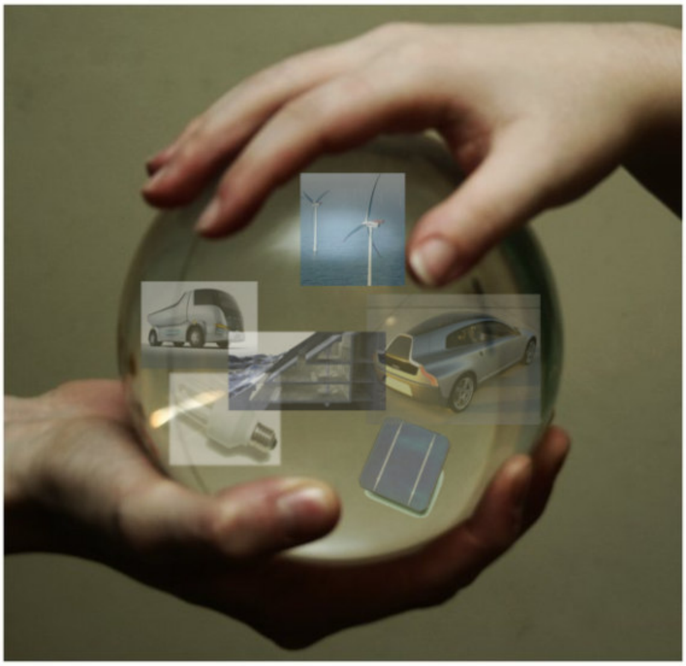
Future Energy Systems in South Europe

ALEXANDROS FILIPPIDIS



AALBORG UNIVERSITY
DENMARK 2008

Future Energy Systems in South Europe

A roadmap towards 2030

This project was prepared by

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As Master Thesis

for the

10th semester, Sustainable Energy Planning and Management

Aalborg University,Denmark

Submitted on 11. June 2008

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Abstract

Several challenges are faced nowadays due to the nature of the modern energy systems. High dependency on the global rising prices of fossil fuels and the environmental impacts call for actions, changes and long term strategies. In this research possible energy systems were modeled for South Europe towards 2030. The scenarios were compared on reaching targets of 50% oil reduction compared to 2005 levels and 50% reduction of the CO2 emissions compared to 1990. Only by combining significant improvements on the transport sector by introducing high share of electric/hybrid vehicles, high share of renewable sources in the power and heat sector and energy savings for all sectors made such a future energy system reach both targets. In order to assist the creation of such system a roadmap was created identifying the challenges while providing guidelines towards these changes.

To my family and Lu

Contents

Synopsis

This report begins with an introduction strongly inspired by the author's perspectives describing the general problems regarding oil dependency and climate change and the reasons led to the selected research theme.

In *Chapter 1* the methodology used throughout this research is described summarizing how the implementation of quantitative and qualitative approach will result towards answering the research question.

In *Chapter 2* a description of the STREAM model used for the creation of different scenarios is made by mainly showing the different parts of this scenario building tool.

Chapter 3 describes the main findings of three scenarios created – A reference, a moderate and an optimistic scenario as well as their performance towards the reduction targets set for year 2030.

In *Chapter 4* a presentation of the current policies for the different countries of South Europe are presented as well as the main developments in European level. This shows the differences and obligations towards 2020 for each country as well as the energy status in 2005 which was used as a base in the scenarios.

Chapter 5 describes a roadmap for the region that can maximize the realization of the proposed optimistic scenario and will facilitate the necessary changes for reaching the targets in 2030. The challenges and changes are divided in three key parts based on the measures used in the scenarios – energy savings, renewable energy and transport sector.

Conclusions are completing this research and present the overall results.

Introduction

"There are two roads, most distant from each other: the one leading to the honorable house of freedom, the other the house of slavery, which mortals must shun. It is possible to travel the one through manliness and lovely accord; so lead your people to this path. The other they reach through hateful strife and cowardly destruction; so shun it most of all"[1]

In the 9th century B.C. in ancient Greece an omen was given to Lycurgus, the famous Spartan law maker by Pythia at the Oracle of Delphi. In response he went to the leading men of Sparta asking for their support with the blessings of the Oracle. As a result Lycurgus established a constitution for the state of Sparta combining monarchy of two kings, a land-owning aristocracy and a democracy. However the Oracle gave another prediction

"Love of money and nothing else will ruin Sparta"

Again, Lycurgus trying to follow Pythia's recommendation abolished the silver money trading in Sparta, replacing with iron currency. However, the Oracle was right again since the silver, gold and the slaves captured by the Spartan army during the Peloponnesian War and sent to Sparta, led to its corruption and decline.

The interpretation and the actual actions of that era's policy makers towards a better future were govern by recommendations made by persons like oracles, prophets and so. However, the results may not have been the desirable due to wrong implementation or actual choices. Predicting the future has been considered as a very powerful asset since the ancient times. People who could read the "signs" of nature could easily guide the rest into a more favorable or promising future. Additionally, they were almost always considered very important by the people in power and often consulted, since either the predictors could grant credibility and justification to the decisions made while the predictors could also impose their desires by "exploiting" this relation to the decision making process.

[1] Plutarch "Life of Lycurgus"

Energy is linked to almost every human activity. Hence is directly linked to our quality of life, prospect, health, economy and environment. The developed world has chosen doomly to heavily depend on fossil fuels for powering its prosperity with obvious consequences. Due to geographical restrains of the availability of these resources the world has seen many war conflicts, the latest on Iraq which is still ongoing after five years[2]. Currently volatile market conditions and prices dominate all major energy commodities, uprising economies thirsty for resources/energy and a constant rally towards security of the supply of these resources, bring out the need for defining the proper changes not only currently but in the mid and longer term. Oil dependency is obvious resembling the oil crisis of 1979 while prices have soared to 138,54 $/barrel of crude oil in NYMEX while experts expect prices above 150 $/barrel as early as July 2008[3]. This constant rise of oil prices has led to continuous rise on all other commodities and services bringing global economies to turmoil while oil companies hit record profits (see Appendix).

> What we do today about climate change has consequences that will last a century or more.
> The part of that change that is due to greenhouse gas emissions is not reversible in the foreseeable future.
> The heat trapping gases we send into the atmosphere in 2008 will stay there until 2108 and beyond.
> We are therefore making choices today that will affect our own lives, but even more so the lives of our children and grandchildren. This makes climate change different and more difficult than other policy challenges.
>
> *Human Development Report 2007/2008*

Climate change is a scientific undisputable fact defining human development issue of our generation[4]. Its potential impacts although difficult to quantify and specify in an exact time horizon do not limit the certainties over the global risks opposed for the current and next generations. The impact of climate change is not limited in certain region although it has already stroke poorer areas where infrastructure is absent sending to all the first alerting signals. Unfortunately the whole world is not viewed by all as one unified region. The paradox of modern times however is that commercial activities and this "limited" version of globalization do not hesitate to bring to the daily life in developed countries coffee from Brazil, bananas from Panama,

[2] "I am saddened that it is politically inconvenient to acknowledge what everyone knows: the Iraq war is largely about oil,", Alan Greenspan ,elder statesman of finance , Sunday Times, 16/9/2007
[3] http://edition.cnn.com/2008/BUSINESS/06/06/oil.prices.ap/index.html#cnnSTCText
[4] Watkins et. al. , Human Development Report 2007/2008, UNDP

cigars from Cuba, meat from New Zealand or electronics from China, Malaysia or Taiwan. So why an agreed global problem that can eventually jeopardize everyone's life is not effectively dealt both in global and regional view down to personal level? Actions were taken like the partially implemented Kyoto Protocol which reaching its end of life, still the great polluters like USA or China refuse to implement it. Surely this does not give satisfactory answers to the above question.

But how actually predicting a future relating to energy and environment for a region can be done nowadays? How different paths for the future can be chosen and how a positive outcome may be guaranteed? Firstly we should establish a common view of the current status whether we are "Pythia" or Lycurgus. We currently live in a world which has significantly increased the exchange of information in astronomical figures by the creation of new media with greater example the internet[5] while changes are happening and presented in an impressive rate as well. Institutions and societies struggle to collaborate towards prosperity, peace and solution of greater issues such as in our case, energy which is directly linked with every aspect of human action. However, the pace and the results are many times criticized or do not deliver the promising positive impacts either by providing a modern status of life quality on the sacrifice of environment or by extrapolating further the differences and the problems such as famine between developed and developing world.

