimed at improving general energy efficiency
- Supply information on their final customers needed to develop and implement programs to improve energy efficiency
- At the discretion of the Member States, possibly using voluntary agreements or other market-based measures, offer and promote energy services to their final customers or offer and promote energy audits and/or measures to improve energy efficiency or contribute to the financial instruments for improving energy efficiency

Member States must ensure that market operators are provided with transparent information on programs and measures to improve energy efficiency.

Member States must also repeal or amend national legislative provisions and regulations which unnecessarily or disproportionately impede or restrict the use of financial instruments or other measures for making energy savings on the energy services market. Model contracts for financial instruments must be made available to interested parties.

They must also develop high-quality energy auditing systems for all final customers aimed at determining which measures can be taken to improve energy efficiency and which energy services it must be possible to provide and prepare for their implementation. Certification following such audits is equivalent to that obtained under the Directive on the energy performance of buildings.

Member States must also ensure that end-users are provided with competitively priced individual metering and informative billing that shows their actual energy consumption. As far as possible, bills must be based on actual energy consumption and must include, in addition to other information, the following: current actual prices and consumption, a comparison of current consumption with consumption for the previous year, contact details of bodies from which information on improving energy efficiency can be obtained. Individual meters must be installed at a competitive price wherever economically and technically feasible.

Finally, Member States must draw up reports in 2011 and 2014 on the administration and implementation of this Directive.

Energy savings according to ESD recommended method

The proposed method for ESD is based on a summation of energy savings by end-use or sub-sector. The final energy savings for each end-use equipment or sub-sector are calculated from the variation of the relevant energy efficiency indicator between 2007 and the year of reporting multiplied by an indicator of activity in the final year at the time of reporting as required by Directive 2006/32/EC.

The indicators have been classified by the Commission in three types, as follows:

- Preferred energy efficiency indicators (P) to be used wherever practicable to measure energy savings at the sub-sectoral level
- Alternative energy efficiency indicators (A) to be used when a lack of data impedes the use of the preferred energy efficiency indicators
- Minimum energy efficiency indicators (M) to be used when the preferred and alternative indicators cannot be applied.

The approach relying on the preferred indicators is very similar to the ODEX approach which will be described below. The only difference may come from the indicator used to represent the unit consumption. For instance, for cars, ODEX used the specific consumption in liters/100 km whereas koe/passenger-km was proposed for ESD.

3.1.2 EED

Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing directives 2004/8/EC and 2006/32/EC also known as the Energy efficiency Directive or EED.

The goal of this Directive is to achieve the Union's energy efficiency target of 20% by 2020 compared to projections and to pave the way for further energy efficiency improvements beyond that date. It includes a requirement for all Member States to set indicative national energy efficiency targets for 2020.

The Directive promotes energy efficiency across the Union through a common framework of measures. They cover every stage of the energy chain, from the transformation of energy and its distribution to its final consumption. Some measures - building on those in the Energy Efficiency Plan 2011 - are legally binding.

3.1.2.1 National energy efficiency targets

Member States had until mid-2014 to bring most of the Directive's provisions into national law. They must notably establish indicative national energy efficiency targets by 30 April 2013. Due for review by the European Commission in June 2014, these targets should be calculated with reference to so-called primary or final energy limits already set for the Union in 2020.

Each Member State must also establish an energy efficiency obligation scheme or equivalent options. The aim is to ensure that energy providers achieve a cumulative end-use 1.5% energy savings target by the end of 2020. These savings will only be counted if they are truly new and additional for final consumers, in each year from 1 January 2014 to the end of 2020.

3.1.2.2 Public bodies

The Directive calls on public bodies at all levels to play an 'exemplary role' in energy efficiency, since they have great potential to stimulate market transformation towards more efficient products, buildings and services. Each Member State must therefore ensure that 3% of the total floor space of heated and/or cooled buildings owned by their central government is renovated each year, taking into account existing obligations in Directive 2010/31/EU.

Member States must establish a long-term strategy for funding the renovation of public and private buildings. They also must assess in depth the energy savings that could be realized from use of high-efficiency cogeneration and efficient district heating and cooling.

Further provisions in the Directive cover help everything from energy audits and metering to consumer billing and help for SMEs.

The Directive contributes to EU efforts to reduce its dependence on energy imports and scarce energy resources, whilst addressing climate change by reducing greenhouse gas emissions in a cost-effective way. It also accelerates the spread of innovative technological solutions and improves Union industry's competiveness. This will boost economic growth and create high-quality jobs, in line with the Europe 2020 Strategy.

The EED 2012/27/EU was published in November 2012 in the Official Journal of the European Union. It does not introduce binding targets at national level, but "binding measures" such as an obligation to renovate public buildings and other initiatives. Key measures of the Directive are:

- That each country has to present national indicative targets by April 2013. If the European Commission estimates that those are insufficient to meet the EU's overall 2020 goal, then it can request member states to re-assess their plans. In the first semester of 2014, the Commission will review the progress towards the 20% energy efficiency target, report on it and assess whether further measures are needed.
- That energy companies should reduce energy sales by 1.5% per year with their customers. However, 25% of the 1.5% annual obligation can be achieved through a series of different measures, in particular: o Early action: Member states will be able to include “early action" taken by energy companies since 2009. Energy Efficiency Policies in the European Union 7 o Countries will also be able to count energy savings made in the energy transformation sector, before it is

distributed to clients. Industries already make under the EU Emissions Trading System for carbon dioxide (EU-ETS) will now be accounted for in the yearly obligation.
- That the public sector should renovate 3% of buildings "owned and occupied" by the central government in each country which focuses on the smaller part of the public stock as many buildings belong to regional or local authorities. Buildings need to have a useful area larger than 500 m2 in order to be covered by this requirement (lowered to 250 m2 as of July 2015).
- That EU countries should set up a roadmap to make the entire buildings sector more energy efficient by 2050 (commercial, public and private households included).
- That energy audits and management plans are required for large companies, with cost-benefit analyses for the deployment of combined heat and power generation (CHP) and public procurement.

Europe started the Odyssee Mure project in 1994 which objective is to provide a comprehensive monitoring of energy consumption and efficiency trends as well as an evaluation of energy efficiency policy measures by sector for EU countries and Norway. The latest projects has 2 main goals:
- Evaluate and compare energy efficiency progress by sector, and relate this progress to the observed trends in energy consumption.
- Contribute to the evaluation of national energy efficiency policy measures and analyze the dynamics of implementation over the NEAAPs.

ODYSSEE is managed by Enerdata and contains detailed energy efficiency and CO2-indicators with data on energy consumption, their drivers (activity indicators) and their related CO2-emissions.

MURE is managed by ISIS (the Institute of Studies for the Integration of Systems which is an independent Italian research institute), that contains a description, with their impact evaluation whenever available, of all energy efficiency measures implemented at EU or national level. (European Commission, 2012)

3.2 Odex

In ODYSSEE, energy savings are derived from ODEX, an indicator that measures the energy efficiency progress by main sector (industry, transport, households and tertiary) and for the whole economy (all final consumers).

The value of an energy efficiency index depends on the degree of sector disaggregation. Efficiency indexes based on unit consumptions calculated at levels that are too aggregated will be influenced by structural effects, which should generally be avoided. The greater the disaggregation, the more structural effects will be removed from the indicator and the closer this indicator will get to the ‘real’ energy efficiency.

However, some structural effects might be considered as energy savings, for example the shift from one process to another. If the cement sector is considered as a single sector, the shift from the wet process to the dry process will be considered as an efficiency improvement in the above formula. If the dry and the wet processes are considered as two different sectors, it will not.

For each sector, the index is calculated as a weighted average of sub-sectoral indices of energy efficiency progress; sub-sectors being industrial or service sector branches or end-uses for households or transport modes.

The sub-sectoral indices are calculated from variations of unit energy consumption indicators, measured in physical units and selected so as to provide the best “proxy” of energy efficiency progress, from a policy evaluation viewpoint. The fact that indices are used enables to combine different units for a given sector, for instance for households kWh/appliance, koe/m2, toe/dwelling…

The weight used to get the weighted aggregate is the share of each sub-sector in the total energy consumption of the sectors.

Energy savings by sector in absolute values (ktoe, GWh) are directly calculated from the ODEX. Indeed, ODEX can also be defined as the ratio between the energy consumption at year t (E) and a fictive consumption that would have happened without energy savings (ES). Therefore, energy savings are equal to:

$$ES = E\ x\ ((\frac{ODEX\ t-1}{ODEX\ t}) - 1)$$

Equation 1

A value of ODEX equal to 90 means a 10% energy efficiency gain.

The weighting method has been defined in such a way that the calculation of energy savings is strictly equal to the sum of energy savings by end-use, with energy savings obtained by multiplying the variation in unit energy consumption by an indicator of activity. For instance, energy savings for refrigerators are equal to the variation in kWh per refrigerator multiplied by the number of refrigerators.

ODEX represents a better proxy for assessing energy efficiency trends at an aggregate level (e.g. overall economy, industry, households, transport, services) than the traditional energy intensities, as they are cleaned from structural changes and from other factors not related to energy efficiency but does not incorporate rebound effects however (more appliances, more cars…).

For each sector, the energy efficiency index is calculated as a weighted average of sub-sectoral indices of energy efficiency progress; sub-sectors being industrial or service sector branches, end-uses for households and transport modes for transport.

3.2.1 Decompositions

The following decompositions will be performed by the EC to analyze the energy efficiency in different sectors, as to estimate as exact as possible the energy efficiency increases in the entire EU. This information can be found as well on the website of odyssee/mure.[1]

3.2.1.1 Services

The variation of the final energy consumption in the tertiary sector (i.e. services) can be explained by:

- An activity effect, measuring the effect of a change in the value added of tertiary
- Structural changes, measured by the change in the structure of the value added by branch
- Productivity effect, measured by the change in the ratio of the value added per employment
- Energy savings, due to a decrease in the energy consumed per employee by branch

The activity effect in tertiary is measured by the variation of the value added multiplied by the energy intensity by branch

Activity effect:

$$EQT_{t/t_0} = \sum_{i=0}^{n} \Delta VA_{i,t/t_0} * I_{i,t_0}$$

Equation 2

EQT: activity effect

VA: value added by branch i

I: Energy intensity by branch i

i: hotel-restaurant, health, education, public, private offices, wholesale and retail trade

[1] http://www.isi.fraunhofer.de/isi-de/x/projekte/odyssee-mure_31-463-3.php

The energy savings are calculated by multiplying the number of employees by the variation of unit consumption per employee by branch.

Energy savings :

$$ESH_{t/t_0} = \sum_{i=0}^{n} \Delta CU_{i,t/t_0} * EMP_{i,t}$$

Equation 3

ESH: energy savings
EMP: number of employees
CUi : Energy consumption per employee in branch i
i: electric, non electric or by branch (hotel-restaurant, health, education, public, private offices, wholesale and retail trade)

The productivity effect is calculated by difference between the energy consumption variations, the activity effect and energy savings effect.

The calculation can be done at an aggregate level if detailed data by branch are not available; in this case we consider the evolution of the unit consumption of the tertiary sector, by separating fuel consumption ("non electric") and electricity

3.2.1.2 Industry

The variation of the final energy consumption in industry can be explained by 5 effects:

1. An activity effect, measuring the effect of a change in the value added of industry, i.e. the effect of the industrial growth
2. Structural changes, measured by the change in the structure of the industrial value added by branch
3. Changes in the value of product, i.e. in the ratio valued added over physical production (for steel, paper and cement) or production index
4. Energy savings, measured by the ODEX, i.e. calculated from changes in specific energy consumption at branch level
5. Other effects: mainly "negative" savings due to inefficient operations in industry

The effect of change in physical production at branch level is actually the sum of three effects: activity, structural changes and value of products.
The sum of "energy savings" and "other effects" show the impact of changes in specific energy consumption at branch level.

The activity effect captures the changes in the value added and measures the impact of the economic activity on the energy consumption. It is calculated by multiplying the energy intensity of the previous year t_0 by the variation of the value added between t and t_0.
Activity effect:

$$EQ_{t/t_0} = \Delta VA_{t/t_0} * \left(\frac{Ct_0}{VAt_0} \right)$$

Equation 4

EQ: activity effect
VA: value added of manufacturing or industry
C: Energy consumption

The effect of structural changes is calculated as the difference between the actual energy consumption Ct and a fictive energy consumption calculated with an energy intensity at constant structure. This fictive energy consumption reflects the variation of the energy intensity assuming a constant structure of value added, between the various branches or sub-branches, so as to leave out the influence of structural changes. In other words, structural changes illustrate the fact that individual branches with different energy intensities are not growing at the same rate.

Structural effect:

$$SE_{t/t_0} = \Delta Cf_{t/t_0} - \Delta C_{t/t_0}, with\ Cf = IEc_t * VA_t$$

Cf: fictive consumption based on the energy intensity at constant structure IEc
C: Energy consumption
IEc: Energy intensity at constant structure
VA: value added in constant prices

Energy savings are based on ODEX.
Energy Savings:

$$ESI = C_t * (\frac{100}{ODEX} - 1)$$

Equation 5

with C_t : Energy consumption
ODEX: Energy savings measured with ODEX

For industry, ODEX is carried out at the level of 12 branches (10 manufacturing branches, mining and construction if available):

- 4 main branches: chemicals, food, textile & leather and equipment goods (machinery and transport equipment);
- 3 energy intensive branches: steel, cement and pulp & paper
- 3 residual branches: other primary metals (i.e. primary metals minus steel), other nonmetallic minerals (i.e. non-metallic mineral minus cement) and other industries.
- Mining industry
- Construction

The unit consumption is expressed in terms of energy used per ton produced for energy intensive products (steel, cement and paper) and in terms of energy used related to the production index for the other branches. The change in the value of products is measured by the ratio of the value added by production index or physical production of the current year t divided by this ratio for the previous year t-1.

The last effect (residual) represents the influence of changes in the value of products measured by the ratio of the value added by production index or physical production of the year t divided by this ratio for the base year t0. It can also be calculated by difference between the total energy variation and the sum of the other effects

3.2.1.3 Transport

The variation of the final energy consumption of transport is decomposed into four main factors:

1. Change in passenger traffic including air and traffic of goods ("activity effect")
2. Energy savings, measuring the impact of the variation of the energy consumption per passenger kilometer or ton-km for each mode of transport
3. Modal shift effect measuring the impact of changes in the distribution of each mode in total traffic of passengers and goods
4. Other effects, i.e. behavioral effects and "negative savings" in freight transport due to low capacity utilization

The activity effect is calculated for the different modes of transport separately and summed up. For passengers, it is calculated by multiplying the variation of the traffic measured in passenger kilometer for each mode (cars, bus, rail, tram and metro), by the specific energy consumption per passenger km at base year. For goods, it is calculated by multiplying the traffic in ton-km of each mode (road, rail, inland waterways) by the specific energy consumption per ton-km at base year.

Activity effect (passenger):

$$EQT_{t/t_0} = \sum_{i=0}^{n} (\Delta pkm_{n,\frac{t}{t_0}} * CU_{n,t-1})$$

Equation 6

Activity effect (good):

$$EQT_{t/t_0} = \sum_{i=0}^{m} (\Delta tkm_{m,\frac{t}{t_0}} * CU_{n,t-1})$$

Equation 7

EQT: activity effect
CU: energy consumption per passenger or good kilometer by mode
n=cars, bus, rail for passengers
m= trucks and light vehicles, rail for goods, inland waterways
pkm : number of passenger kilometer by mode
tkm : number of ton kilometer for goods by mode.

The savings effect is measured by multiplying the variation of the specific energy consumption per passenger-km or ton-kilometer of each mode of transport by the number of passenger/ goods kilometre.