Towards fighting the climate change impacts in the long term ideally we should see beyond economics. However if chosen not to we could simplify the actions need to be taken as an investment. Like every investment it has certain capital costs and maintenance but in the long term can produce large net profits[6]. If this is the case things can be easier if in every activity we include the social costs in a realistic way. If so maybe the costs of any renewable technology could compete from today with any conventional ones even nuclear. However, only the last years the competition with "dirty" technologies included partially these costs through emissions quotas keeping green technologies' struggle for market penetration still on hold. This leads to another aspect of how we have reached today's energy and economic status, heavily shaped by the political decision making and the dominant power relations. Governments have the power to apply rules and legislations in a way that will drive changes into the energy market and consequently reinforce the fight for oil "independence" and against climate change. However power relations many times do not let the significance of making the

[5] http://www.internetworldstats.com/stats.htm
[6] Watkins et. al. , Human Development Report 2007/2008, UNDP

right decisions come into force or even acquire the necessary attention to the provided solutions existing today and call for wide implementation.

In Europe, significant steps have been taken regarding tackling climate change respecting the Kyoto Protocol and currently setting the base for a longer term strategy for year 2020. The European Spring Council held in March 2007 called for a proposal of a new Directive on renewable energy setting new binding targets for 2020[7]. These targets aim for 20% reduction of the CO2 emissions compared to 1990 levels, 20% reduction on overall consumption, 20% share of renewable sources in the EU overall energy consumption as well as a minimum share of 10% biofuels for the transport sector. In response to this agreement the Commission presented a proposal for the new Directive on 23 January 2008 which is currently forwarded for approval by the European Parliament and Council. This directive will be adopted by the first half of 2009 while the member states will have to present national plans and strategies for reaching these binding targets by 31 March 2010[8].These latest policy developments might set a framework for fighting climate change and energy import dependency until 2020. But how is possible to create favorable policy conditions for a time horizon beyond 2020? If the 20/20/20 targets are to be achieved by 2020 how greater changes could be achieved by 2030? What if member states were presenting national plans for 2020 but with further views towards 2030?

These reflections presented an opportunity for this research theme. This research attempts to mainly project a better future for the region of South Europe in the area of energy and climate change. Several aspects were taken into consideration which did not limit this “journey” by simply extrapolating the current trends and their link to energy resources or documenting a sterile representation of the energy systems in year 2030.

The main pursuit of this project is to identify potential energy mixes for the countries in South Europe for year 2030 in a realistic approach while proposing a common roadmap for achieving ambitious targets after 2020. In order to define the needed changes two main targets are set. Firstly, the reduction of oil consumption by 50% compared to the levels of 2005 as well as a 50% reduction on CO2 emissions compared to the 1990 registered data. Achieving these targets could strengthen the security of supply of the region as well as European Union’s whereas complying with future EU and post-Kyoto protocol targets which are expected to be announced in the near future

[7] http://www.eu2007.de/en/Meetings_Calendar/Dates/March/0308-ER.html
[8] http://www.euractiv.com/en/energy/eu-renewable-energy-policy/article-117536

The results of this research could be utilized for the creation of necessary policies regarding energy demand and production. In this way national strategies with common goals may be drawn regarding not only technological innovation but also energy savings and increase of efficiency towards achieving common goals as described in the following sections. Additionally public and market stakeholders may find useful information for understanding the need existing for behavioral and business changes. It is also important to stress out the need of enhancing the international collaboration in this part of Europe presenting both benefits and business opportunities.

Research question

How can South Europe reach the targets of 50% reduction of oil consumption and CO2 emissions by year 2030 compared to 2005 and 1990 levels respectively?

The main axis of methodology used in this research is a combination of quantitative results deriving from a scenario modeling tool called STREAM as well of qualitative ones by reviewing policy and industry views for creating a common roadmap for the region. The South Region was chosen as a focus area for this research and this seemed as a natural follow up of the writer's previous reports[9]. By investigating policies for issues like biofuels in the general EU area and solar market and policy aspects in Greece brought the writer closer to energy problems in that region. Similar climatic conditions, resources, energy demand patterns but different policy implementations made this choice both challenging and interesting to investigate. Moreover South Europe is the second most consuming region in Europe after Central Europe. In energy policy levels there are some similarities but different developments have occurred in the last years between the different countries. It seemed that if a common vision for that area for year 2030 if investigated and proposed could diminish these differences or at least provide a platform for common policy making and energy market orientation. These ideas will be incorporated towards finding answers for the research question.

This project was carried out in combination with the author's internship at EA EnergiAnalyses A/S[10] during the period February 2008 – June 2008. During this period the author assisted on the development of the STREAM model and the project "Future Energy Systems in Europe"[11] which was commissioned by the STOA[12] panel which is the

[9] Filippidis, Livijn The making of the Directive on Biofuels, 2007
Filippidis, Policy and Market aspects of the Greek PV sector, 2008
[10] http://ea-energianalyse.dk/
[11] http://www.tekno.dk/subpage.php3?article=1442&survey=15&language=uk

European Parliament's Scientific and Technological Options Assessment unit. The project is carried out in collaboration with the Danish Board of Technology, RISØ National Laboratory and Ea EnergiAnalyses A/S. In 23 April 2008 the author participated in the dinner debate organized by STOA with members of the European Parliament and rapporteurs in the European Parliament in Strasburg as member of the project group. This project is expected to be completed in September 2008.

[12] http://www.europarl.europa.eu/stoa/default_en.htm

Chapter 1 - Methodology

This section outlines the methodology used during this research. The purpose of methodology is to set the base needed that will guide the research towards concrete results. Understanding the methodological issues is very important since it affected the gathering and presentation of information, both reviewed and newly created. In that respect the chapter is divided into two main sections, firstly the quantitative approach and how this contributes to the final results and secondly the qualitative approach and its effect as well.

The research theme is focusing on energy issues dealt not with just merely covering the energy demand by proposing energy mixes but also more qualitative issues such as modal changes and the necessary policy decisions required for reaching the desirable targets. The main purpose is to present alternative pictures of the future in a way that in the short term necessary policy and decision making frameworks can support their realization. If achieved, the results and the proposed roadmap may be beneficial for both governmental and industry stakeholders. However this research has also scientific value in the context of setting the base for further improvement and assessments of energy futures for this or maybe other regions as well. Finally and most important since the energy future of the South Europe has multiple impacts for a great extent such as economical, environmental and consequently on the overall quality of life in the region it can be assumed that this research addresses problems and solutions available for further understanding and dissemination to the general public.

Both quantitative and qualitative approaches were chosen due to the need for a more holistic and realistic view on the research issue. It is agreed thought that real world most of the times may be different from pure arithmetic modeling especially when the topic is energy systems and the creation of future scenarios.

Overall the quantitative part of this report presents different views of future energy systems focusing in South Europe and the different impacts of these scenarios. The qualitative approach serves as a mean to establish the necessary targets and strategies for the South region in order to achieve the scenario with the best performance in relation to the targets of 50% reduction on both oil consumption and CO_2 emissions levels. Moreover it will attempt to prove if technology specific measures currently available can be implemented in specific extent to reassure the achievement of these targets.

1.1 Quantitative approach

In order to be able to answer the research question and propose solutions toward achieving the 2030 targets establishing transparent and publicly accepted numerical results will be created. In that way it will be able to quantify the existing energy systems in the South Europe while extrapolate their future for year 2030.

For creating the quantitative results a scenario modeling tool was used called STREAM. The description of this modeling tool is further described in Chapter 2. There are several reasons that led on choosing this tool. Firstly, is publicly available, combines a broad variety of datasets and has been already used rather successful for a number of projects. Additionally, it allows to evaluate energy systems for separate countries as well as for groups/regions in aggregated way. It is important to stress out that STREAM uses for baseline data the datasets created by the European Directorate General for Energy and Transport (DG TREN) for year 2005 (EUROSTAT) and the projections for Business as Usual (BAU) scenarios for 2030[13]. It also provides the possibility of analysis in quick but extended way as well as comparison between the different scenarios and their efficiency towards chosen goals. It is possible through this model to quantify the demand for energy services in year 2030 for the Southern European countries and based on the Business As Usual approach provided in the pre mentioned DG TREN report to create different scenarios. Using this approach a part of the research question will be answered regarding whether or not the 50% reduction of CO2 and oil consumption can be achieved using different technology specific measures. However, by creating different scenarios and then comparing those towards their efficiency on achieving these targets it will be easier to connect to the qualitative approach regarding policy proposals and the creation of a roadmap on realizing these scenarios with actual quantitative results.

In order to present different views for the energy systems in 2030 three scenarios will be created. Firstly, a reference scenario which will be based on a Business as Usual approach. This will serve as a comparison base and due to the fact that it will be created in relation to the DG TREN estimates, it will be the connection to the European data. This way will provide creditability on the reference results as it will combine DG TREN data

[13] DG TREN, European Energy and Transport Trends to 2030, update 2005

and the in-house datasets of the STREAM model. A second scenario will be created in which all the available resources for renewable energy as well as significant energy saving measures are to be applied. Finally a third scenario will be created where significant energy savings will still exist, all the available resources will be used and great changes will occur in the transport sector, such as high share of electric vehicles, modal changes and transport work shift. It should be noted that the share of nuclear energy in this scenario will be lower expecting decommissioning of any old plants and no new constructions. Full decommission of old coal and gas plants is also included. In this way, it will be possible to get a picture of three different views for year 2030 and further on compare them. The roadmap however will focus on achieving the scenario with the best performance.

It is rather important to perform an economic assessment of the proposed scenarios despite the obvious difficulties and uncertainties. However there are several limiting factors and in combination with the high levels of uncertainties for both oil and CO2 quotas pricing make the results rather relevant especially due to the high rise of the oil prices which has already hit several record highs in 2008. Several assumptions were made in order to represent an economic picture of year 2030 with the proposed energy systems. Showing the comparison results between the reference scenario and the other two scenarios may give a picture of how economics affected by the significant reduction on fuel consumption and the diversity on the energy mix. Due to the complexity of this research several assumptions and uncertainties regulate the precisions of the outcomes. Therefore the results will be used for comparing the annual costs of each scenario compared to the reference and should be interpreted with caution.

1.2 Qualitative approach

The qualitative approach is expressed in chapters 4 and 5. In chapter 4, the latest policy status for the different South European countries is described in relation to the broader policy environment of the European Union. In that way, the differences between the countries can be pinpointed. Moreover, with the current status explained it will be possible to comment on how difficult the implementation of the proposed scenarios and how radical the necessary changes might be. This will lay the path to combine the results of the quantitative part of the research to create the roadmap in Chapter 5 and lead to the conclusions. The guidelines expressed in Chapter 5 will derive from several different sources presenting best practices and ideas for implementation.

In the following schematic (Figure 1) is possible to find the steps towards the conclusions which have been the backbone of this research and illustrates the overall methodology used.

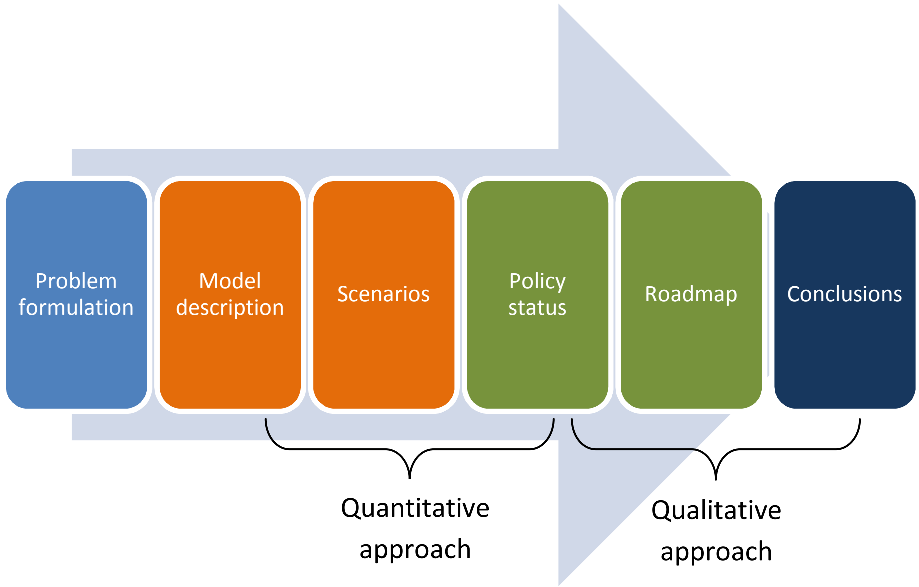


Figure 1 - Methodology outline

Chapter 2 - Model Description

As described in the previous section the quantitative approach is heavily depended on the creation of scenarios for the Southern Europe using the modeling tool called STREAM. In this section the basic parts and the potential outcomes of this tool will be describe. In this way the transition to the actual scenarios described in the following chapter can be more natural and will allow the reader to have a broader view on how the results derive.

During this research a modeling tool has been used named STREAM – Sustainable Research and Energy Analysis Model. This model initially developed by cooperation between Energinet.dk, Risø National Laboratory, DONG Energy and Ea EnergyAnalyses A/S. The model was created during a project initiated by the Danish Board of Technology entitled "The Future Danish Energy System"[14] and was presented in 2007 with the scope of setting objectives and possible futures of the Danish Energy system. In addition to the use of this model in this project it has been further developed and used in the project "Future Energy Systems for Europe in 2030[15]" which was commissioned to the Danish Board of Technology by the STOA unit of the European Parliament.

2.1 General characteristics

This modeling tool is rather unique since it can provide an overview of the complete energy flow of the given system from fuel exploration down to conversion and end use. Due to its simplicity it can be promptly altered and adapted into changes making the comparison and creation of different scenarios a rather quick and transparent process. This transparency is further enhanced due to the sources of the data bases used which are mainly derived from publicly available sources and included in the model.
In addition the model has been created with the collaboration of different actors (university/energy company/TSO/consultants) providing creditability as well as a focus on problem solving and policy expressing in a bottom up approach expressed in the final results.

[14] http://www.tekno.dk/pdf/projekter/STOA-Energy/p07_The_Future_Danish_Energy_System.pdf
[15] http://www.tekno.dk/subpage.php3?article=1442&toppic=kategori11&language=uk

The model is consisted by four mainly Excel spreadsheet models in addition to a comparison spreadsheet for better evaluation of the different scenarios.

- Country Data file
- Savings model
- Energy Flow model
- Duration Curve model
- Comparison sheet

The flow and interaction behavior of the model is shown in figure 2

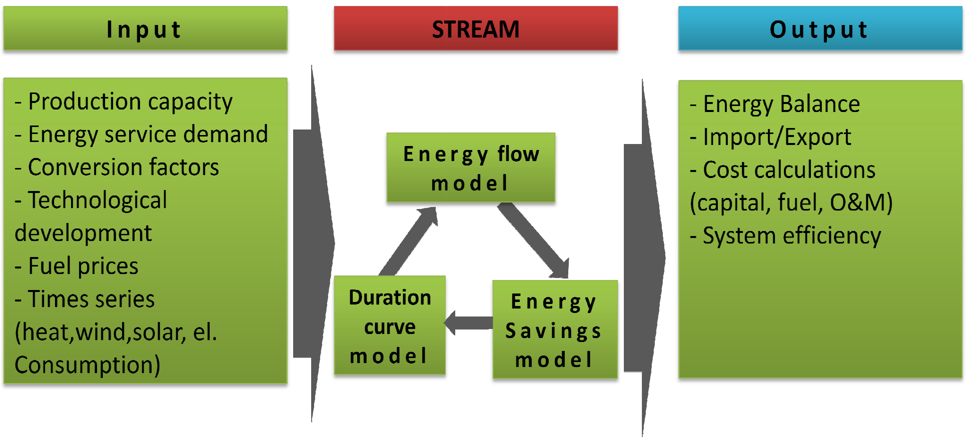


Figure 2 - The STREAM model

2.1.1 Country data file

In this spreadsheet the main input data of the model are concentrated. Information for all the EU-27 countries can be found mainly deriving from the baseline scenarios expressed by the Directorate General's report published in 2005[16] but also other sources as well. A module was created which can prepare aggregated results for grouping selected countries into regions. These data are then promoted to the other parts of the model by simple button procedures. In this research the data for the southern European countries are aggregated and further used.