Savings (passenger) :

$$EST_{t/t_0} = \sum_{i=0}^{n} (\Delta pkm_{n,t} * CU_{n,t/t_0})$$

Equation 8

Savings (goods) :

$$EST_{t/t_0} = \sum_{i=0}^{m} (\Delta pkm_{m,t} * CU_{m,t/t_0})$$

Equation 9

EST: savings effect
CU: energy consumption per passenger or good kilometer for all transport mode
n=cars, bus, rail for passengers
m= trucks and light vehicles, rail for goods, inland waterways
pkm: number of passenger kilometer by mode
tkm: number of ton kilometer for goods by mode

At an aggregate level (for passengers or for goods), an additional effect can be calculated, a modal shift effect, corresponding to difference between the sum of savings of each mode for passenger and goods respectively and the aggregate savings calculated directly for passenger or goods as a whole. Indeed modal shift illustrates a change in the distribution of each mode in terms of traffic (for example a decreasing share of public transport in passenger traffic contributed to increase the consumption).

Modal shift for passenger as a whole:

$$MST_{t/t_0} = EST - (\Delta CU_{t/t_0} * pkm_t)$$

Modal shift for goods as a whole:

$$MST_{t/t_0} = EST - (\Delta CU_{t/t_0} * tkm_t)$$

For cars, the variation of the energy consumption is influenced by:

- Change in traffic in passenger-km and distance travelled ("activity effect")

- A “technical efficiency effect”, reflecting the change in the efficiency of cars measured in litre per 100km
- Other effects, which include a substitution effect and the effect of changes in the average rate of car occupancy (person/car). The substitution effect reflects the impact of changes in fuel mix: from gasoline to diesel and from oil products to biofuel, both leading to an increase of the average heat content (in toe/litre)

3.2.1.4 Households

The variation of the final energy consumption of households can be explained by:

- Climatic effect due to the difference in the number of degree days between years t and t0 (“climatic effect”)
- A demographic effect, due to the increasing number of dwellings
- A lifestyle effect, due to the increase in the number of households equipment, to larger homes, and to the diffusion of central heating
- Change in floor area of dwelling for space heating (“larger homes”)
- Energy savings, as measured from ODEX
- Other effects (mainly change in heating behaviors)

The demographic effect due to the increasing number of dwellings is calculated as the variation in the number of dwellings multiplied by the energy consumption per dwelling (with climatic corrections):

Demographic effect:

$$DEH_{t/t_0} = \Delta nbrlprt_{t/t_0} * CU_{t_0}$$

Equation 10

nbrlpr: number of permanently occupied dwellings
CU: Energy consumption per dwelling with climatic corrections

Two lifestyle effects may also influence the energy consumption of households: the increase in the household equipment ownership (electrical appliances and central heating) and in the increasing size of dwellings (i.e. larger homes).

The increasing number of equipment per households is due on one hand to the increasing number of electrical appliances (ICT, small electrical appliances, air conditioning in Southern countries), larger homes which requires more energy and central heating which requires around 25% more energy compared to single room heating6 .

The increasing number of electrical appliances is approximate with the electricity consumption of large appliance (refrigerators, freezers, TV, washing machine, dish washers) per dwelling in relation with the overall index for electrical appliances (based on the evolution of the electricity consumption per appliances weighted by their energy share). For small appliances and lighting, we take into consideration the energy consumption per dwelling.

The “central heating’ effect is calculated as a ratio between the unit consumption per m2 (with climatic corrections) and the unit consumption per equivalent dwelling7 (with climatic corrections).

Energy savings are based on ODEX, expressed in Mtoe.

Energy Savings:

$$ESI = C_t * (\frac{100}{ODEX} - 1)$$

Equation 11

For ODEX, the following indicators are considered to measure efficiency progress:

- Heating: unit consumption per m2 at normal climate (koe/m2)
- Water heating: unit consumption per dwelling with water heating
- Cooking: unit consumption per dwelling
- Large electrical appliances: specific electricity consumption, in kWh/year/appliance

3.2.1.5 Agriculture

The variation of the final energy consumption in agriculture can be explained by:
- An activity effect (measured by the variation of the value added)
- Energy savings

The activity effect is calculated by multiplying the energy intensity of the base year by the variation of the value added between t and t0.

Activity effect:

$$EQ_{t/t_0} = \frac{\Delta VA_{t/t_0}}{VA_{t0}} * C_{t0}$$

Equation 12

VA: value added of agriculture
C0: Energy consumption

The energy savings in agriculture are calculated by multiplying the value added of the year t by the variation of the energy intensity between year t and the previous year t-1.

Energy savings:

$$ESH_{t/t_0} = \Delta I_{t/t_0} * VA_t$$

Equation 13

VA: value added of agriculture
I: Energy intensity (ratio consumption and value added

3.2.1.6 Final energy consumption

The decomposition of the final energy consumption variation is calculated by combining the sectoral decomposition, i.e. by adding the contribution of the different drivers by end-use sector (industry, transport, households, services and agriculture) in broad categories, as follows:

- Activity: change in the economic activity (value added in industry and agriculture, number of employees in services), in the number of dwellings, more traffic for passenger and goods in transport)
- Demography effect due to the increasing number of dwellings
- Lifestyle effect (due to the increase in the number of household equipment and cars, larger homes, change in car occupancy)
- Structural effects: due to a change in the structure of the value added in industry among the various branches, or due to modal shift in transport
- Energy savings (as measured from ODEX)
- Climatic effect in households and services

3.2.1.7 Primary energy consumption

Decomposition of the primary energy consumption Total energy consumption or gross inland energy consumption represents the quantity of energy necessary to satisfy the energy demand of a country. According to the EED, the primary energy consumption means gross inland consumption, excluding non-energy uses.

The variation of the gross inland energy consumption is explained by:

- The variation of the final energy consumption for energy uses
- The variation of the net consumption of the power sector in three effects (changes in electricity consumption, changes in thermal power efficiency and changes in the power mix between thermal, renewables and nuclear)
- The variation of the consumption for non-energy uses

3.2.1.8 Power sector

Three main effects explain the variation of the net consumption for power generation:

- The increased consumption of electricity, that all things being equal, contribute to increase the losses in power generation; this effect, called "electricity penetration" in short, is the result of two factors:
  - increased market share of electricity in the final consumption
  - increase in the total final consumption
- Changes in the power mix (share of renewables, nuclear and thermal)
- Variation in the efficiency of thermal power generation

These last two effects are calculated as the difference between the actual consumption of the power sector in year t and a fictive consumption:

- At year t_0 power mix and power efficiency of year t : power mix effect
- At year t_0 efficiency and power mix of year t: efficiency effect

4 National targets

The EED was published in the Official Journal on 14 November 2012, and entered enter into force on 4 December 2012. Member States had to transpose it by the 5th of June 2014. The EED puts forward legally binding measures to step up Member States' efforts to use energy more efficiently at all stages of the energy chain, from the transformation of energy and its distribution to its final consumption. The most important requirements of the Directive, in terms of future energy policy, are set out briefly below.

In order to reinforce the political commitment made by the Member States in the 2020 Strategy of the EU the EED clearly defines and quantifies the EU energy efficiency target as the ''Union's 2020 energy consumption of no more than 1 474 Mtoe primary energy or no more than 1 078 Mtoe of final energy'' for the first time. With the entry of Croatia on the 1st of July 2013, the targets have been adjusted to ''no more than 1 483 Mtoe primary energy or no more than 1 086 Mtoe of final energy''.

The correct and complete implementation of the EED will play a very important role in achieving the EU 2020 20% energy efficiency target which in turn will be an input for the EU 2030 framework for climate and energy policies. The assessment of progress towards the indicative national energy efficiency targets set by the Member States in accordance with Article 3 of the EED will contribute to the discussion about what types of target and at what level might be appropriate for 2030.

The EED requires the Member States to set national indicative energy efficiency targets for 2020, which can be based on different indicators and will be discussed later. Member States had to notify these targets and how they translate in terms of primary and final energy use in 2020 to the Commission by 30 April 2013 either as part of the National Reform Programs or with a different way of communication.

This information has been fed into the European Semester process, and is being evaluated as an element in assessing the likely achievement of the overall EU target by 2020 and the extent to which the individual efforts will meet the target goal. The national indicative energy efficiency targets as a whole, suggest that the Member States aim to achieve only about 16.4% primary energy savings and 17.7% final energy savings by 2020 which is not the full 20% needed to meet the EU's overall target.

The Directive also required Member States to establish and publish by 30 April 2014 their long term strategies for building renovation, a crucial obligation given that nearly 40% of final energy consumption is in houses, public and private offices, shops and other buildings. Public sector buildings must show a good example, 3% of buildings owned and occupied by central governments should be renovated each year to the level the Member State has set under the Energy Performance of Buildings Directive. The leading role of the public sector is also recognized in the parts of the EED about public procurement, in which the central government is required, under certain conditions, to purchase the most energy efficient products, services and buildings.

Member States must ensure that a certain amount of energy savings are realized over the 2014-2020 period at consumer level by establishing an energy efficiency obligation scheme or some alternative policy measures.

All enterprises are also encouraged to have energy audits, and for companies that are not SMEs it is obligatory every 4 year. Member States are required to develop programs to encourage SMEs to undergo energy audits and to raise awareness amongst households about the benefits of energy audits. Through the identification of energy saving possibilities, energy audits will be the basis for the development of a market for energy services as well.

The EED contains specific requirements on metering and billing for final customers because information on energy consumption is crucial if consumers are to make informed decisions.

About 30% of the EU's primary energy is used by the energy sector, mainly for transforming energy into electricity and heat. Therefore, the EED aims to maximize grid and infrastructure efficiency, promotes demand response and sets in place obligations and encouragement for the greater use of high-efficiency cogeneration and district heating and cooling.

The energy system and society as a whole need to become significantly more energy efficient according to European policy makers. Improving energy efficiency is a priority in all decarbonization scenarios presented in the Energy Roadmap 2050 and therefore the prime focus should be on energy efficiency.

An analysis of trends in key indicators suggests that, with strong energy efficiency policies and full implementation of the EED, the EU could get on track for meeting its target in 2020. If that is achieved, annually up to 2020, European households and industries energy costs would be some €38 billion lower, the need for investment in energy generation and distribution would be around €6 billion lower and there would be about €24 billion invested in the improvement our homes and offices, which provides a better competitive edge of the industries and creates local jobs.

According to the EED each country has to set an indicative national energy efficiency target based on of the following types of energy consumption:

- **Primary energy consumption** : gross inland consumption, excluding non-energy uses
- **Final energy consumption** : all energy supplied to industry, transport, households, services and agriculture. It excludes deliveries to the energy transformation sector and the energy industries themselves
- **Energy savings (primary or final)** : energy savings' means an amount of saved energy determined by measuring and/or estimating consumption before and after the implementation of an energy efficiency improvement measure, whilst ensuring normalization for external conditions that affect energy consumption
- **Energy intensity** : The ratio of energy use to GDP

When doing so, they shall also express those targets in terms of an absolute level of primary energy consumption and final energy consumption in 2020 and shall explain how, and on the basis of which data, this has been calculated.

When setting those targets, Member States have to take into account

- that the Union's 2020 energy consumption has to be no more than 1 483 Mtoe of primary energy or no more than 1 086 Mtoe of final energy;
- the measures provided in the EED;
- the measures adopted to reach the national energy saving targets adopted pursuant to Article 4(1) of Directive 2006/32/EC; and
- other measures to promote energy efficiency within Member States and at Union level.

In the EED articles 6, 7, 8, 14 and 15 explain how Member States have to achieve the total amount of energy efficiency increase that is required. Therefore these articles will be explained a bit, especially article 7 is important for the objective of this thesis. Therefore, it will be explained more in-depth.

4.1 EED Article 6: Purchasing by public bodies

Article 6 requires Member States to ensure that central governments purchase only products, services and buildings with high energy-efficiency performance. The Directive indicates what these items are and what level of performance they must meet by referring to criteria established under a number of EU legislative measures such as the Energy Labelling Directive 2010/30/EU2 and the Energy Performance of Buildings Directive 2010/31/EU.

4.2 EED Article 7: Energy efficiency obligation schemes

4.2.1 Introduction

Article 7 is responsible for half the energy savings the EED should achieve. It is a complex article and some provisions should start to apply before the end of the EED transposition period. The Article requires Member States to establish energy efficiency obligation schemes or use alternative policy measures to achieve a certain targeted amount of energy savings amongst final consumers. The energy savings to be achieved by energy efficiency obligation schemes and alternative measures under paragraph 9 must be at least equivalent to achieving new savings each year from 1 January 2014 to 31 December 2020 of 1.5% of the annual energy sales to final consumers of all energy distributors or all retail energy sales companies by volume averaged over 2010, 2011 and 2012. Furthermore, the amount can be reduced by Member States by up to 25% using four specific possibilities which are explained in 4.2.2.4.

As "new" savings are required, not everything that Member States have done at any time in the field of end-use energy efficiency can count for the purposes of Article 7. Energy savings obtained from individual actions within the obligation period (i.e. from 1 January 2014 to 31 December 2020) can be counted, even if the policy measure that gave rise to the actions was adopted/introduced before 1 January 2014. By 5 December 2013 the Member States had to notify to the EC their detailed planned, proposed or legally defined methodology for the workings of their energy efficiency obligation scheme, and as well the policy measures they plan as alternative measures.

In establishing the policy measures, the MS's need to follow a number of steps:

1. Establish the total quantity of energy savings that has to be achieved and its spread over the obligation period (see 4.2.2).
2. Decide whether to use energy efficiency obligation schemes or alternative policy measures, or both, and, while designing the schemes or measures, ensure that certain criteria are met (see 4.2.3).
3. Establish which sectors and individual actions are to be targeted so that the required amount of energy savings is achieved (see 4.2.4).
4. Establish how energy savings from individual actions are to be calculated (see 4.2.5).
5. Ensure control, verification, monitoring and transparency of the scheme or alternative policy measures (see 4.2.6).
6. Report and publish the results.

4.2.2 Calculation of energy savings

The quantity of energy savings that is to be achieved over the seven-year obligation period (1 January 2014 to 31 December 2020) is calculated in the same way regardless of the methods that will be used to achieve it

4.2.2.1 Datasets to be used in the calculation

The average of the annual energy sales, to final customers of all energy distributors or all retail energy sales companies for the three years before 1 January 2013, i.e. for 2010, 2011 and 2012 needs to be calculated to calculate the overall amount of savings that are required. Therefore, the following terms have to be defined :

- Energy distributor means a natural or legal person, including a distribution system operator, responsible for transporting energy with a view to its delivery to final customers or to distribution stations that sell energy to final customers
- Retail energy sales company means a natural or legal person who sells energy to final customers
- Final customer means a natural or legal person who purchases energy for own end use

So the Directive prescribes that all final energy (with the possible exception of energy used in the transport sector) that is sold to a natural or legal person is included in the calculations.

Energy volumes transformed on site and used for own-use, and those that are used for the production of other energy forms for non-energy use, are excluded.

In terms of statistical datasets to be used in the calculation of the required amount of savings, the Commission services consider that the Eurostat categories "Final energy consumption" and possibly partially or fully excluding "Final energy consumption – transport" contain the elements that are required in Article 7, paragraph 1. Using Eurostat categories would mean that any possible double counting is avoided.

Eurostat definitions

- **Final energy consumption** covers energy supplied to the final consumer's door for all energy uses. It is the sum of final energy consumption – industry, final energy consumption - transport and final energy consumption - household, commerce etc...

- **Final energy consumption – industry** covers the consumption in all industrial sectors with the exception of the "Energy sector". The fuel quantities transformed in the electrical power stations of industrial auto-producers and the quantities of coke transformed into blast-furnace gas are not entered under overall industrial consumption but under transformation input.

- **Final energy consumption – transport** covers the consumption in all types of transportation, i.e., rail, road, air transport and inland navigation.

- **Final energy consumption – households**, commerce, etc. covers quantities consumed by private households, services, agriculture/forestry, fishing and non-specified.

- In addition, for information **final non-energy consumption** covers the use of energy products for non-energy purposes. It is the sum of final non-energy consumption in the chemical industry and in non-chemical industries.