[16] European Energy and Transport – Trends to 2030 – update 2005

2.1.2 Savings model

In this model the demand for energy services in a given year is projected. This demand is considered to increase in relation to the economic growth. However, a factor is used to express the fact that not all the economic growth is directly link to increase of energy services demand, related especially for the future demand of housing spacing. Since the model was initially created for Danish energy system a factor is used to represent how close to the Danish potential savings the investigated region is.
This demand is divided into four main sectors

- Residential sector
- Tertiary sector
- Industrial sector
- Transport

For every sector there are different savings that can be expressed such as lighting, cooling, appliances, industrial processes etc. as well as the share of different fuels for electricity and heat demand. In the transport sector is possible to quantify modal changes such as increased use of electric vehicles or different fuels, public transportation and share of work load.

It is important to notice that this model examines energy services mainly and not energy use. In that frame it is possible to analyze the benefits from increased efficiencies in different technologies and sectors. However, the costs for modal changes or behavior are not included as well as the necessary investments in infrastructure or technological developments towards achieving the proposed goals.

2.1.3 Energy flow model

The energy flow model is focused on presenting the CO2 emissions of the proposed systems, the use of the different energy resources, the fuel consumption and the conversion to energy products and services in the system. Moreover economic assumptions are included in this model providing the necessary information for the costs of investing in production facilities. It is also possible to review the fuel consumption for the different sectors or energy services.

2.1.4 Duration curve model

In this model it is possible to investigate the correlations between electricity and heating systems for the given area at an hourly level. Every technology is considered as one big plant making it easier to combine the different technologies at given hours.

This model is based on historical time series for electricity and heat consumption by creating normalized profiles for each demand. The supply side is modeled as big plants which include a combined heat and power plant, heat storage, heat pump, heat only boiler, four types of wind turbines, photovoltaic plant, solar heating plant etc.

It should be noticed that the selected region is considered as an interconnected system without national transmission constrains for both heat and electricity production and distribution. The results from this model are forming the basis for the energy flow model which performs the economic calculations based on the capacity of the different "plants".

However these results cannot be compared completely with advanced models used by electricity sector but can give a satisfactory view on the general energy system and the interchanges between heat and electricity production sectors of the system for a given year.

2.1.5 Comparison sheet

This Excel file serves as an overview of the created scenarios. The user is able to make a quick comparison of different scenarios regarding a group of options such as economy, energy mixes, fuel usage and graphically represent the performance of scenarios regarding the targets. This file has been modified to be able to receive different scenarios for the same region.

The scenarios created using the STREAM model are presented in the following chapter. More detailed information of the results and the created files can be found in the Appendix as well as in the electronic version provided with this report.

Chapter 3 - Energy Scenarios

In this chapter the three created scenarios are described. This section summarizes the main results, although is possible to get an in depth view of these in the provided electronic files accompanying this report. The purpose of this section is to show how the different scenarios bring results comparable to the targets of the research and will set the quantitative base towards the creation of the roadmap for South Europe in chapter 5 and answering the research question.

Three main scenarios are described in this chapter; a Reference Scenario, a Moderate Scenario and an Optimistic Scenario. The improved scenarios are heavily based on increased share of renewable energy technologies (mainly wind, biomass and solar power/heat), energy savings for the different sectors as well as changes in the transport sector. These measure were identified as the main parts of the energy system and is possible to be modified through this model.

The reference scenario is used for comparison with the other two scenarios and expresses mainly a Business As Usual approach in relation to the DG TREN expectations for year 2030. The Moderate Scenario presents an even greater share of renewable energy technologies in the overall energy consumption, additional improvements on efficiency for all sectors and a slight modal and technological change regarding the transport sector. The Optimistic Scenario uses similar savings with the Moderate one but introduces even greater changes into the transport sector and high share of renewable sources in the power and heat production.

The main targets on which all three scenarios are evaluated are 50% reduction on oil consumption compared to the 2005 levels and 50% reduction on CO_2 emissions compared to the 1990 levels (Table 1). In this way energy security is improved significantly as well as the environmental impacts of the future energy systems are reduced regarding CO_2 emissions and climate change.

Table 1 - Scenarios' targets for 2030

Oil consumption target (PJ)		CO2 emissions target (million tons)	
2005	2030	1990	2030
7099	3550	702,7	351,35

All scenarios are based on EUROSTAT data as expressed in the DG TREN report and are incorporated in the model. The data are dealt as an aggregate result for all the countries in the region of South Europe. The STREAM model in-house databases were used for evaluating the different potential sources and demands in which the outcomes rely on.

Common assumptions were used in the scenarios regarding the nature of the energy sources used, the potential recourses and the exclusion of certain technologies. Nuclear plants are expected not increase significantly their share in the energy mix and possibly decommission of some plants will happen. Since Spain is the only country with nuclear energy all other countries are assumed that will not introduce this technology. Additionally hydro power is kept in the same capacity since is assumed that it has been already exploited in almost full extent. The potential sources for renewable energy are based on the GREEN-X[17] expectations of viable and feasible exploitation regarding the different technologies as included in the model. Regarding the biomass resources although they might be higher only the share that could be utilized in a sustainable and environmental way are included as calculated by EEA[18]. Moreover the available biomass resources are used almost exclusively on combined heat and power plants connected on district heating systems. Certain technologies have not been included such as Carbon Capture and Storage due to the current immature technology and the doubtful economics[19]. Additionally any potential breakthrough that can contribute higher than the assumed technological improvements cannot be quantified or predicted hence will change the future energy systems and the overall results.

For better overview of scenarios the same structure of presentation was chosen (Figure 3). Initially the main characteristics and ideas behind the following scenario are explained. The projected consumption demands of each sector (based on GDP growth)

[17] Vienna University of Technology, Energy Economics Group, Green-X Deriving optimal promotion strategies for increasing the share of RES-E in a dynamic European electricity market, 2004

[18] Europe Environment Agency, How much bioenergy can Europe produce without harming the environment? ,2006

[19] Rochon et. al , False Hope: Why carbon capture and storage won't save the climate, 2008

are following as well as the efficiency improvements for each sector. The different shares of technologies in the transport sector are also presented since is a great contributor on both oil consumption and CO2 emissions. The contribution of renewable energy in the electricity and heat production is shown as calculated using the model and finally follows the overall results of the scenario towards the common targets described above. The detailed characteristics of the proposed future energy systems can be found in the appendix as well as in the files provided with the report.

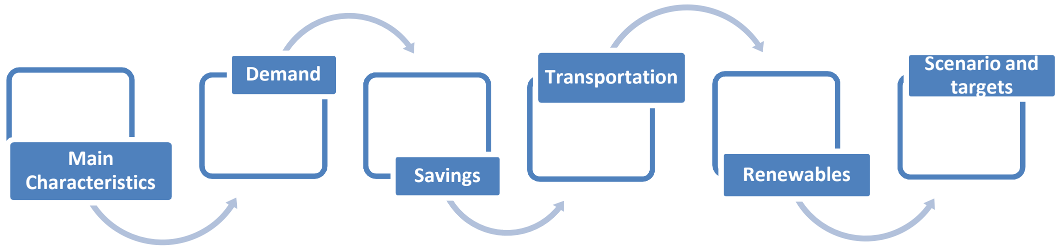


Figure 3 - Scenario presentation

In the end of this section a comparison between the different scenarios is made as well as an economic evaluation compared to the reference scenario.

3.1 Reference Scenario

3.1.1 Main characteristics

The reference scenario follows closely the predictions of the DG TREN baseline in order to set a base for comparison between the different proposed scenarios as explained in the introduction of this chapter. The purpose of creating a reference scenario is to set a baseline for further policy analysis while projecting the effects of current trends and policies for year 2030. In this way the changes needed can be identified by presenting how current trends will shape the energy systems of 2030. Choosing a baseline that slightly differentiates from the DG TREN was made for several reasons. The STREAM model provides several extra datasets which were used for all of scenarios (production and consumption profiles, technology costs etc.) while DG TREN incorporates future policy results and in-house data without fully providing background data. By combining both DG TREN results and STREAM it was possible to get the best out of both "worlds" while allowing the baseline to be comparable with other scenarios. Additionally, the DG TREN data have not been updated with the latest 2008 published version allowing to expect a better future view since a lot of policies have changed or introduced since the 2005 version used in the model. The purpose of the quantitative approach in these scenarios is not the comparison with DG TREN model but the use of a data background for policy roadmapping that can be both transparent and credible.

No additional savings are assumed apart from the ones included in the DG TREN baseline. On the electricity sector a share of 33% of the electricity (compared to 21% of 2005 level) in which wind power accounts for 10% and bioenergy (biomass, municipal waste and biogas included) for 8% followed by solar energy for 1%. District heating contributes up to 7% on the final energy consumption. The transport sector follows a similar pattern with the current status and no electric/hybrid vehicles are included but a small share of 5% is fuelled by biofuels. Consequently the targets are far from achieved as shown in figures 8 and 10.

3.1.2 Energy demand

End use energy demand is calculated as proportional to the expected GDP growth towards 2030 and growth in the transport sector. Additionally the limited savings also define the final energy demand. The consumption regarding end use divided into sectors for the Reference Scenario compared with the status in 2005 is shown in table 2.

Table 2 - End use energy consumption per sector

End use	Consumption	GDP	Reference
Energy consumption sectors	2005	Economic growth	2030
	TJ/year	% p.a.	TJ/year
Tertiary	1,396,856	2.1	1,836,774
Industry	3,605,829	1.9	4,444,719
Residential - heating	2,225,602	2.0	2,656,544
Total	**7,228,287**		**8,938,036**
		Growth in transport work	
Transport, person	2,757,080	1.0%	3,066,748
Transport, gods	1,693,792	1.6%	2,042,980
Total incl. transport	**11,679,160**		**14,047,764**

The energy demand for every sector is further divided in demand for heat and electricity. The heat demand is covered in the reference scenario by fuels such district heating systems, coal, oil, natural gas and biomass. In table 3 the shares for heat demand covered by different fuels is presented as well as the share of electricity used in each sector. The share of electricity accounts for the percentage of the total energy demand in each sector.

Table 3 - Fuel consumption per sector

	Sectors						
	Tertiary		Residential			Industry	
Fuel consumption	TJ	%	TJ	%		TJ	%
Electricity	**951711**	**52%**	**789801**	**30%**		**1102010**	**25%**
Appliances	730445		539471		**Appliances**	465304	
Space heating	221266	20%	236025	11%	**Process power**	636706	16%
District heat	165949	15%	386223	18%		79588	2%
Coal	0	0%	0	0%		159177	4%
Oil	254456	23%	257482	12%		875471	22%
Natural gas	387215	35%	965557	45%		1989707	50%
Biomass	55316	5%	257482	12%		238765	6%
Solar heating	22127	2%	0	0%		0	0%
Heat pumps			42914	2%			
Total	**1836774**		**2656544**			**4444719**	

3.1.3 Savings

All the scenarios, including the reference scenario as well, are based on potential savings for the four distinct sectors tertiary, industry, residential and transport. Due to lack of detailed data for potential savings specific for this region normalized data based on the Danish potentials were assumed. Denmark has achieved low energy density by investing significantly on energy savings in the past. This led to the assumption that potential savings in the South region will be higher and expressed through comparison factors. These savings vary on the reference scenario as seen in table 4.

Table 4 - Savings per sector

Percentage saving compared to today's level	Energy form	Efficiency improvement in reference scenario
Tertiary	Electricity	21%
	Heating	23%
Industry	Energy	19%
Residential	Electricity	20%
	Heating	20%

3.1.4 Transport sector

The transport sector in year 2005 was heavily dominated by the use of cars for personal transportations and the use of trucks/cargo vans for goods transportation (76% and 80% of the sector respectively) powered in conventional ways like fossil fuels. Till 2008 although hybrid cars are introduced in the market the share is still very small to be quantified (cumulative sales for Toyota hybrids in Europe reached 100.000 vehicles in 2008[20]). In the reference scenario similar share is projected for year 2030 with almost no changes regarding the methods of transportation as well as the fuels used. In the figures 4 and 5 the shares are shown of the different vehicle types and a comparison between the 2030 scenario and the 2005 status.

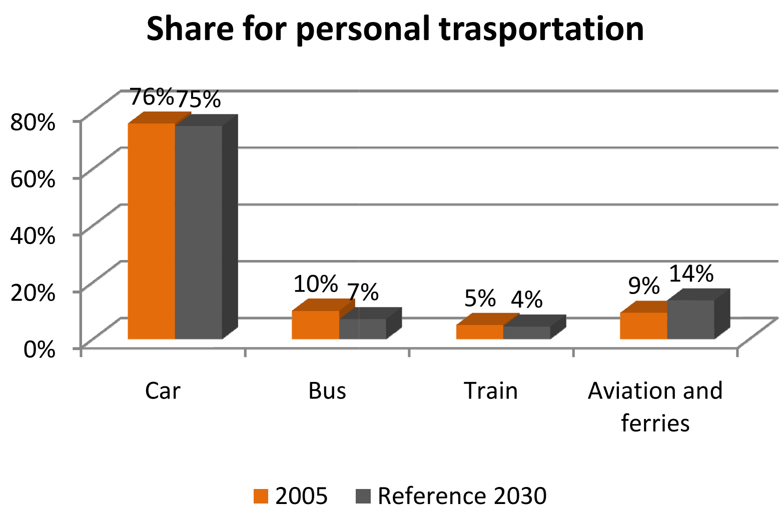


Figure 4 - Transport sector for personal transportation

[20] http://www.toyota-media.com/

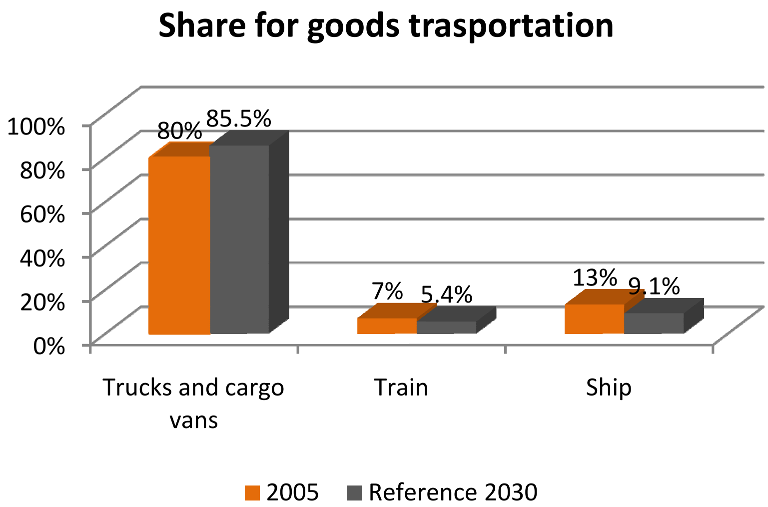


Figure 5 - Transport sector for goods transportation

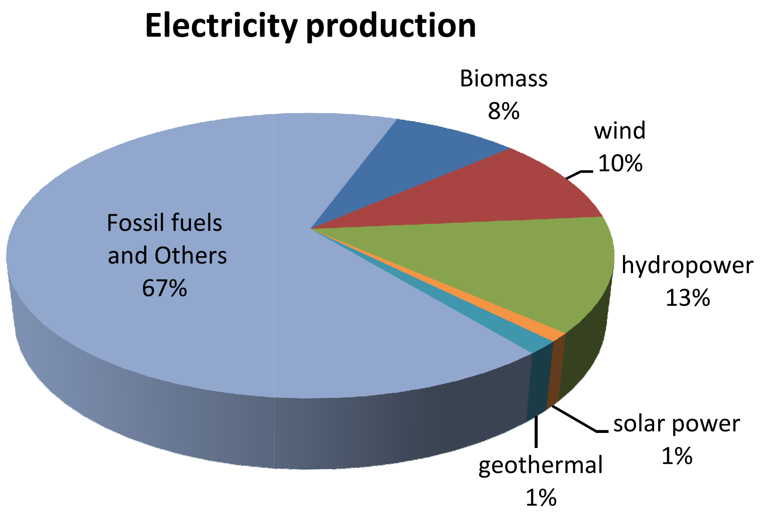
3.1.5 Renewable energy

In order to achieve the targets in every scenario a great share of renewable sources in the electricity and heat production is proposed. The projections are calculated by combining DG TREN expectations as well as the available and exploitable resources from the GREEN-X project.