This way the following categories are automatically excluded from the calculation:

- Final non-energy consumption
- Input to auto-producers thermal power stations
- Input to blast-furnace plants
- Electricity used for purposes of balancing of energy system that has not occurred at final energy user level

The use of electricity for electric cars and energy generated by households for their own use can be excluded from this calculation. However, Member States would need to develop a methodology and justify this in the notification to the Commission.

4.2.2.2 Calculating overall amount of energy savings

The next step is to multiply by 1.5% the average figure of 2010, 2011 and 2012 to calculate the new yearly amount to be saved. In addition each individual energy-saving action is considered to deliver savings not only in the year of implementation, but it will also deliver savings in future years up to 2020. For this reason, the required amount of savings has to be accumulated year-on-year (if not, one year's actions could be considered enough to fulfil the entire requirement). The overall amount to be reached over the whole period is therefore a sum of the following cumulative percentages as can be seen in Table 1.

For example, a Member State could have an energy use of 102 million tons of oil equivalent (Mtoe) in 2010, 98 Mtoe in 2011 and 100 Mtoe in 2012 – giving an average of 100 Mtoe for the three years before 1 January 2013. The total amount of savings required in this Member State in relation to 2014 through the implementation of Article 7 would therefore be (100 x 1.5% x 1 year) = 1.5 Mtoe. The total amount required in relation to 2015 would be (100 x 1.5% x 2 years) = a cumulative 3 Mtoe. Similar calculations can be performed for each of the subsequent years, up to 2020 in relation to which the total amount required would be (100 x 1.5% x 7 years) = 10.5 Mtoe. This implies that the total amount of energy savings required over the whole seven-year period would be 42.0 Mtoe.

Year	Energy savings [Mtoe]							Total
2014	1.5							1.5
2015	1.5	1.5						3.0
2016	1.5	1.5	1.5					4.5
2017	1.5	1.5	1.5	1.5				6.0
2018	1.5	1.5	1.5	1.5	1.5			7.5
2019	1.5	1.5	1.5	1.5	1.5	1.5		9.0
2020	1.5	1.5	1.5	1.5	1.5	1.5	1.5	10.5
Total	**42.0 Mtoe**							

Table 1 Cumulative energy savings

4.2.2.3 Spreading of the energy savings over the seven-year obligation period

If energy efficiency obligation schemes are used, there is no obligation to report how the effort is spread over the obligation period. However, Member States should establish how the savings are to be phased over the period.

4.2.2.4 Exemptions to save less energy than the target

There are certain possibilities that allow for certain national circumstances to be taken into account and can lead to a lower amount of end-use energy savings required to be achieved over the seven-year period.

The following four possibilities are included in the text:

a) Calculation based on a lower annual saving rate
b) Full or partial ETS industry exclusion
c) Counting certain energy savings from energy transformation and transmission sectors
d) Early actions after end-2008 that still deliver savings in 2020

Possibilities (a) and (b) are related to the overall amount of energy savings to be achieved. The other two possibilities (c) and (d) are related to the question of which energy savings can be counted towards the achievement of the required amount of energy savings.

There is no limitation on Member States' choice or combination of these four possibilities except that, all the selected possibilities taken together must amount to no more than 25% of the savings required under Article 7(1).

4.2.3 Policy instruments

4.2.3.1 Energy efficiency obligations & other measures

Article 7 sets out that the required amount of energy savings is achieved through national energy efficiency obligation schemes or other policy measures. These policy measures need to be designed to achieve end-use energy savings which are among final customers and are defined as a regulatory, financial, fiscal, voluntary or information provision instrument formally established and implemented in a Member State to create a supportive framework, requirement or incentive for market actors to provide and purchase energy services and to undertake other energy efficiency improvement measures.

This wording excludes policy measures that are primarily intended to support policy objectives other than energy efficiency or energy services as well as policies that trigger end-use savings that are not achieved among final consumers. Examples of such policy measures would be construction of new roads to ease traffic congestion, various energy grid networks charges, or feed-in tariffs.

Energy efficiency obligations schemes

Each Member State has to set up an energy efficiency obligation scheme. That scheme shall ensure that energy distributors and/or retail energy sales companies achieve a cumulative end-use energy savings target by 31 December 2020. That target shall be at least equivalent to achieving new savings each year from 1 January 2014 to 31 December 2020 of 1,5 % of the annual energy sales to final customers of all energy distributors or all retail energy sales companies by volume, averaged over the most recent three-year period prior to 1 January 2013. The sales of energy, by volume, used in transport may be partially or fully excluded from this calculation.

The energy efficiency obligation schemes, are mandatory schemes, established by a Member State, that place an obligation on energy providers to achieve savings amongst final consumers. The energy providers subject to obligations under these schemes are obligated parties and are to be designated by each Member State, on the basis of objective and non-discriminatory criteria, amongst the energy distributors and/or retail energy sales companies operating on its territory. Transport fuel distributors or transport fuel retailers operating on a Member State's territory may also be included, irrespective of whether the energy used in the transport sector is included in the calculation and irrespective of whether individual actions in the transport sector are allowed to be counted within the schemes.

Member States must establish how the calculated amount of energy savings is to be phased over the obligation period. To allow obligated parties flexibility in how they reach the required savings, Member States may permit them to obtain energy savings from energy service providers or third parties, provided there is in place a process of approving these savings. Energy efficiency obligation schemes can also be used to promote social aims, such as tackling energy poverty. Member States may allow parties obligated under an energy efficiency obligation scheme to fulfill their obligations by contributing to the Energy Efficiency National Fund. The contributed amount should be equal to the investments which obligated parties would otherwise have to make to achieve the amount of savings they would be required to achieve.

Alternative policy measures

The alternative policy measures could take different forms. The following are some of the possibilities:

1. Energy or CO_2 taxes

   These are taxes established by a Member State that have the effect of reducing end-use energy consumption. The party under these schemes is an 'implementing public authority', which 'is a body governed by public law which is responsible for the carrying out or monitoring of energy or carbon taxation, financial schemes and instruments, fiscal incentives, standards and norms, energy labeling schemes, training or education'

2. Financing schemes and instruments, and fiscal incentives

   These are policy measures established by a Member State that lead through a monetary and fiscal incentive to the application of energy-efficient technology or techniques and have the effect of reducing end-use energy consumption. The monitoring of this policy measure must be carried out by an 'implementing public authority' or 'entrusted party'. An 'entrusted party' is a legal entity with delegated power from a government or other public body to develop, manage or operate a financing scheme on behalf of the government or other public body. In case of the financing schemes or instruments the funding ought to come either only from public sources (European or national) or from a combination of both public (European or national) and private (e.g. banks, investment funds, pension funds) sources explicitly targeting the realization of individual actions that lead to end-use energy savings.

3. Energy Efficiency National Fund

In terms of European funding, it is to be noted that Member States shall devote at least 20% of the European Regional Development Fund allocation for 2014-2020 in more developed regions, 15% in transition regions and 10 to 12% in less developed regions, to renewable energy and energy efficiency. This can be any fund established by a Member State with the purpose of supporting national energy efficiency initiatives. The monitoring of this policy measure must be carried out by an 'implementing public authority' or 'entrusted party'. To count for the purposes of Article 7, the funding ought to come either only from public sources (European or national) or from a combination of both public (European or national) and private (e.g. banks, investment funds, pension funds, obligated parties) sources explicitly targeting the realization of individual actions that lead to end-use energy savings.

4. Regulations and voluntary agreements

These are policy measures established by a Member State that lead to the application of energy-efficient technology or techniques and have the effect of reducing end-use energy consumption. These could be legally binding measures that impose specific energy efficiency technologies or techniques or voluntary agreements where actors - industry or local authorities - commit to certain actions. Those participating in these policy instruments are called 'participating parties' and include 'enterprises or public bodies that have committed themselves to reaching certain objectives under a voluntary agreement, or are covered by a national regulatory policy instrument'.

5. Standards and norms

These are policy measures (such as building codes, minimum performance requirements for processes) established by a Member State that aim to improve the energy efficiency of, for example, products, services, buildings and vehicles. Standards and norms that are 'mandatory and applicable in Member States under Union law' do not count.

6. Energy labeling schemes

These are labeling schemes established by a Member State, with the exception of those that are mandatory and applicable in that Member States under Union law (e.g. savings coming from the pure introduction of an Energy Label as required under Energy Labeling Directive cannot be counted). It should be noted that careful consideration of the impact of such labels is required so as to establish the link between the label and the individual actions attributable to it.

7. Training and education, including energy advisory programs

These are policy measures established by a Member State that lead to the application of energy-efficient technology or techniques and have the effect of reducing end-use energy consumption through, for example, training programs for energy auditors, education programs for energy managers or energy advisory programs for households. The monitoring of this policy measure must be carried out by an 'implementing public authority'. It should be noted that careful consideration of the impact of such measures is required so to establish the link between the training or education activity and the individual actions attributable to it.

8. Other alternative policy measures

The list is not exhaustive and other policy measures may be applied. However, Member States must explain in their notification to the Commission how an equivalent level of savings, monitoring and verification will be achieved. To reduce the administrative burden and provide for a comprehensive policy framework a Member State may group all individual policy measures to implement Article 7 into a comprehensive national energy efficiency program. Any combination of the policy instruments mentioned above may be used. Because of the diverse nature of the challenges for the different end-use sectors, there could be different policy instruments that target each of these sectors. For example, a Member State could achieve part of the required savings through a new or existing energy efficiency obligation scheme; part through new or existing financial policy instruments for the residential sector; part through agreements with industrial sectors; part through fiscal policies (such as CO_2 taxes); and part through the implementation of the energy audit provisions; and part through local programs for the promotion of more efficient urban transport.

4.2.3.2 Double counting

The combination of several policy measures may result in the realization of a single individual action. No double counting of energy savings coming from this individual action can be made. The method to ensure this has to be decided at a national level.

4.2.4 Target sectors and individual actions

4.2.4.1 Limitations to the choice of sectors

Article 7 aims to save energy end use and there are no limitations as to which final energy use sectors can be targeted. Savings from policy measures in the transport sector and ETS industries may be counted, even if these sectors' energy use has been excluded from the calculation of the overall amount of energy savings.

In addition to end-use energy savings, some Member States may decide to target certain supply side savings from the energy transformation, distribution and transmission sectors, including efficient district heating and cooling infrastructure.

4.2.4.2 From which individual actions can savings be counted?

To quantify the impact of policy measures, only energy savings that are a result of real actions that result from the implementation of these policy measures can be taken into account. Savings can be counted from any actions that save energy and are undertaken as a result of a policy measure of a Member State.

The automatic rolling out of EU legislation cannot be taken into account. Member States may not count actions that would have happened anyway. The activities of the national public sector parties that are implementing the policy measure must have contributed to the realization of the carrying out of the action and the subsidy or involvement of the obligated, participating or entrusted party must have had more than only a minimal effect in the end user's decision to undertake the energy efficiency investment.

In some cases, only savings that go beyond the minimum requirements originating from EU legislation can count. This is relevant for individual actions that are a result of energy efficiency obligation schemes, alternative policy measures and a national energy efficiency fund, are related to, for example, the following EU laws :

- For products : the requirements established by implementing measures under the Ecodesign Directive

- For new passenger cars and light commercial vehicles : the emission performance standards established by Regulations 443/2009 and 510/2011

- For taxes : the minimum levels of taxation applicable to fuels as required in Council Directive 2003/96/EC on restructuring the Community framework for the taxation of energy products and electricity or in Council Directive 2006/112/EC on the common system of value added tax.

There are no limitations on the type of end-use energy saving measures that can be counted.

4.2.4.3 Timing of the individual actions

Because new savings are required, Member States can not count everything they have done as policy measures in the area of end-use energy efficiency for the purposes of Article 7. The Article contains rules to define when actions need to take place in order to be counted towards the energy savings required.

Two broad approaches could have been taken:

- The requirements of the Article could have had to be fulfilled by new policy measures. Savings from policy measures that existed before a given cut-off date could have been excluded; or

- The requirements of the Article could have had to be fulfilled by new individual actions. Savings from individual actions undertaken after the cut-off date could have been counted, even if the policy measure that had given rise to the actions had been introduced before that date.

Savings from individual actions carried out within the obligation period (after 1 January 2014 and until 31 December 2020) can be counted, even if the policy measure that gave rise to the actions was introduced before that date.

4.2.5 Energy saving calculation from each individual action

4.2.5.1 Quantity attributed to each action

The rules on what quantity of energy savings can be attributed to each individual action are to be established by Member States in accordance with the framework set in Article 7 and Annex V.

For all policy measures except taxation the principles in Annex V, part 1 must be followed. In part 1, four methods for calculating the savings for different types of action are mentioned:

- **Deemed savings**, by reference to the results of previous independently monitored energy improvements in similar installations. The generic approach is termed 'ex-ante';
- **Metered savings**, whereby the savings from the installation of a measure, or package of measures, is determined by recording the actual reduction in energy use, taking due account of factors such as additionality, occupancy, production levels and the weather which may affect consumption. The generic approach is termed 'ex-post';
- **Scaled savings**, whereby engineering estimates of savings are used. This approach may only be used where establishing robust measured data for a specific installation is difficult or disproportionately expensive, e.g. replacing a compressor or electric motor with a different kWh rating than that for which independent information on savings has been measured, or where they are carried out on the basis of nationally established methodologies and benchmarks by qualified or accredited experts that are independent of the obligated, participating or entrusted parties involved;
- **Surveyed savings**, where consumers' response to advice, information campaigns, labeling or certification schemes, or smart metering is determined. This approach may only be used for savings resulting from changes in consumer behavior. It may not be used for savings resulting from the installation of physical measures.

For energy efficiency obligations, deemed and scaled savings have to date been the most commonly used methodologies.

Member States will need to determine the eligible energy efficiency measures for which there are independently proven or well established energy saving norms. For these measures, deemed or engineering savings can be used. It is recommended that Member States publish information on how the deemed or scaled savings are determined and what quantity of savings is attributed to different individual measures and to ensure that this information is openly accessible. **This information was not openly accessible. It was requested from IDAE, but unfortunately they didn't share this information.**

For policy measures that are taxes, the calculation is based on elasticities of demand with respect to the price to estimate how the price increases caused by the tax only (i.e. not from inflation or other policies) would lead to changes in consumers' behavior.

If several types of policy measures are used in combination, e.g. an energy efficiency obligation scheme and fiscal incentives double counting must be avoided and it must be clear which of the achieved savings attributes to which measures.

4.2.5.2 Lifetime of energy efficiency improvements

Having decided what amount of energy savings is to be attributed to each individual action, the next step is to establish over what period this action will continue to deliver energy savings. Article 7 focuses on the quantity of savings that must be achieved by 2020. A Member State may choose to attribute to each individual action the 'real' savings that this action will achieve between the year of its implementation and 2020. This method is called hereafter the "straightforward" method.

Alternatively, and in particular to promote long-term energy efficiency improvements, Member States may deviate from this method - provided that their choice still leads to the required quantity of energy savings, actually being achieved by 2020. Member States that have savings schemes in place have addressed this problem in different ways. All of these are more complicated than the 'straightforward' approach.

4.2.6 Measurement, control, quality, monitoring and verification

Proper measurement, control, quality, monitoring and verification of savings has to be ensured according to the provisions of paragraphs 6 and 10.

The following relevant elements are required to be reported:

- quality standards
- monitoring and verification protocols and how the independence of these from the obligated, participating or entrusted parties is ensured
- audit protocols

Member States have to lay down rules on effective, proportionate and dissuasive penalties applicable in case of non-compliance with the national provisions adopted and must take the necessary measures to ensure that they are implemented.

4.3 EED Article 8: Energy audits and energy management systems

An energy audit is a procedure which has as a purpose obtaining knowledge about the energy consumption profile of a building or group of buildings, an industrial or commercial operation or installation or a private or public service, identifying and quantifying cost-effective energy saving opportunities, and reporting the findings.

Energy audits are an essential tool to achieve energy savings. They are necessary to assess the existing energy consumption and identify the opportunities to save energy. This should result in proposals of saving measures for the management, public authorities or home owners. Furthermore, energy audits allow the identification and prioritization or ranking of opportunities for improvement. In this way, energy audits tackle the information gap that is one of the main barriers to energy efficiency.