In the reference scenario the share of renewable sources accounts in total of 33% of electricity production and 19% of the heat production respectively. Dominant share comes from hydro power, wind power, 10% of the electricity production and is followed by biomass and solar power.

In the heating production from renewable sources, district heating is assumed an increase up to 7% compared to today's 5% of the final energy demand and solar heat accounts for 10% while geothermal heat for 1%. The share of renewable technologies in the electricity and heating production are shown in figure 6.

Resources like municipal waste or biogas are not included as it is assumed that these resources stay unexploitable for the reference scenario.



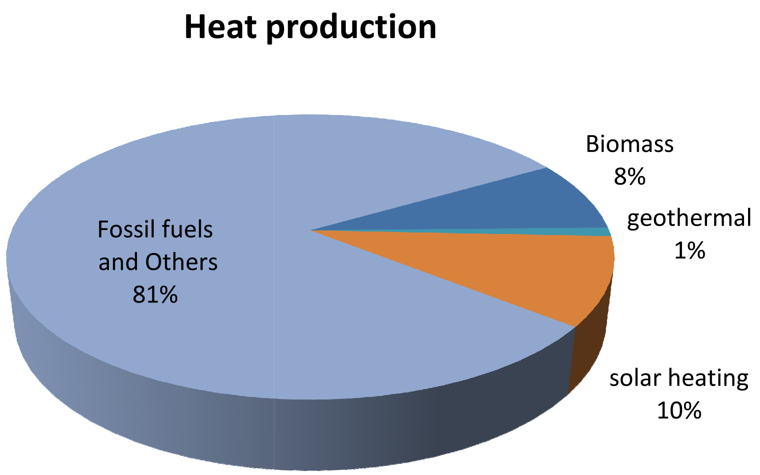
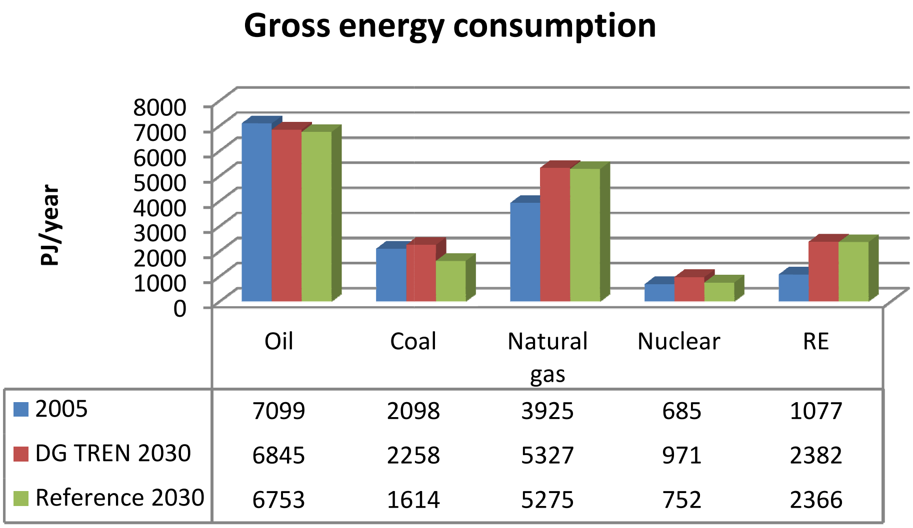


Figure 6 - Renewable technologies' contribution in electricity and heat production

This shift towards renewable energy and in combination to savings and efficiency improvements allows to evaluate the reference towards achieving the 50% targets as expressed in the introduction of this chapter. In the following figure it is possible to compare the different energy sources contributing in the gross energy consumption for the 2005 status, the DG TREN baseline and the reference scenario created.



	Oil	Coal	Natural gas	Nuclear	RE
2005	7099	2098	3925	685	1077
DG TREN 2030	6845	2258	5327	971	2382
Reference 2030	6753	1614	5275	752	2366

Figure 7 - Gross energy consumption per source

3.1.6 Scenario and targets

In the reference scenario the target of 50% oil reduction compared to the 2005 levels is not achieved due to the increasing demand despite the significant increased share of RE. In figures 8 and 10 the reference results are compared to the targets as well as with the status for 2005 and the expectations of the DG TREN scenario.

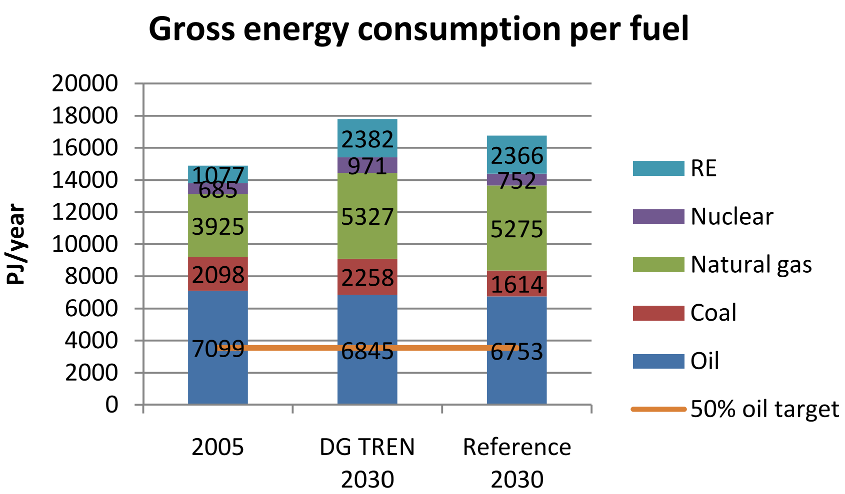


Figure 8 - Gross energy consumption and oil target

However it is necessary to present the end use energy consumption for each sector where the high demand of the transport sector is highlighted and accounts for 36,4% of the overall consumption as shown in Figure 9.

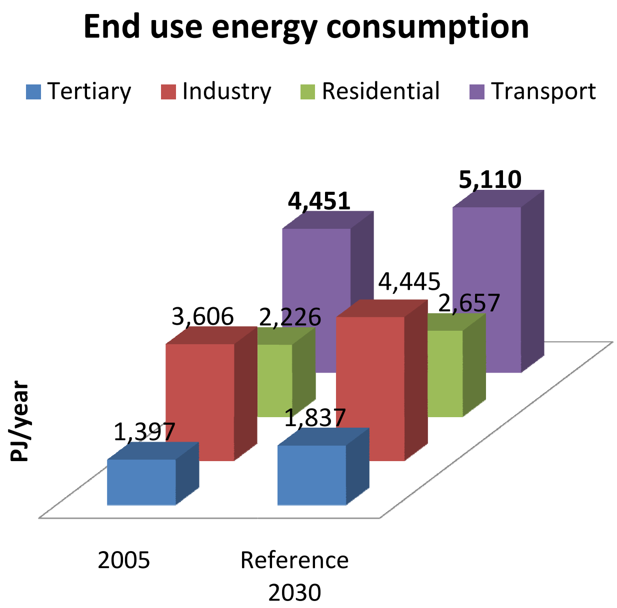


Figure 9 - End use energy consumption per sector

As expected despite the increased share of renewable energies in the energy system the reference scenarios doesn't reach the target of oil reduction. This occurs mainly due to increased energy demand expected, almost 2,5 mil. TJ just in the transport sector, which is mainly fueled by conventional means such as gasoline and diesel.

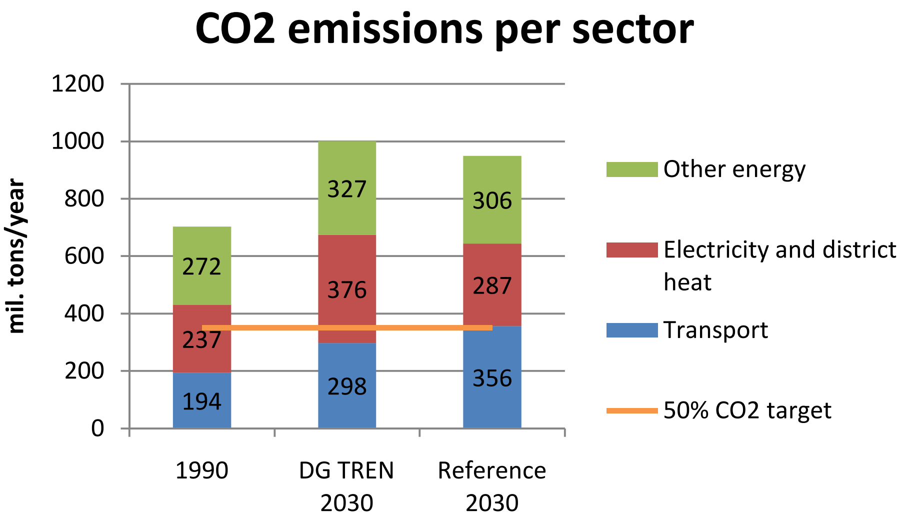


Figure 10 - CO2 per sector and target

Same results exist for the CO2 target as for the oil reduction target with main contributor again the transport sector. An increase of more than 80% on the CO2 emissions for only this sector was calculate for this reference scenario. However this scenario will serve as a baseline scenario for evaluating and comparing the following two scenarios which will be govern by additional changes in the energy systems.

3.2 Moderate Scenario

3.2.1 Main characteristics

In the previous section the reference scenario was presented which will serve as baseline for comparison with the two following scenarios. In this section the Moderate Scenario was created. For better comparison in all the provided information the reference results, as well as DG TREN expectations, are included.

The Moderate Scenario expresses a view for the future energy systems in 2030 introducing some significant changes compared to the reference scenario. The share of renewable technologies in the electricity and heating sector is increased significantly – double share than the reference scenario – while more old coal and gas plants are decommissioned. Furthermore additional savings and efficiency improvements are introduced in all sectors, transportation included. Some modal changes are also assumed in the transport sector reducing the use of car by 7% and a share of 10% of electric/hybrid cars is also included. Higher share of electric trains also contributes in this scenario.

This scenario in general assumes a background towards 2030 that very important changes have occurred on the renewable energy sector and energy savings as well. In the transport sector only a small percentage of people are using electric vehicles while some improvements have been made in all the technologies.

3.2.2 Energy demand

The end use energy demand in the different sectors is shown in the following table 5. Compared to the reference scenario there are some significant changes mainly due to the additional savings introduced in this scenario for all the sectors (see table 7). Overall the energy consumption is reduced by 20% including the actions taken for the transportation sector as well.

Table 5 - End use energy consumption per sector in Moderate scenario

End use	Consumption	GDP	Reference	Moderate scenario
Energy consumption sectors	2005	Economic growth	2030	2030
	TJ/year	% p.a.	TJ/year	TJ/year
Tertiary	1,396,856	2.1	1,836,774	1,515,702
Industry	3,605,829	1.9	4,444,719	3,639,942
Residential - heating	2,225,602	2.0	2,656,544	2,101,462
Total	**7,228,287**		**8,938,036**	**7,257,106**
		Growth in transport work		
Transport, person	2,757,080	1.0%	3,066,748	2,307,914
Transport, gods	1,693,792	1.6%	2,042,980	1,682,325
Total incl. transport	**11,679,160**		**14,047,764**	**11,247,345**

The heat demand in this scenario is characterized by increased usage of district heating and solar heating which expand to all sectors, since the one can be used through the extended infrastructure while the second is much more independent and can be applied almost everywhere. A small share of heat pumps is also included. Overall is assumed a relocation of the conventional ways for heating while significant reductions are made on electricity usage.

Table 6 - Fuel consumption per sector in the Moderate scenario

	Sectors						
	Tertiary		Residential			Industry	
Fuel consumption	TJ	%	TJ	%		TJ	%
Electricity	**681494**	**45%**	**497565**	**24%**		**868434**	**24%**
Appliances	566995		416208		**Appliances**	379344	
Space heating	98142	10%	52301	3%	**Process power**	489090	15%
District heat	294426	30%	523010	30%		652120	20%
Coal	0	0%	0	0%		65212	2%
Oil	98142	10%	34867	2%		391272	12%
Natural gas	245355	25%	523010	30%		1304239	40%

Biomass	49071	5%	87168	5%	195636	6%
Solar heating	147213	15%	435842	25%	163030	5%
Heat pumps	49071	5%	87168	5%		
Total	**1515702**			**2101462**	**3639942**	

3.2.3 Savings

The main measures in this scenario focus on high penetration of renewable technologies and the shifting of fossil fuels consumption. However in order to reduce effectively the overall energy demand additional improvements are assumed for the different sectors as seen on table 7.

Table 7 - Savings per sector in reference and additional improvements

Percentage saving compared to today's level	Energy form	Efficiency improvement in reference*	Additional improvement in Moderate Scenario
Tertiary	Electricity	21%	18%
	Heating	23%	9%
Industry	Energy	19%	15%
Residential	Electricity	20%	18%
	Heating	20%	15%

3.2.4 Transport sector

This sector is a major contributor on both oil consumption and CO2 emissions as show in the reference scenario. It was an obvious option to investigate the effect that potential changes would have in the proposed energy system. In that respect a shift of 5% was made mainly by moving the use of cars for personal transportation to bus and trains (1% was assumed for bikes and other means) while in the commercial sector a shift was assumed towards trains and ferries. The shares compared to the 2005 status and the reference scenario is show in Figures 11 and 12 regarding the two main sector for personal and goods transportation respectively.