Through the identification of energy saving possibilities and proposed recommendations or follow-up, audits are also the basis for the development of a market for energy services. Energy audits may also be part of a broader environmental audit that considers storage possibilities, connection to district heating and cooling networks or potential for demand response in industries and commercial buildings. A private or public service, e.g. city public transport system, may also be subject to an energy audit that results in the identification of cost-effective energy saving opportunities.

Having an energy management system in place requires enterprises to carry out detailed energy review processes, which also result in the systematic identification and reporting of energy saving opportunities. This may also be the case for enterprises implementing environmental management systems.

4.4 EED Article 14: Promotion of efficiency in heating and cooling

The overall objective of Article 14 is to encourage the identification of cost effective potential for delivering energy efficiency, mainly through the use of cogeneration, efficient district heating and cooling and the recovery of industrial waste heat. But when these are not cost effective, other efficient heating and cooling supply options have to be searched. Member States are required to identify the potential for high-efficiency cogeneration and efficient district heating and cooling and to analyze the costs and benefits of the opportunities that may exist. Article 14(4) then requires Member States to take adequate measures to ensure these are developed if there is cost-effective potential.

Efficient heating and cooling encompasses principally the use of heat from cogeneration and renewable energy sources, the recovery of waste heat from industrial processes to meet demand for heating and cooling, and in general all those heating and cooling options that achieve primary energy savings compared to a baseline scenario. It is therefore a comprehensive concept that covers all heating and cooling options in line with the general definition of energy efficiency provided in the Directive.

4.5 EED Article 15: on Energy Transformation, Transmission and Distribution

The aim of article 15 is to maximize grid and infrastructure efficiency and to promote demand response. There are 3 main obligations which will be discussed below.

4.5.1 Network tariffs and regulation

National regulatory authorities have to pay attention to energy efficiency in carrying out there regulatory tasks specified in Directives 2009/72/EC and 2009/73/EC.

The transmission and distribution tariffs have to be defined in a way that there are no incentives for reducing energy efficiency because these tariffs allow suppliers to improve consumer participation in system efficiency, including demand response, depending on every countries circumstances.

4.5.2 Demand response

- National regulatory authorities encourage demand side resources, such as demand response, to participate alongside supply in wholesale and retail markets;
- Access and participation of demand response in balancing, reserve and other system services markets is promoted, requiring that the technical or contractual modalities to promote participation of demand response in such markets –including the participation of aggregators- be defined;

- High-efficiency cogeneration operators can offer balancing services and other operational services, where technically and economically feasible and subject to the safety and reliability requirements of the grid; and
- Transmission system operators and distribution systems operators, in meeting requirements for balancing and ancillary services, treat demand response providers, including aggregators, in a non-discriminatory manner (this is subject to technical constraints inherent in managing networks).

4.5.3 Operation and design of the gas and electricity infrastructure

- National regulatory authorities, within the framework of Directive 2009/72/EC and taking into account the costs and benefits of each measure, provide incentives for grid operators to improve energy efficiency;
- Rules relating to the ranking of the different access and dispatch priorities, where such priorities are granted in their electricity systems, are clearly explained and published; and
- An assessment and improvement of energy efficiency in the design and operation of the gas and electricity infrastructure is undertaken.

4.6 Policy measures Spain NEEAP 2014

The following measures are being or were introduced in order to obtain the required energy efficiency results and are mentioned in the Mure database :

Sector	Title	Status	Type	Starting Year
Household	PAREER Program (Aids Program for Energy Rehabilitation in Buildings in Household and Hotel Sectors).	Ongoing	Financial	2014
Transport	PIVE Program- Efficient Vehicle Incentive Program	Ongoing	Financial	2012
Transport	Efficient Driving Program in the Driving License of new drivers	Ongoing	Information/Education/Training	2013
Transport	MOVELE 2014 Program	Ongoing	Financial	2014
Transport	Plan to promote Environment (PIMA Aire)	Ongoing	Financial	2014
General cross-cutting	JESSICA-F.I.D.A.E Fund (Energy Saving And Diversification Investment Fund)	Ongoing	Financial Measures	2013
General cross-cutting	Law on Tax Measures for Energy Sustainability	Ongoing	Fiscal Measures/Tariffs	2013
General cross-cutting	Energy Efficiency Obligation Scheme	Proposed(advanced)	Legislative/Normative Measures	2015
General cross-cutting	National Energy Efficiency Fund	Ongoing	Financial Measures	2015

Table 2 Policy Measures for energy efficiency in Spain

Forecast cumulative final energy savings in ktoe								
	2014	2015	2016	2017	2018	2019	2020	Total 2014-2020
OTHER PROGRAMMES DIRECTLY IMPLEMENTED BY IDAE	**84**	**87,9**	**85,6**	**85,6**	**85,6**	**85,6**	**85,6**	**599,8**
MOVELE Project	1,6	1,6	1,6	1,6	1,6	1,6	1,6	11,4
PIVE 3	3,5	3,5	3,5	3,5	3,5	3,5	3,5	24,8
PIVE 4	17,1	17,1	17,1	17,1	17,1	17,1	17,1	119,7
PIVE 5	51	51	51	51	51	51	51	356,9
PAREER plan	1,8	3,7	7,4	7,4	7,4	7,4	7,4	42,5
JESSICA fund	2,9	4,9	4,9	4,9	4,9	4,9	4,9	32,5
Communication campaign	6	6						12
OTHER PROGRAMMES AND MEASURES	**93,5**	**170,4**	**170,4**	**170,4**	**170,4**	**170,4**	**170,4**	**1116**
PIMA Sol	8,4	8,4	8,4	8,4	8,4	8,4	8,4	58,9
PIMA Aire	8,2	8,2	8,2	8,2	8,2	8,2	8,2	57,3
Efficient driving permit	76,9	153,8	153,8	153,8	153,8	153,8	153,8	999,8
TOTAL	**177,5**	**258,3**	**256**	**256**	**256**	**256**	**256**	**1715,8**

Table 3 Estimated energy savings from the ongoing measures

The Spanish 2011–2020 Energy Efficiency Action Plan, drafted to satisfy the requirements of Directive 2006/32/EC, evaluated the savings obtained as a result of previous plans up to 2010, using the years 2004 and 2007 as references; the first for being the reference year for the 2004–2012 Energy Saving and Efficiency Strategy and the Action Plans deriving from it (2005–2007 Action Plan and 2008–2012 Action Plan), and the second for being the reference year commonly adopted by all Member States.
In that Action Plan, an integrated top-down and bottom-up approach was followed, in accordance with European Commission recommendations. In the new Spanish 2014–2020 NEEAP, to facilitate understanding and interpretation of the results in terms of savings, the calculations were made following a bottom-up approach. But use of the final intensity indicator, calculated according to GDP, as a single top-down indicator in the new Plan offers a single result for all sectors covered by Directive 2006/32/EC.

In summary, it can be said that the savings were calculated (for each of the sectors of final use, modes or energy uses) as the difference between the value of the indicator in the reference year and the value of the same indicator in 2013, multiplied by the level of activity bottom up (value added, passenger-kilometers transported, tonne-kilometres transported, household stock, population, etc.). If, as anticipated, the energy efficiency indicator is less, the previous calculation offers some energy savings.

The ascending or bottom-up indicators enable, the identification of direct savings attributable to each of the measures individually considered within the action plans as will be explained in 5.2.

4.6.1 Pareer

The Ministry of Industry, Energy and Tourism through the Institute for Energy Diversification and Saving (IDAE), has implemented a specific program to promote comprehensive actions favoring energy efficiency improvement and the use of renewable energies in the housing stock of existing buildings in the residential sector, and also to comply with article 4 of Directive 2012/27/EU, relating to energy efficiency. This program, allocated with 125 million euros, is estimated to be implemented between October 2013 and October 2015.

The actions are to fit one or more of the following typologies:
1. Improvement of the thermal envelope energy efficiency.
2. Improvement of energy efficiency in thermal and lighting installations.
3. Replacement of conventional energy for biomass in thermal installations.
4. Replacement of conventional energy with geothermal energy in thermal installations

The actions subject of this aids are to improve the total energy rating of the building by at least one letter on the carbon dioxide emission scale (kg CO2/m2 year) as compared to the initial energy rating of the building.

Eligible beneficiaries of the aids from this Program are:

- Natural and legal persons, owners of residential and hotel buildings.
- Associations of property owners or Associations of residential-building property owners.
- Owners of single-family houses or sole owners of residential buildings.
- Energy service companies.

The kind of aid (repayable loan and/or repayable loan) depends on the kind of action:

Action	**Total Economic support (M€)**	**Maximum Public Aid**	**Maximum Loan**
Casing	31,25	30% eligible cost	60% eligible cost
Improvement of lighting and thermal installations	31,25		90% eligible cost
Biomass	31,25		90% eligible cost
Geothermic	31,25		90% eligible cost

Table 4 Pareer aids and loans

According to this, the measure is deemed to produce a total amount of 42.5 ktoe of accumulated saving during the 2014 – 2020 period.

4.6.2 PIVE

PIVE Program was approved in Cabinet Meeting of 27 September 2012 with an initial budget allocation of M€ 75, with a view to promoting the replacement of vehicles, passenger cars and light-commercial vehicles and enhancing the purchase of efficient vehicles with lower fuel-consumption levels.

The Program will facilitate the scrapping of vehicles over 10 years' old in the case of passenger vehicles and of seven years' old in the case of light-commercial vehicles, and their replacement with high-efficiency models with lower fuel consumption and CO_2 emission levels. The price of the purchased vehicles, before VAT, cannot be over 25,000 Euros except for electric, plug-in hybrid and range-extended vehicles, in which case the limit is set at 30,000 Euros. This very limit will be applied to beneficiaries such as large families applying for vehicles of over five seats, and disabled persons purchasing adapted vehicles.

The public aid amounts to a thousand Euros per vehicle (1,500 for large families and adapted vehicles). The manufacturer, importer, dealer or selling point is to contribute with an additional discount amounting to the same figure. These aids are compatible with others in force whenever these come from the Regional Governments' own funds and from European funds.

PIVE Program management is carried out under IDAE's responsibility, an activity that started with the accession of the sales points to the program so wishing, and accounts now for a total number of 2,885 car dealers registered as collaborators.

PIVE Program was enforced on 1 October 2012 through a first announcement (PIVE Plan), set out through a Ruling of Ruling of 28 September 2012, of the Secretariat of State for Energy. Its initial success, along with the market forecast which advises maintaining measures of the kind, have accounted for the continuity of PIVE Program. This is materialized with other four additional announcements (PIVE 2, PIVE 3, PIVE 4 and PIVE 5 Plans), with slight amendments in the eligibility criteria for financial aid granting (age reduction of the vehicle to be scrapped, acknowledgement of disabled people as beneficiary, etc.).

	PIVE 1	**PIVE 2**	**PIVE 3**	**PIVE 4**	**PIVE 5**
Budget (M€)	75	150	70	70	175
Nº Vehicles to renew	75,000	150,000	70,000	70,000	173,940
Launching	October 2012	February 2013	July 2013	October 2013	January 2014

Table 5 Pive budget

The experiences of the Fuel-Efficient Vehicle Incentive Program in its various calls - whose funds have run out in a shorter time than initially envisaged – accounts for the excellent response this Program has received.

Taking the energy and environmental impact PIVE, PIVE 2, PIVE 3 and PIVE 4 Plans have had on the Fuel- Efficient Vehicle Incentive Program, the accumulated energy saving estimated nears 127 million liters fuel a year, the equivalent to 808,000 barrels of petrol, and a significant reduction of greenhouse effect gases amounting to 262,000 tons CO_2/year. This has been possible with the renovation of nearly 365,000 passenger cars and light commercial vehicles.

4.6.3 Efficient Driving Program in the Driving License of new drivers

This program is the result of the compulsory introduction of efficient driving in the training and assessment of new drivers to achieve their driving license from 1 January 2014.

Order INT/229/2013 was published 2 December 2013, modifying Annexes I, V, VI and VII of the Drivers' General Regulation, approved in turn by Royal Decree 818/2009 of 8 May, and Order INT/2323/2011 was published on 29 July, regulating the training to have progressive access to Class A driving license.

This order introduces a demand for training and knowledge in efficient driving from 1 January 2014 for all new drivers. In practice, it is equivalent to the delivery of courses in efficient driving to all new drivers since these are to be trained both in theory and in practice on the subject to achieve the driving license, and the said knowledge shall be taken into account in control tests.

The public authority in charge of the implementation of these measures is the Directorate-General for Traffic, dependent on the Ministry of the Interior. The parties involved are the entire network of driving schools and training centers on vehicle driving in Spain.

The beneficiaries of the program are all the candidates to obtain the vehicle driving license with the exception of motorbikes (Class A driving license).

4.6.4 Electric Mobility Program (MOVELE 2014 Program)

MOVELE 2014 Program takes place within the Comprehensive Strategy to Promote the Electric Vehicle in Spain 2010-2014, which consists in a series of measures meant to determinedly promote the introduction of electric vehicles by as enhancing the demand of these vehicles, endorsing the manufacturing and R&D of this technology, facilitating the adaptation of the electric infrastructure for a suitable recharge and demand management, and promoting a series of cross-cutting programs related to the spreading, communication, training and standardization of these technologies.

These measures on the promotion of electric vehicles do not only intend to promote more efficient and eco-friendly technologies but also facilitate a wider use of vehicles of this kind so as to contribute to a better exploitation of renewable energies, favor the CO2 emission reductions in places with a higher concentration and reduce the dependence on oil derivatives, all of which gives Spain the chance of having an outstanding place in an evidently emergent market.

MOVELE 2014 Plan entails an extension or continuity of the 2011, 2012 & 2013 aid programs. To this end, the Plan has a budget allocation of €M 10 for the direct granting of aids to purchase new electric vehicles. Additionally, other aids will be provided to funding operations for financial leasing and renting or operational leasing for these vehicles, on condition that the agreement should be in force for at least two years.

All the vehicles supported with the measure are to comply with Directive 2007/46/EC of the European Parliament, and of the Council of 5 September 2007, establishing a framework for the approval of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, depending on the case, as well with Directive 2002/24/EC of the European Parliament and of the Council of 18 March 2002 relating to the type-approval of two or three-wheel motor vehicles. The latter Directive was incorporated into the Spanish legal system through Royal Decree 2028/1986 of 6 June, establishing the regulations to implement specific ECC directives, relating to the type-approval of motor vehicles, trailers and semi-trailers, as well as the spare parts of the said vehicles.

The above-mentioned aids, regulated by Royal Decree 414/2014 of 6 June, will be allocated by the IDAE, the appointed managing body of incentives of this kind as a result of its success with PIVE Program, on the management of incentives to efficient vehicles. The beneficiaries of this program may be natural persons, self-employed professionals and private firms. The purchase of vehicles has to take place from 1 January 2014 to 31 December of the same year and applications have to be filed in the management telemetric system of MOVELE 2014 Program aids of the Institute for Energy Diversification and Saving (IDAE).

4.6.5 Plan to Promote the Environment with Efficient Vehicles (PIMA Aire)

Plans to Promote the Environment with Efficient Vehicles (PIMA Aire) (PIMA Aire, PIMA Aire 2 & PIMA Aire 3), are meant to improve air quality in Spain with the renewal of the commercial vehicle fleet and its replacement with more efficient models and with lower environmental impact, as well as the purchase of electric and hybrid motorbikes, mopeds, and electric motor pedal-assist bikes.

PIMA Aire Plans make up a global strategy designed and implemented by the Ministry of Agriculture, Fisheries and Food and the Environment, aimed at improving air quality in Spain through the renewal in the Spanish market of the current car fleet by more efficient models with a lower environmental impact. This will contribute to a significant reduction of air pollutant emissions and of greenhouse effect gases, as well as an improvement of energy efficiency in diffuse sectors.

The total budgetary allocation for these plans amount to M€43.5, of which M€38 correspond to PIMA Air and PIMA Air 2 Plans, which were enforced on 10 February and 26 October 2013, respectively, and which remained operational until the fund run out on 26 April 2014. For its part, Pima Air 3 Plan has been operational since 6 March 2014 and will end up when the allocated fund of M€5.5 runs out.

PIMA Air Plan is aimed at the scrapping of old commercial vehicles, as well the renewal of motorcycles, hybrid mopeds and electric bikes. The third edition of these aids brings in two new aspects: on the one hand, not only firms and self-employed professionals can join these aids but also individuals; and on the other hand, second-hand vehicles under one year old will also be subject to these aids.

The aids in the case of commercial vehicles amount to 1,000 euro per vehicle in category M1, or N1 for under 2,000 kg. As regards category N1 for equal or over 2,500 kg, the amount reaches 2,000 euro per vehicle. In both cases, the aid is subject to the application - by the selling point - of an invoice discount equivalent to the aid amount. The vehicles purchased under these categories have to be categorized in compliance with the energy efficiency classifications stated on the database "Fuel Consumption and CO2 emissions in new cars", drafted by the IDAE, pursuant to Royal Decree 837/2002 of 2 August as Class A, B, C or D. Models fuelled with LPG, Natural Gas and Diesel Gas labeled as enhanced environmentally friendly vehicle (EEV) pursuant to Directive EC 2005/55, as well as type-approved models as pure electric vehicles, plug-in hybrid electric vehicles and of range extended electric vehicles.

The aid amounts to 400 euro plus 200 euro more to purchase electric and hybrid motorbikes, to be provided by the selling point if the scrapping of another vehicle is credited. As regards electric mopeds, the aid amounts to 250 euro plus 100 euro by the selling point, and the buyer must definitely unregister the vehicle. When deregistration of another vehicle is not proved, the aid will amount to 230 euro plus 70 euro provided by the selling point. As regards bikes with electric motor pedal-assist, the aid amounts to 200 euro.

4.6.6 PIMA SOL (Plan for Promoting Energy Renovation in the Hotel Sector)

The Plan to Promote the Environment in the hotel sector, PIMA SOL, approved in Cabinet Meeting on 2 August 2013, is an initiative devoted to reducing greenhouse gas emissions (GHG) in the Spanish tourism sector through the energy renovation of hotel installations. The Ministry of Agriculture, Food and the Environment shall purchase the greenhouse gas emission reductions that are generated in hotels through renovation projects, with a financial aid package allocation of €5,21 million. The Plan will also count on the financing of the European Investment Bank (EIB), which approved on 29 July 2013 a line worth M€ 200 through Spanish banks. The banks would in turn, contribute another M€ 200 with very advantageous interest rates and repayment periods. The beneficiaries of PIMA SOL – to be in force for a year - will be hotel facilities with energy renovation projects meeting the minimum conditions set out in the Plan. Renovation projects are to reach a minimum energy improvement rate that will translate in, at least, two letters higher on the energy rating or else, reach letter B.

Some of the measures included in the Plan are the insulation improvement actions for façades, windows and roofs; the inclusion of control systems for heating & cooling, and lighting; plate waterheating systems; passive heating and cooling systems attained with smarter architecture; more efficient heat-cool equipment; geothermal energy and biomass in heating & cooling; and water-efficient management systems. The provisions stated in Royal Decree 235/2013, of 5 April, approving the basic procedure to certify energy efficiency in buildings, will be taken into account in order to determine eligible projects to achieve a reduction in gas emissions with the Fund's purchase of carbon credits.

The Plan intends to boost the renovation of hotel infrastructures on the basis of a significant reduction of CO_2 emissions in the sector (between 40% and 70%), and also of other pollutants like nitrogen oxide (NO_x) and of particles.

4.6.7 JESSICA-F.I.D.A.E Fund (Energy Saving and Diversification Investment Fund)

Holding Fund F.I.D.A.E. is a fund allocated with nearly M€123, whose aim is to finance urban sustainable development projects to improve energy efficiency, use renewable energies and be developed by energy services companies (ESCOs) or other private enterprises.

It is a Fund co-funded by FEDER and IDAE and operated by the European Investment Bank (EIB). This fund is to finance all the investments directly bound to the issue of energy efficiency and the use of renewable energies in urban environments, and it is compatible with other public or private funding sources, as well as with subsidies either co-funded or not by the FEDER.

These are the conditions that a project must meet to be fundable:

1. Being located in one of the Spanish Regions included in F.I.D.A.E. - Andalusia, the Canary Islands, Castile & Leon, Castile-La Mancha, Ceuta, Valencia, Galicia, Melilla & Murcia Region.
2. Being included in one of the following sectors:

   i. Building: public and private buildings
   ii. Industry: firms of any size
   iii. Transport: infrastructures, equipment and both public and private transport fleet (for public use).
   iv. Public services infrastructures related to energy:

      a) Outdoor public lighting and traffic lights.
      b) Local infrastructures, inclusive of intelligent networks, information technology and communications (TIC) related to priority issues.

3. Take part in one of the priority issues:

   i. Energy Efficiency Projects and energy management:

      a. Renovation of existing buildings, with actions on the thermal envelope, heating installations, cooling, lighting, etc.
      b. New buildings with energy rating A or B.
      c. Renovation or enlargement of the heat/cool existing networks.

   ii. Renewable Energy Projects:

      a. Solar thermal.
      b. Solar PV if integrated in an energy efficiency project.
      c. Biomass

   iii. Projects related to clean transport, contributing to improvement of energy efficiency and the use of renewable energies (electric recharge infrastructures for electric or plug-in hybrid vehicles, braking energy recovery from electric public transport, fleet management, electric or hybrid buses, etc.)

4. Ensuring an acceptable return of the investment.
5. Being included in an integrated plan for sustainable urban development
6. Not being finished on receiving the funding.

The management and marketing of JESSICA-F.I.D.A.E. Fund was entrusted by the European Investment Bank to BBVA through public tender.

4.6.8 Law 15/2012 of 27 December, on tax measures aimed at energy sustainability

Law 15/2012, of 27 December on tax measures aiming at energy sustainability, in force since 1 January 2013, set forth, on a permanent basis, the tax mechanisms meant to send energy end-users a suitable price signal to promote its rational and efficient use. This step is in line with the basic principles regulating the tax, energy and environmental policies in the European Union, with the ultimate purpose of being a stimulus in improving the energy efficiency levels.

This Law has brought in a tax reform with a view to internalizing the environmental costs stemmed from electric power production and the storage of the nuclear fuel spent or the radioactive waste, and therefore, becoming a stimulus to improve Spain's levels of energy efficiency. With this law: regulated: a new tax on the value of electric energy production has been regulated - the tax on the production of the spent nuclear fuel and the resulting radioactive waste from nuclear energy generation; a tax on the storage of the spent nuclear fuel and radioactive waste in centralized plants; a levy has been created for the use of continental waters in electric power production; the established tax rates have been modified for natural gas and coal; and the envisaged exemptions for energy products used in producing electric energy and electric power co-generation and useful heat have been withdrawn.

Tax rates for each of the new chargeable events are as follows:

- Tax on spent nuclear fuel (10%).
- Tax on hydropower generation (22%).
- Tax on fossil fuels:
    - Natural gas (cent€2.79 /m3).
    - Coal for electric power generation (€14.97/Tm).
    - Fuel oil for electric power generation (€12.00 /Tm).
    - Diesel oil for electric power generation (€29.15/1000l).
- Tax on electric power generation, on all generation sources, both under the under the ordinary scheme and the Special Scheme (6%).

Law 15/2012, published in the Spanish Official Gazette (BOE) on 27 December 2012, has an impact on related energy product prices from 1 January 2013. The Law is expected to remain so as to keep constant, suitable price signals for consumers, and it is therefore envisaged to maintain this tax measure for the entire Directive's implementation period as an incentive to save energy.

4.6.9 System of Energy Efficiency Obligations

4.6.9.1 Obligated parties

Implementing an energy efficiency obligation scheme that will make it possible to fulfill the target in Article 7(1) of Directive 2012/27/EU requires Member States to designate obligated parties, which must be done on the basis of objective and non-discriminatory criteria. In the case of the energy efficiency obligation scheme that is going to be implemented in Spain, the obligated parties will be electricity, gas and oil product retailers, including transport; Spain will nonetheless make use of the option granted to Member States not to impose this obligation on "small energy distributors, small retail energy sales companies and small energy sectors to avoid disproportionate administrative burdens"

4.6.9.2 Distribution of obligation

Obligations regarding the parties will be established annually, distributing the overall target linearly over the seven-year commitment. The saving target calculated pursuant to Article 7(1) will be distributed among the obligated parties (electricity, gas and oil product retailers, including transport), using as a benchmark the market shares of each of the electricity, gas and oil product retailers whose sales exceed the threshold determined by law. The baseline information for the initial distribution of the targets by sources will be the sales from the 2012 financial year of each and every one of the retailers of these energies that surpass the threshold; in successive years, the baseline information for the distribution of targets will be the sales from the year n-2. The obligations to which the energy retailers operating in Spain will be subject, pursuant to Article 7(1) of Directive 2012/27/EU, will result from applying the market shares of each retailer5 to the previous saving target. The savings obligations will be set in terms of final energy and expressed in GWh.

4.6.9.3 Operation of the obligation scheme

In order to facilitate achievement of the savings arising from the energy efficiency obligation scheme, a standardized energy savings certificate scheme will be developed, based on a catalogue of measures and savings associated with each of these energy efficiency actions and measures. These certificates will be negotiable, and the issuing and registration thereof will ensure transparency in all cases. At the end of each annual period, the obligated parties must provide the certificates obtained that are necessary to fulfill their obligation, or, alternatively, provide an equivalent amount of compensation to the Energy Efficiency National Fund. Diagram 1 below illustrates the general operation of the energy efficiency obligation scheme that will be implemented by Spain.

In accordance with the requirements of point 4 of Annex V, the required details on the operation of the energy efficiency obligation scheme are outlined below. The obligated parties in the scheme that will be implemented in Spain will be all electricity, gas and oil product retailers that, individually, sell to final customers by a volume greater than the threshold determined by law. These companies will be obliged to provide the energy efficiency obligation scheme managing authority (IDAE) with the energy efficiency certificates accrediting sufficient fulfillment of the obligation that has been set for them by law. As managing authority, IDAE will assume the tasks of supervising fulfillment of the energy efficiency obligations by the obligated retail companies.

IDAE will also be responsible for issuing and registering energy efficiency certificates. Any obligated party and/or energy service company (as participating party in the energy efficiency obligation scheme) may request that IDAE issues energy efficiency certificates subject to accreditation of having implemented a measure that led to achieving energy savings among final consumers. The energy efficiency and savings measures that will give rise to the right to have energy efficiency certificates issued for an amount equal to the energy saving arising from the measures must be included in the catalogue. Once completed, the catalogue will include the estimate of the savings (ex ante) that will be accepted from the companies for implementing each of the actions included therein, as well as the full list of the supporting documentation that the companies must submit to the IDAE to request the issuing of the energy efficiency certificates that may apply to them.

Energy service companies and/or obligated parties must obtain explicit approval from the final consumer for the action of promoting, supporting and/or funding investments in energy saving and efficiency measures. These investments will be those that give energy service companies (as participating parties and/or obligated parties) the right to receive energy efficiency certificates for the savings arising from such investments.

The actions included are energy saving and efficiency measures in all final energy consuming sectors: industry, transport, buildings (residential and business use, both privately and publicly owned) and agriculture, considering all the final energy consuming sectors as targets.

The energy saving target arising from applying Article 7 for the entire period 2014–2020 will be distributed linearly and annually. When the rules on the operation of the energy efficiency obligation scheme have been approved by law, an annual ministerial order will lay down the saving targets that will apply to each of the obligated parties, once the savings obtained through the use of the alternative measures have been discounted.

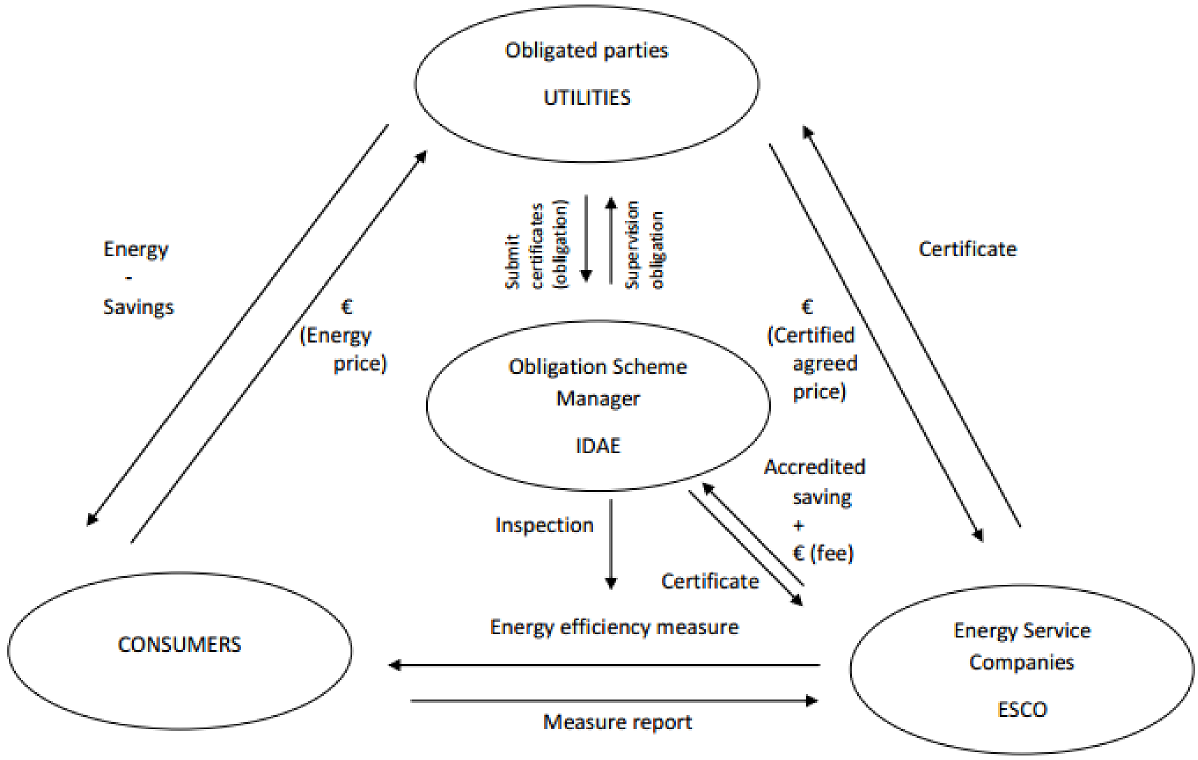

Figure 1 Diagram on the operation of the energy efficiency obligation scheme

4.6.10 National Energy Efficiency Fund

Spain has created a National Energy Efficiency Fund as a means to enhance the enforcement of energy efficiency objectives. The Fund has a nationwide scope and will make up the main support vehicle to the Government's actions to meet the saving objective. Its main goals are the public intervention to obtain efficient saving in mid and long term return periods to which markets do not provide an effective response which is the case of energy renewal in buildings or in transport sectors. The said action may be developed through subsidy programs, preferential funding, guarantee funds, etc.

The Fund will draw its financial sources from the State's General Budget, from the contributions the obliged parties make to meet their duties within the framework of the national Energy Efficiency Obligation Scheme.

5 Top down versus bottom up

5.1 Top down

Generally speaking, descending or top-down indicators define the total savings achieved, either as a direct result of saving and energy efficiency measures implemented, or as an indirect result of the same or a result of other variables. Among these, we note the general evolution of prices or the effect that policies —with distinct saving and energy efficiency objectives— may have had on final energy consumption. The results achieved by descending or top-down indicators (M or P) include, therefore, different effects which aren't always linked, closely, to improved energy efficiency—this is more pronounced when M indicators are used instead of P indicators; logically, the consumption reductions observed in 2010,derived from the economic crisis, were determined by calculating the top- down indicators in all the sectors, for this reason the results of these indicators may not always be improved energy efficiency, since, at times, that which presents itself is the reduction of consumption recorded as a result of less economic activity. The ascending or bottom-up indicators enable, on the contrary, the identification of direct savings attributable to each of the measures individually considered within the action plans.

Top-down energy savings are derived from the multiplication of the variation of a unit energy consumption by an indicator of activity over a reference period. For instance, the energy savings of a given appliance (e.g. refrigerators) are derived from the variation in the average specific energy consumption per appliance (in kWh/year) multiplied by the stock of refrigerators; for example, a reduction of the specific consumption of refrigerators from 400 to 300 kWh in a country with one 1 million of refrigerators will result in total electricity savings equal to 100 GWh.

The final energy savings for each end-use equipment or sub-sector are calculated from the variation of the relevant energy efficiency indicator between the base year and the year of reporting multiplied by an indicator of activity in the final year as required by the ESD. There are four types of energy efficiency indicators:

- Preferred (P) indicators - means preferred energy efficiency indicators to show the savings by end-use,
- Alternative (A) indicators - means alternative energy efficiency indicators,
- Minimum (M) indicators - minimum indicators that can be calculated with Eurostat data (overall energy consumption data) – for industry sector only.

The energy efficiency indicators are calculated in four sectors of energy consumption:

- Households
- Services
- Transport
- Industry

The descending approach uses top-down indicators (called M or P indicators by the European Commission) based on differences between the units consumed in the reference years (2004 and 2007) and the calculation year (2010). These indicators use aggregated information concerning the sector's consumption, means of transport or energy use and statistical data from the different activity variables.

5.2 Bottom up

The ascending or bottom-up (BU) indicators use specific and quality information on each of the actions performed during the analysis period. The result from the same will be the product of the difference between consumption before and after the implementation of the improvement by the number of actions.

There are four steps in the calculation of a bottom up approach:

- Step 1: unitary gross annual energy savings (in kWh/year per participant or unit)
  Example: how much energy is saved annually by using an A+ fridge instead of an A fridge?

  Then we add the number of participants or units

- Step 2: total gross annual energy savings (taking into account the number of participants or units, in kWh/year)
  Example: how many A+ fridges were sold (within the EEI program)?

  Following we add double counting, multiplier effect, + other gross-to-net correction factors

- Step 3: total EED annual energy savings in the first year of the EEI measures (taking into account double counting, multiplier effect, and other gross-to-net correction factors, in kWh/year)
  Example: how many A+ fridges are promoted by more than one EEI program and might be double-counted?

  And ultimately we incorporate the timing and lifetime (within EED period)

- Step 4: total EED energy savings achieved in the year 2016 (in kWh/year, taking account of the timing of the end-use EE action, and its lifetime)
  Example: how many A+ fridges due to the program are still in use in 2016?

6 Elasticity & Rebound Effects

6.1 Elasticity

The degree to which a demand or supply curve reacts to a change in price or income is the curve's elasticity when holding other determinants of demand constant (ceteris paribus).

6.1.1 Price elasticity of demand

Elasticity varies among products because some products may be more essential to the consumer. Products that are necessities are more insensitive to price changes because consumers would continue buying these products despite price increases such as electricity. On the other hand, a price increase of a good or service that is considered less of a necessity will deter more consumers because the opportunity cost of buying the product will become too high.

A good or service is considered to be highly elastic if a slight change in price leads to a sharp change in the quantity demanded or supplied. Usually these kinds of products are readily available in the market and a person may not necessarily need them in his or her daily life. On the other hand, an inelastic good or service is one in which changes in price witness only modest changes in the quantity demanded or supplied, if any at all. These goods tend to be things that are more of a necessity to the consumer in his or her daily life.

To determine the elasticity of the supply or demand curves, we can use the following equation:

Price Elasticity of Demand = (% change in quantity / % change in price)

If elasticity is greater than or equal to one, the demand function is considered to be elastic. If it is less than one, the curve is inelastic.

The demand curve is a negative slope, and if there is a large decrease in the quantity demanded with a small increase in price, the demand curve looks flatter, or more horizontal. This flatter curve means that the good or service in question is elastic.

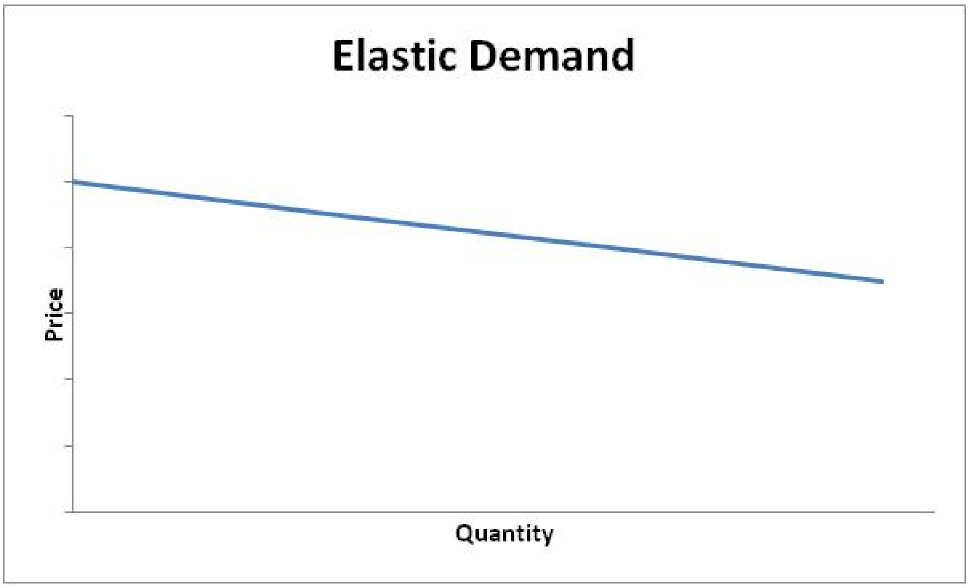

Figure 2 Price elastic demand

Meanwhile, inelastic demand is represented with a much more upright curve as quantity changes little with a large movement in price.

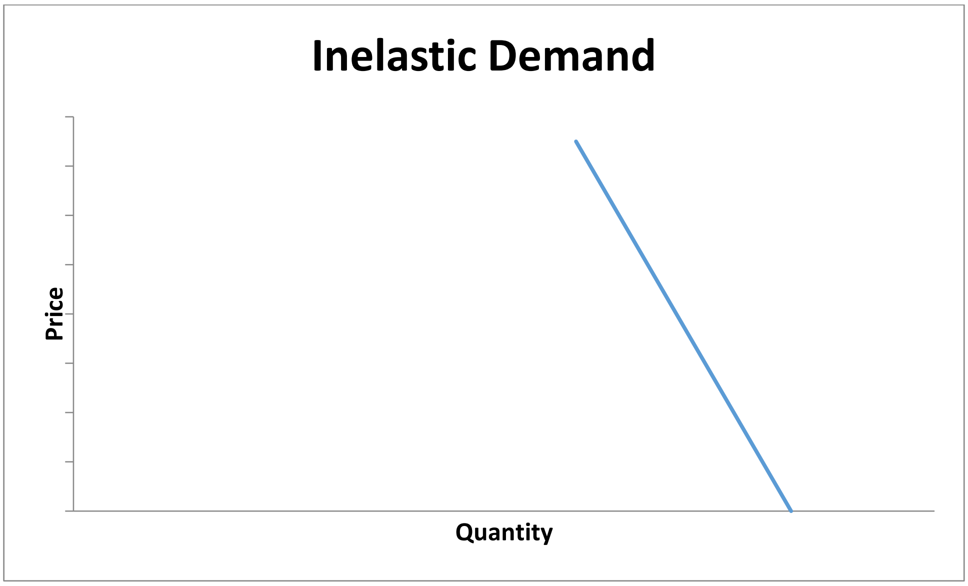

Figure 3 Price inelastic demand

6.1.2 Price elasticity of supply

Elasticity of supply works similarly. If a change in price results in a big change in the amount supplied, the supply curve appears flatter and is considered elastic. Elasticity in this case would be greater than or equal to one.

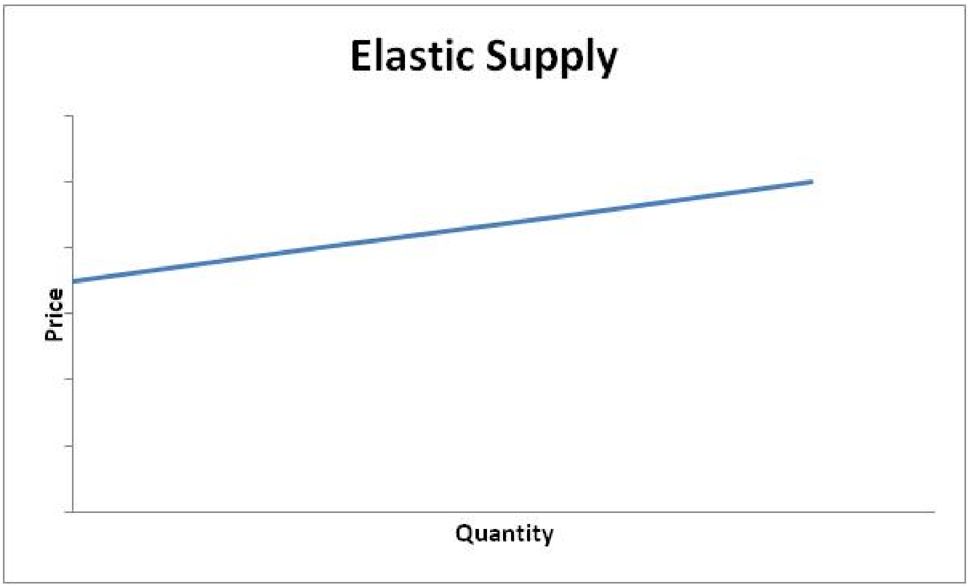

Figure 4 Price elastic supply

On the other hand, if a big change in price only results in a minor change in the quantity supplied, the supply curve is steeper and its elasticity would be less than one.

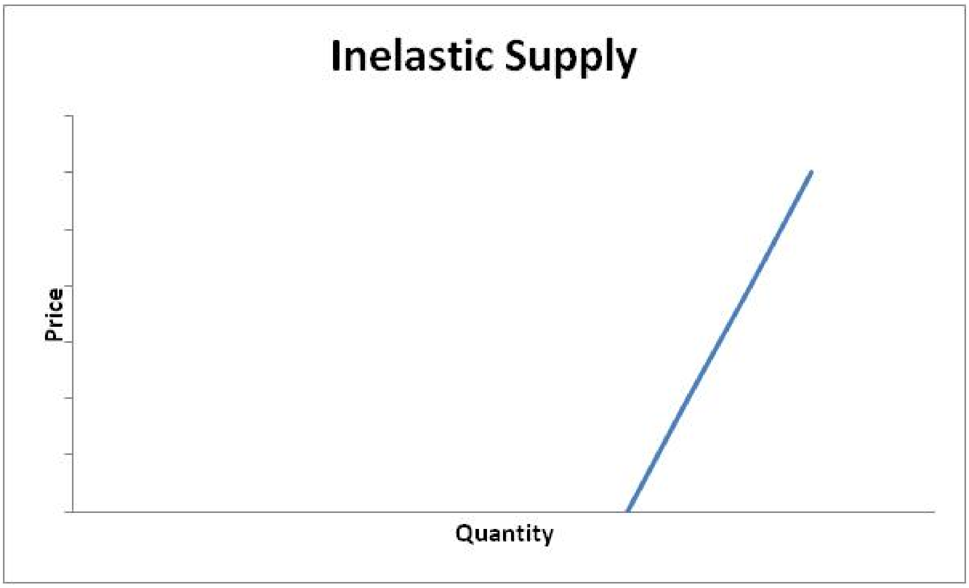

Figure 5 Price inelastic supply

6.1.3 Income Elasticity of Demand

With some goods and services, a decrease in demand is possible as income increases. These are considered goods and services of inferior quality that will be dropped by a consumer who receives a salary increase.

Normal goods have a positive income elasticity of demand. As incomes rise, more goods are demanded at each price level. The quantity demanded for normal necessities will increase with income, but at a slower rate than luxury goods. This is because consumers, rather than buying more of the necessities, will likely use their increased income to purchase more luxury goods and services. During a period of increasing incomes, the quantity demanded for luxury products tends to increase at a higher rate than the quantity demanded for necessities. The quantity demanded for luxury goods is very sensitive to changes in income.

Inferior goods have a negative income elasticity of demand - the quantity demanded for inferior goods falls as incomes rise. For example, the quantity demanded for generic food items tends to decrease during periods of increased incomes.

6.2 Rebound effects

The full rebound effect can be split into three different economic reactions to technological changes:

1. The direct rebound effect
   This refers to increases in consumption of a good because there is a lower cost of use of the good
2. The indirect rebound effect
   This comes from the fact that decreased costs in one consummation enables increased consumption of other goods and services
3. Economy wide effects

These occur because improved technology creates new production possibilities and can increase economic growth

There are three possible outcomes regarding the size of the rebound effect:

1. The rebound effect is negative. In this case the actual resource savings are higher than what was expected
2. The rebound effect is between 0% and 100%. The actual resource savings are less than expected savings. This is the most common rebound effect
3. The rebound effect is higher than 100%. The actual resource savings are negative. This situation is also known as the Jevons paradox or back-fire.

In what follows, the rebound effect calculation of (Sorrell & Dimitropoulos, 2008) will be briefly discussed to explain the formula that was used to obtain the rebound effect results.

The demand for energy (E) derives from the demand for energy services such as heating, transportation and industrial processes. These services, in turn, are delivered through a combination of energy commodities and associated energy systems, including energy conversion devices. Consumers are assumed to derive utility from consuming these services, rather than from consuming energy commodities and other market goods directly. In practice, nearly all services require energy in some form, although energy may form a much smaller proportion of total costs for some services than for others. An essential feature of an energy service is the useful work (S) obtained, which may be measured by a variety of thermodynamic or physical indicators.

The energy efficiency (ε) of an energy system may be defined as ε=S/E, where E represents the energy input required for a unit output of useful work. The energy cost of useful work P_S is given by $P_S = P_E/\varepsilon$, where P_E represents the price of energy.

The direct rebound effect may be estimated from the following energy-efficiency elasticity $\eta_\varepsilon(E)$.
The change in energy demand following a small change in energy efficiency may be measured by the efficiency elasticity of the demand for energy :

$$\boldsymbol{\eta_\varepsilon(E) = \frac{\delta E}{\delta \varepsilon} * \frac{\varepsilon}{E}}$$

Equation 14

Substituting E =S/ε in the equation for $\eta_\varepsilon(E)$ and taking partial derivatives we can derive the following relationship :

$$\boldsymbol{\eta_\varepsilon(E) = \eta_\varepsilon(S) - 1}$$

Equation 15

The actual saving in energy consumption will only be equal to the predicted saving from engineering calculations when this elasticity is zero $\eta_\varepsilon(S)=0$. Under these circumstances, the efficiency elasticity of the demand for energy ηε(E) is equal to minus one.

If other inputs are held constant, we can write the demand for useful work solely as a function of energy prices and energy efficiency: $S = S(P_E/\varepsilon)$. The demand for energy is then given by: $E = S(P_E/\varepsilon)/\varepsilon$. Assuming that energy prices are exogenous (i.e. P_E does not depend upon ε), we can differentiate this equation with respect to energy efficiency to give an alternative definition of the rebound effect:

$$\eta_{\varepsilon}(E) = -\eta_{PS}(S) - 1$$

Equation 16

Hence, under these assumptions, the efficiency elasticity of energy demand ηε(E) is equal to the energy cost elasticity of the demand for useful work $\eta_{PS}(S)$, minus one. Effectively, the negative of the energy cost elasticity for useful work $\eta_{PS}(S)$ is being used as a proxy for the efficiency elasticity of useful work ηε(S), which in turn is the primary definition of the rebound effect. If useful work is a normal good, we expect that $\eta_{PS}(S) \leq 0$.

For example, if the elasticity of vehicle km (S) with respect to energy cost per kilometer (PS) is estimated as −0,10, then the elasticity of gasoline demand with respect to fuel efficiency can be estimated from equation 1 as −0,90. This implies that the demand for gasoline will fall by only 9% if the fuel efficiency of vehicles improves by 10% — or, alternatively, that 10% of the potential savings in gasoline consumption will be 'taken back' by increased vehicle use.

With the elasticities given in *"INFORME SOBRE LAS MEDIDAS DE ACTUACIÓN DE AHORRO Y EFICIENCIA ENERGÉTICA EN CUMPLIMIENTO DEL ARTÍCULO 7"* and the previous mentioned formulas we can calculate the rebound effects of the energy savings measured in 2014 NEEAP Spain on the electricity demand. The rebound effects we calculate are the direct rebound effects, because they are the main effects to be considered for the purpose of this thesis. Indirect energy saving rebounds and economy wide rebound effects can occur, while not changing the electricity demand much. Therefore these will be neglected.

The residential elasticities are confirmed by a study of Fan and Hyndman 2011 who found a range from -0.2 to -0.4, but also found a significant variation by income and time of the year, probably reflecting the different elasticities for different energy services.

Year	Residential electricity	Electricity in service sector	Industrial electricity
2014	-0,236	-0,055	-0,073
2015	-0,287	-0,083	-0,094
2016	-0,338	-0,111	-0,115
2017	-0,388	-0,14	-0,137
2018	-0,439	-0,168	-0,158
2019	-0,489	-0,196	-0,179
2020	-0,53	-0,2	-0,2

Table 6 Elasticities according to NEEAP 2014 Spain

We calculate the rebound for residential electricity for the year 2013 according to **Error! Reference source not found.**, the elasticity of demand for electricity services use in homes with respect to the price of energy is estimated at -0.236 in the year 2014, then the elasticity of electric consumption is equal to -0.764. This implies that the demand for electricity will fall by only 76.4% of the increased efficiency measure, or that the rebound effect is 23.6%.

	Residential electricity	Electricity in service sector	Industrial electricity
2014	-0,764	-0,945	-0,927
2015	-0,713	-0,917	-0,906
2016	-0,662	-0,889	-0,885

2017	-0,612	-0,86	-0,863
2018	-0,561	-0,832	-0,842
2019	-0,511	-0,804	-0,821
2020	-0,47	-0,8	-0,8

Table 7 Efficiency elasticity of energy demand

This way we are able to calculate the rebound effects for electricity saving measures.

7 Model of REE

The model of REE is an econometric top down model which was created by a different university from ICAI and will be treated in this thesis as a black box, in which we enter the data related to the saving measures, and we will analyze the results on the demand that come out of the model.

This means that it is a quantitative analysis based on statistical methods applied to the economic data that REE possesses and has obtained from the ministry of industry.

Based on the previous mentioning of the savings and efficiency elasticity of energy demand, the following data will be implemented into the model :

7.1 Pareer for housing sector

	2014	2015	2016	2017	2018	2019	2020	Total
Residential electricity	-0,764	-0,713	-0,662	-0,612	-0,561	-0,511	-0,47	
PAREER plan	1,8	3,7	7,4	7,4	7,4	7,4	7,4	42,5
PAREER plan with rebound effects	1,375	2,638	4,899	4,529	4,151	3,781	3,478	24,851

Table 8 Pareer energy savings

7.2 Pive for the transport sector

	2014	2015	2016	2017	2018	2019	2020	Total
Transport	-0,764	-0,713	-0,662	-0,612	-0,561	-0,511	-0,47	
PIVE 3	3,5	3,5	3,5	3,5	3,5	3,5	3,5	24,8
PIVE 4	17,1	17,1	17,1	17,1	17,1	17,1	17,1	119,7
PIVE 5	51	51	51	51	51	51	51	356,9
Pive Total	71,6	71,6	71,6	71,6	71,6	71,6	71,6	501,4
Pive total with rebound effects	54,702	51,051	47,400	43,820	40,168	36,588	33,652	307,379

Table 9 Pive energy savings

7.3 Movele for the transport sector

	2014	2015	2016	2017	2018	2019	2020	Total
Transport	-0,764	-0,713	-0,662	-0,612	-0,561	-0,511	-0,47	
MOVELE Project	1,6	1,6	1,6	1,6	1,6	1,6	1,6	11,4
Movele project with rebound effects	1,222	1,141	1,059	0,979	0,898	0,818	0,752	6,869

Table 10 Movele energy savings

7.4 Jessica fund

Because this fund covers the residential, the services and the industry sector, assuming the funds will be equally divided, the average of the rebound effect of the 3 industries will be calculated.

	2014	2015	2016	2017	2018	2019	2020	Total
Residential electricity	-0,764	-0,713	-0,662	-0,612	-0,561	-0,511	-0,47	
Electricity in service sector	-0,945	-0,917	-0,889	-0,86	-0,832	-0,804	-0,8	
Industrial electricity	-0,927	-0,906	-0,885	-0,863	-0,842	-0,821	-0,8	

Average rebound	-0,879	-0,845	-0,812	-0,779	-0,745	-0,712	-0,69	
JESSICA fund	2,9	4,9	4,9	4,9	4,9	4,9	4,9	32,5
Jessica fund with rebound effects	2,548	4,142	3,979	3,814	3,651	3,489	3,381	25,00

Table 11 Jessica Fund energy savings

7.5 Pima Aire

	2014	2015	2016	2017	2018	2019	2020	Total
Transport	-0,764	-0,713	-0,662	-0,612	-0,561	-0,511	-0,470	
PIMA Aire	8,200	8,200	8,200	8,200	8,200	8,200	8,200	57,300
PIMA Aire with rebound effects	6,265	5,847	5,428	5,018	4,600	4,190	3,854	35,203

Table 12 Pima Aire energy savings

7.6 Pima Sol

	2014	2015	2016	2017	2018	2019	2020	Total
Service sector	-0,945	-0,917	-0,889	-0,86	-0,832	-0,804	-0,8	
PIMA Sol	8,4	8,4	8,4	8,4	8,4	8,4	8,4	58,9
PIMA Sol with rebound effects	7,938	7,703	7,468	7,224	6,989	6,753	6,72	50,795

Table 13 Pima Sol energy savings

7.7 Efficient driving permit

	2014	2015	2016	2017	2018	2019	2020	Total
Transport	-0,764	-0,713	-0,662	-0,612	-0,561	-0,511	-0,47	
Efficient driving permit	76,9	153,8	153,8	153,8	153,8	153,8	153,8	999,7
Efficient driving permit with rebound effects	58,752	109,659	101,816	94,126	86,282	78,592	72,286	601,512

Table 14 Efficient driving permit energy savings

The goal in the model would be to see what the effect on the demand is according to the model when the energy savings from the measures are incorporated.

7.8 GDP

The GDP values mentioned in the 2014 NEEAP of Spain are the following:

2014	2015	2016	2017	2018	2019	2020
0,70%	1%	1,40%	1,80%	2%	2,20%	2,40%

Table 15 GDP forecast 2014 NEEAP

These are in fact underestimations in the short term and overestimations in the long term according to the estimations of the IMF[2]. Therefore, the GDP's inserted into the model to obtain the future electricity demand will be the ones forecasted by the IMF which were updated to include the real GDP growth of 2014 [3]

[2] http://ec.europa.eu/economy_finance/eu/countries/spain_en.htm

[3] http://www.imf.org/external/pubs/ft/weo/2015/01/weodata/weorept.aspx?sy=2013&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=65&pr1.y=11&c=184&s=NGDP_RPCH&grp=0&a=

2014	2015	2016	2017	2018	2019	2020
1,389%	2,455%	2,047%	1,768%	1,748%	1,743%	1,745%

Table 16 GDP forecast IMF

Lastly, because the elasticities are estimations we will apply a ±10% change in the value to see how this influences the demand and get a better idea of the influence of errors in the elasticity estimations on the final outcome.

8 Electricity savings calculation

Below the calculation for all the electricity demand savings that are obtained from the energy saving measures are calculated. Everything that involves electricity demand changes is marked in yellow for clarity.

	2014	2015	2016	2017	2018	2019	2020	Total
PAREER plan								
Residential electricity rebound	24%	29%	34%	39%	44%	49%	53%	
savings in ktoe	1,8	3,7	7,4	7,4	7,4	7,4	7,4	42,5
1/4 will save electricity in homes and 1/4*0,15 will save electricity for warming houses[4]	0,9	1,85	3,7	3,7	3,7	3,7	3,7	21,25
savings in ktoe with rebound effects	0,688	1,319	2,449	2,264	2,076	1,891	1,739	12,426
Gwh electricity savings including the rebound effect	**7,997**	**15,341**	**28,487**	**26,335**	**24,14**	**21,989**	**20,225**	**144,513**
+10% rebound effect	**8,244**	**15,958**	**29,941**	**28,005**	**26,029**	**24,093**	**22,505**	**154,775**
-10% rebound effect	**7,750**	**14,723**	**27,032**	**24,665**	**22,251**	**19,885**	**17,944**	**134,25**
Pive								
Transport rebound	24%	29%	34%	39%	44%	49%	53%	
PIVE 3	3,5	3,5	3,5	3,5	3,5	3,5	3,5	24,5
PIVE 4	17,1	17,1	17,1	17,1	17,1	17,1	17,1	119,7
PIVE 5	51	51	51	51	51	51	51	357
Total savings in ktoe	71,6	71,6	71,6	71,6	71,6	71,6	71,6	501,2
savings in ktoe with rebound effects	54,702	51,051	47,399	43,819	40,168	36,588	33,652	307,379
Gwh electricity savings including the rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
+10% rebound effect	**0,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
-10% rebound effect	**0,000**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
No influence								

[4] Data obtained from Encuesta de Presupuestos Familiares (EPF)

	2014	2015	2016	2017	2018	2019	2020	Total
MOVELE Project								
Transport rebound	24%	29%	34%	39%	44%	49%	53%	
savings in ktoe	1,6	1,6	1,6	1,6	1,6	1,6	1,6	11,2
savings in ktoe with rebound effects	1,222	1,141	1,059	0,979	0,898	0,818	0,752	6,869
Gwh energy savings including the rebound effect	14,217	13,268	12,318	11,388	10,439	9,509	8,746	79,884
33 of savings are demand increase because electric cars are using 1/3th of energy of normal cars[5]								
Electricity demand decrease (negative because of increase)	**-4,739**	**-4,423**	**-4,106**	**-3,796**	**-3,48**	**-3,17**	**-2,915**	**-26,628**
+10%rebound effect	**-4,885**	**-4,601**	**-4,316**	**-4,037**	**-3,752**	**-3,473**	**-3,244**	**-28,307**
-10%rebound effect	**-4,592**	**-4,244**	**-3,897**	**-3,555**	**-3,207**	**-2,866**	**-2,587**	**-24,949**
JESSICA fund								
Residential electricity rebound	24%	29%	34%	39%	44%	49%	53%	
Electricity in service sector rebound	6%	8%	11%	14%	17%	20%	20%	
Industrial electricity rebound	7%	9%	12%	14%	16%	18%	20%	
Average rebound	12%	16%	19%	22%	26%	29%	31%	
savings in ktoe	2,9	4,9	4,9	4,9	4,9	4,9	4,9	32,5
savings in ktoe with rebound effects	2,548	4,142	3,979	3,814	3,651	3,489	3,381	25,003
Gwh energy savings including the rebound effect	29,635	48,173	46,273	44,355	42,455	40,575	39,321	290,787
(over) estimation 1/2 is reducing electricity demand	**14,817**	**24,087**	**23,137**	**22,177**	**21,228**	**20,287**	**19,661**	**145,394**
+10% rebound effect	**15,022**	**49,054**	**47,345**	**45,618**	**43,908**	**42,216**	**41,088**	**284,251**
-10% rebound effect	**14,613**	**47,292**	**45,202**	**43,092**	**41,002**	**38,934**	**37,554**	**267,688**

[5] https://www.fueleconomy.gov/feg/evtech.shtml

	2014	2015	2016	2017	2018	2019	2020	Total
PlMA Aire								
Transport	24%	29%	34%	39%	44%	49%	53%	
savings in ktoe	8,2	8,2	8,2	8,2	8,2	8,2	8,2	57,3
svings in ktoe with rebound effects	6,265	5,847	5,428	5,018	4,6	4,19	3,854	35,203
Gwh electricity savings including the rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
+10% rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
-10% rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
For electric bicycle and motos there will almost not be any increase in demand (rough estimation 12MW)								
PIMA Sol								
Service sector	6%	8%	11%	14%	17%	20%	20%	
Savings in ktoe	8,4	8,4	8,4	8,4	8,4	8,4	8,4	58,9
Savings in ktoe with rebound effects	7,938	7,703	7,468	7,224	6,989	6,753	6,72	50,795
Gwh electricity savings including the rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
+10% rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
-10% rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
No influence on electricity demand								
Efficient driving permit								
Transport rebound	24%	29%	34%	39%	44%	49%	53%	
Savings in ktoe	76,9	153,8	153,8	153,8	153,8	153,8	153,8	999,7
Savings in ktoe with rebound effects	58,752	109,659	101,816	94,126	86,282	78,592	72,286	601,512
Gwh electricity savings including the rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
+10% rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
-10% rebound effect	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
No influence								

9 Results

To get an idea of the Spanish evolution, in the past and in the future, of the GDP, the electricity use, the electricity intensity and the energy use, these are all plotted in the graph below. The data that is shown from 1964 till 2012 was obtained from the world bank. After 2012 the data of GDP was calculated according to the changes from the IMF, The electricity intensity and the electricity use were calculated according to the model of REE. The future energy use was obtained from the 2014 NEEAP Spain. As we can see the electricity intensity is going down after 2014, but this is mainly because of the increased efficiency of the overall electricity use, rather than the energy saving measures from the EED as we will explain later. As of 2014 the electricity use is also clearly on the rise again after the effects of the crisis that lasted till 2012-2013. This crisis had as a consequence that the electricity use in 2014 was around the same level as that of 2005 which is a clear sign of how hard the crisis has hit Spain.

What is also remarkable is that in fact the electricity intensity and the GDP seem inversely correlated as of 2003. If the GDP goes up the electricity intensity goes down and the other way around.

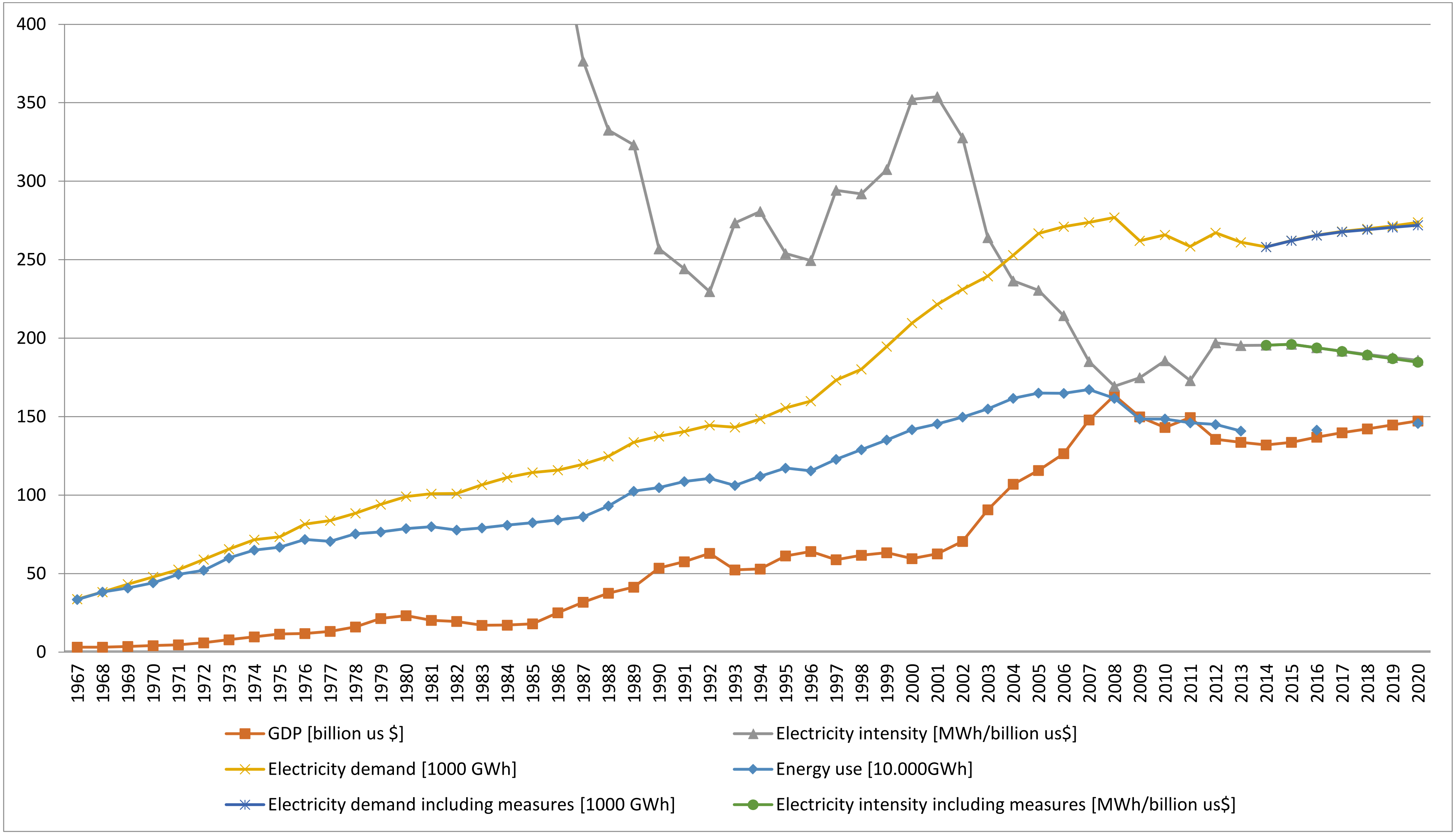

Figure 6 Evolution Energy indicators for Spain

Below we can see the difference between the electricity demand with and without energy efficiency measures in 1000 GWh for 2015 to 2020. As we can observe the changes are not very big. A change in the elasticities of energy service demand, and therefore the rebound effect, of +10 and -10% do not have much of an influence on the predictions.

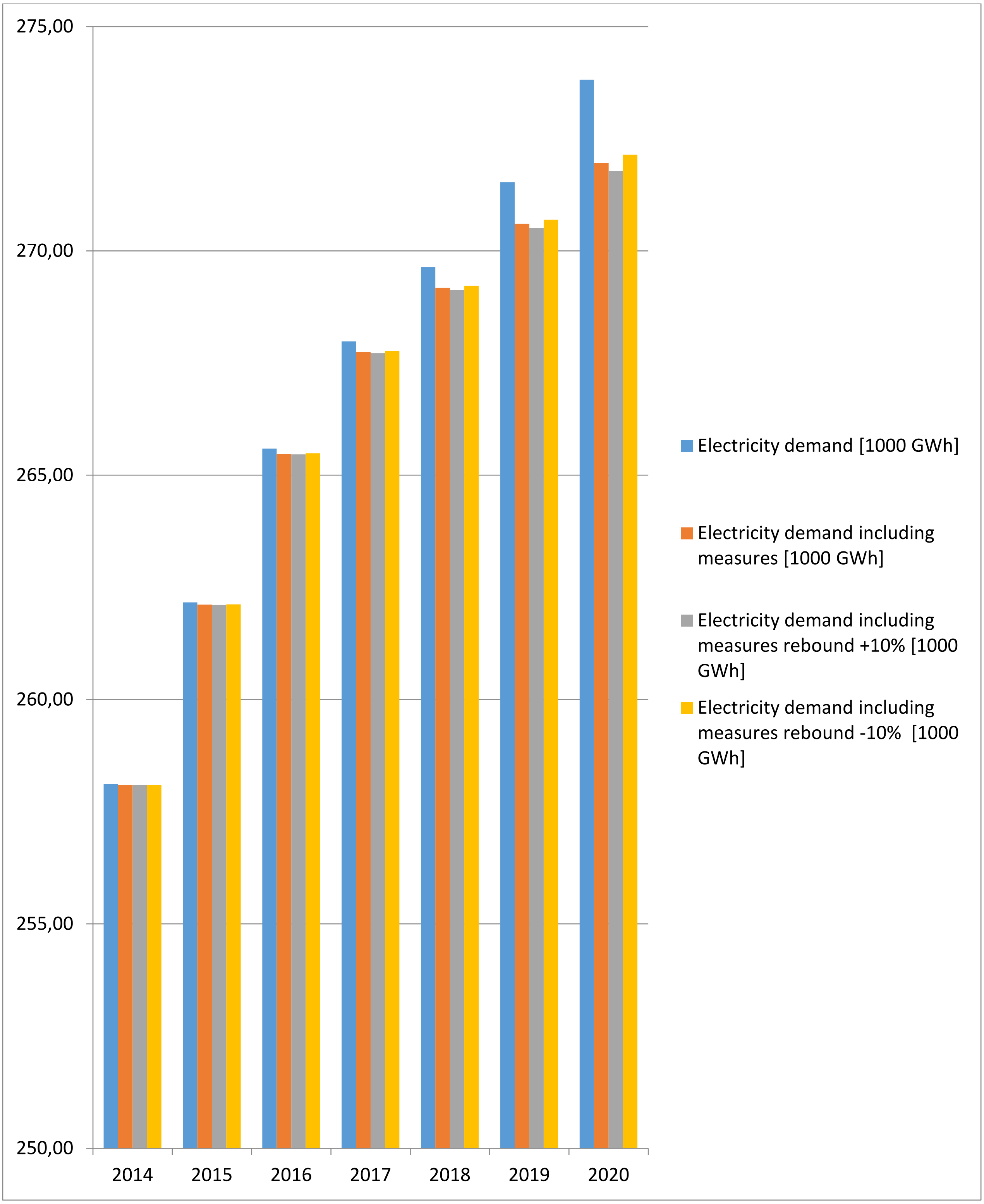

Figure 7 Difference between electricity demand with and without the efficiency measures

To get an idea about the future electricity intensity, these are plotted below. The estimation is that in 2015 the electricity intensity goes up, even with the measures. After 2015 the intensity will slowly go down. However, with the energy efficiency measures implemented, the intensity is going down faster than business as usual. Here as well we can observe that a change in the elasticities of energy service demand, and there rebound effect, of +10 and -10% do not have much of an influence on the predictions.

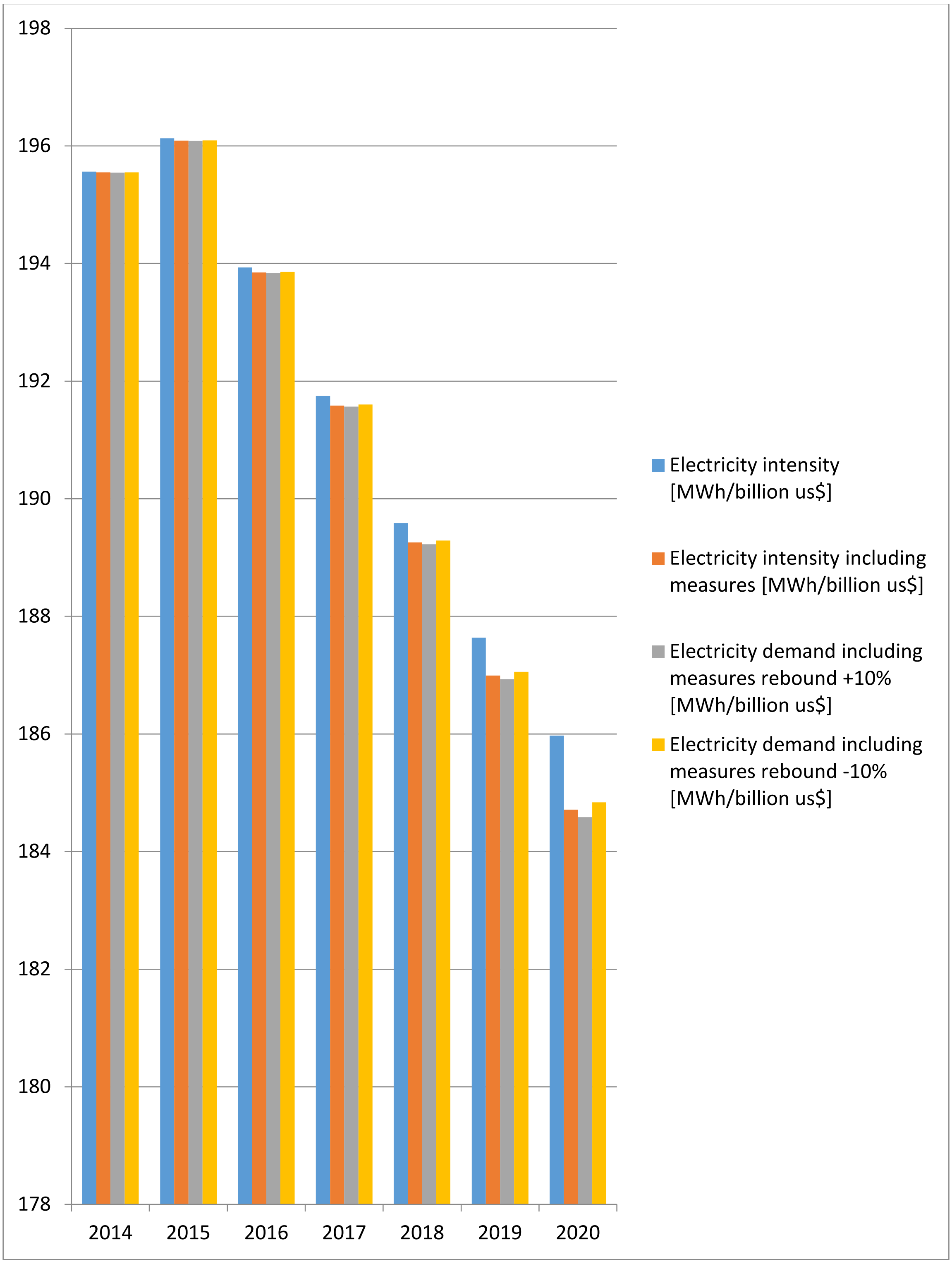

Figure 8 Difference between electricity intensities with and without the efficiency measures

10 Conclusions

As a conclusion of this master thesis, which includes the literature study, the calculations and the eventual results obtained from the model, it is safe to assume that the 20% energy efficiency target of the EU and the EED will not have much of an influence on the electricity demand in the future in Spain. Even when we increase and decrease the energy saving rebound effect calculations by as much as 10% the electricity demand changes less than 1%. There is in fact an estimation of a difference of 1857 GWh created by the energy saving measures on a total electricity demand of 273817 GWh in 2020, which amounts to around 0.68% difference. This is mainly because there are only a few of the energy saving measures which will change the electricity demand and on top of that, there is one measure, namely the MOVELE project, that, while decreasing energy use, will increase electricity demand.

What we can also deduct from the research in this paper and the electricity demand results, obtained from the model of REE, is that it is not because the energy saving measures don't change the electricity demand much, that the overall electricity efficiency will not increase. On the contrary, there is a clear downward trend in the electricity intensity, which is a very good case for the country as a whole and for the environment, because as we said in the beginning of this document, energy - and as a consequence electricity - efficiency is the most cost effective way to tackle modern day environmental, and security of supply issues.

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12 List of tables

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14 List of equations

15 Annexes

15.1 ANNEX A

data used to make figure 6, 7 and 8 about the evolution of GDP, electricity demand, electricity intensity and energy use in time.

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Energy use [10.000GWh]	33,50161	38,26659	40,82842	44,16748	49,55099	52,14181	59,97828	65,0051	66,86023	71,77951	70,53871
GDP [billion us $]	3,164712	3,147555	3,603871	4,088166	4,64928	5,897181	7,842593	9,70098	11,44653	11,81853	13,20895
Electricity demand [1000 GWh]	33,764	38,23	43,259	47,876	52,534	58,949	65,558	71,599	73,459	81,532	83,775
Electricity intensity [MWh/billion us$]	1066,89	1214,594	1200,348	1171,088	1129,938	999,6133	835,9225	738,0595	641,7578	689,8658	634,2289

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Energy use [10.000GWh]	76,50657	78,72777	79,92676	77,77048	79,08576	80,83922	82,46838	84,17355	86,2315	93,11058	102,4889
GDP [billion us $]	21,40191	23,21346	20,2257	19,54644	17,04869	17,16355	18,03024	25,06385	31,78822	37,51387	41,36305
Electricity demand [1000 GWh]	94,055	99,135	100,864	100,976	106,581	111,286	114,45	115,919	119,694	124,75	133,682
Electricity intensity [MWh/billion us$]	439,4702	427,0583	498,6921	516,5953	625,1567	648,3858	634,7669	462,4949	376,5357	332,5436	323,1918

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Energy use [10.000GWh]	108,6666	110,6366	106,1546	112,0464	117,2174	115,5067	122,8011	128,9434	135,1791	141,7191	145,4188
GDP [billion us $]	57,55985	62,92024	52,36495	52,91216	61,29397	64,09983	58,8692	61,7042	63,31941	59,54026	62,59758
Electricity demand [1000 GWh]	140,579	144,515	143,217	148,548	155,612	159,916	173,225	180,163	194,692	209,647	221,512
Electricity intensity [MWh/billion us$]	244,231	229,6797	273,4978	280,7446	253,8782	249,4796	294,254	291,9785	307,476	352,1096	353,8667

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Energy use [10.000GWh]	154,9069	161,6917	165,0465	164,8532	167,2809	161,6725	148,5528	148,5716	146,0385	145,0017	140,8591
GDP [billion us $]	90,68533	106,9602	115,7248	126,4487	147,9266	163,505	149,8984	143,1588	149,4598	135,5733	133,6673
Electricity demand [1000 GWh]	239,463	252,909	266,774	271,049	273,82	276,909	262,071	265,794	258,476	267,1588	261,0772
Electricity intensity [MWh/billion us$]	264,0593	236,4515	230,5246	214,355	185,1054	169,3582	174,8324	185,6638	172,9401	197,0586	195,3187

	2014	2015	2016	2017	2018	2019	2020
Energy use [10.000GWh]			141,464994				145,70064
GDP [billion us $]	131,9881594	133,6702393	136,9518437	139,7552479	142,2261207	144,7122333	147,2345675
Electricity demand [1000 GWh]	258,12	262,17	265,60	267,98	269,64	271,53	273,82
Electricity intensity [MWh/billion us$]	195,5609804	196,1305261	193,9335975	191,7512309	189,5861486	187,6365084	185,9733146

	2014	2015	2016	2017	2018	2019	2020
Electricity demand including measures [1000 GWh]	258,09926315	262,11506358	265,47696487	267,74786416	269,17476466	270,60324360	271,95966612
Electricity demand including measures rebound +10% [1000 GWh]	258,09745562	262,10975559	265,46509764	267,72440977	269,12813867	270,51026979	271,77393219
Electricity demand including measures rebound -10% [1000 GWh]	258,10107069	262,12037157	265,48883210	267,77131856	269,22139064	270,69621740	272,14540005
Electricity intensity including measures [MWh/billion us$]	195,5472858	196,0908165	193,8469449	191,5834061	189,2583186	186,9940346	184,7118314
Electricity intensity including measures rebound +10% [MWh/billion us$]	195,5459163	196,0868455	193,8382796	191,5666237	189,2255356	186,9297873	184,5856831
Electricity intensity including measures rebound -10% [MWh/billion us$]	195,5486552	196,0947874	193,8556101	191,6001886	189,2911016	187,058282	184,8379798