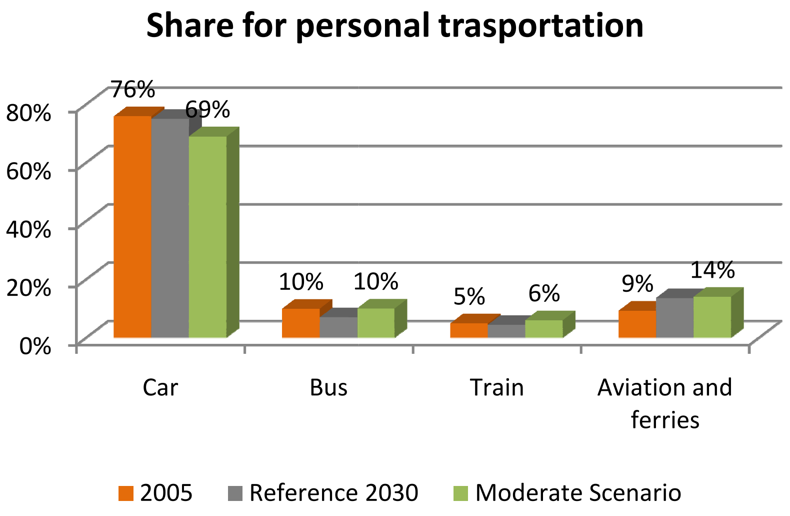


Figure 11 - Transport sector for personal transportation

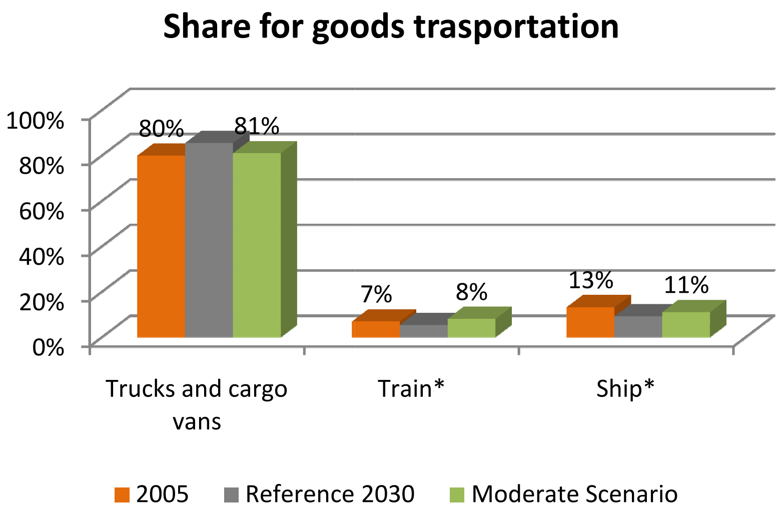
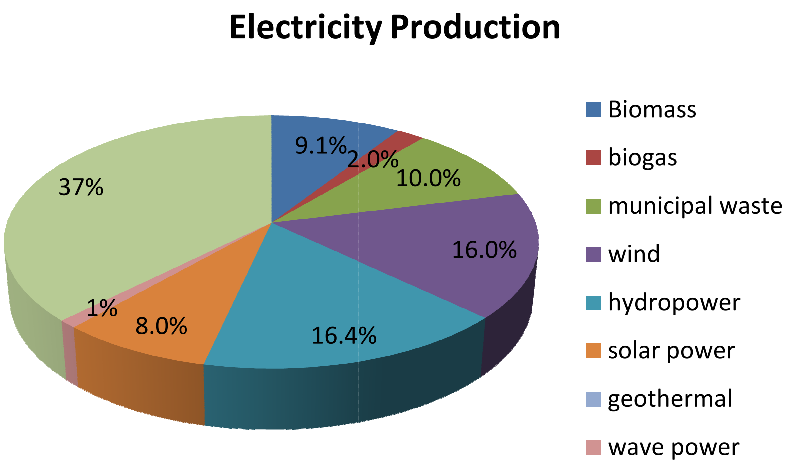


Figure 12 - Transport sector for goods transportation

Additional improvements were assumed compared to the reference scenario regarding the different technologies used for transportation and a higher penetration of electric/hybrid vehicles as well as the use of 80% electric trains compared to 60% assumed in the reference scenario. The shares of different fuels in the transportation all scenarios can be found in the Appendix. Cars fueled by biofuels reach a share of 10% as much as electric/hybrid ones. Natural gas is also used in a share of 10% as well as 5% of electricity for buses.

3.2.5 Renewable energy

The third main measure in the moderate scenario is the high share of renewable energy in the electricity and heat production. That share accounts for almost 63% for the electricity sector and 42% for heat production (Figure 13). Hydropower remains the main renewable technology followed closely wind power. Solar power and biomass for electricity production are increased significantly due to the very high potential resources of the region. In the heat sector mainly biomass powered district heating and solar heat are covering more than 2/3 of the demand.



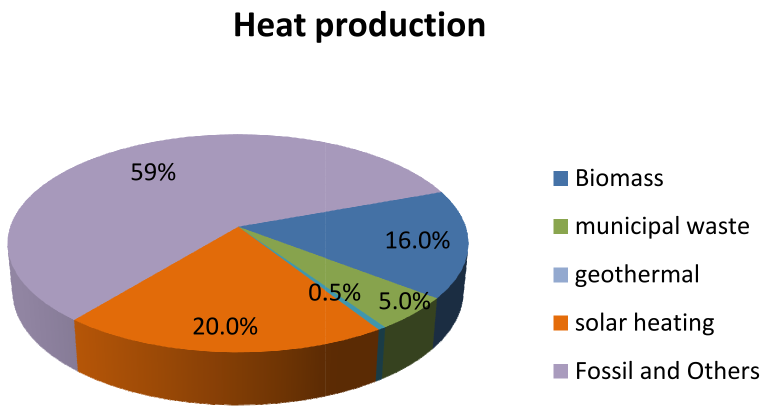
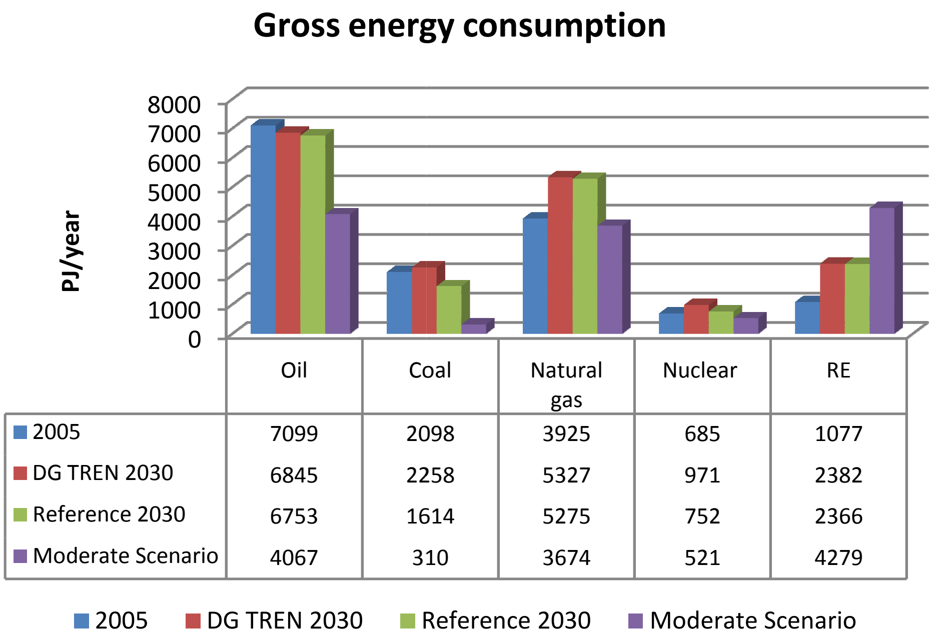


Figure 13 - Renewable technologies' contribution in electricity and heat production

The proposed measures led to an energy system which manages to reduce significantly the use of fossil fuels like oil and coal both main contributors to CO2 emissions and energy dependency. In figure 14 the gross energy consumption based on different energy sources is shown compared to the other scenarios .



	Oil	Coal	Natural gas	Nuclear	RE
2005	7099	2098	3925	685	1077
DG TREN 2030	6845	2258	5327	971	2382
Reference 2030	6753	1614	5275	752	2366
Moderate Scenario	4067	310	3674	521	4279

Figure 14 - Gross energy consumption per source

3.2.6 Scenario and targets

Compared to the reference scenario the Moderate Scenario was expected to present much better results regarding the targets set. However, as seen in Figure 15 the oil target is almost achieved mainly due to the significant changes on the transport sector. The use of coal is brought to very small amounts due to the increase share of RE in the power and heat sectors. Natural gas still accounts for a high share. Due to the reduced emissions of natural gas compared to other fossil fuels is expected to contribute positively towards reaching the CO2 targets as well.

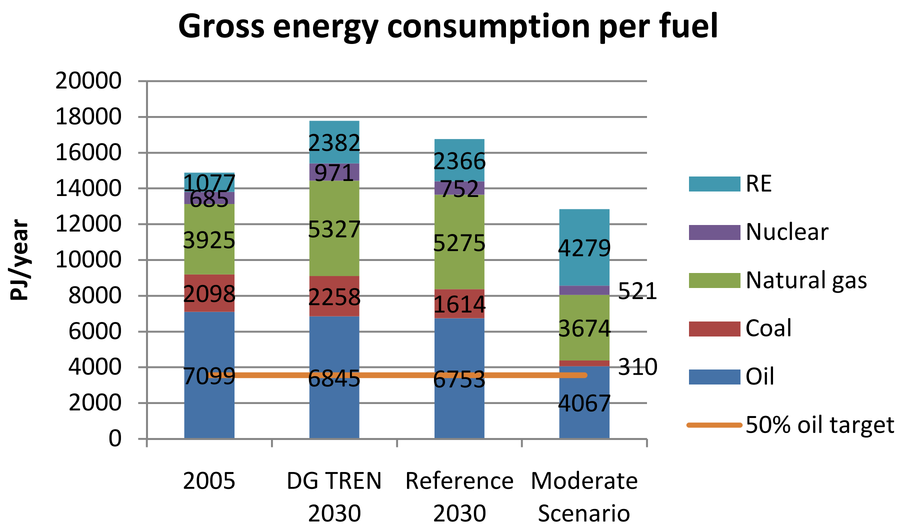


Figure 15 - Gross energy consumption and oil target

The changes introduced in the Moderate scenario have reduced the overall energy demand. The demand for transport services remained the same as the reference although better utilization of the available technologies and modal changes reduced the end use consumption. In Figure 16 the end use energy consumption is presented in comparison with the 2005 status and the reference scenario.

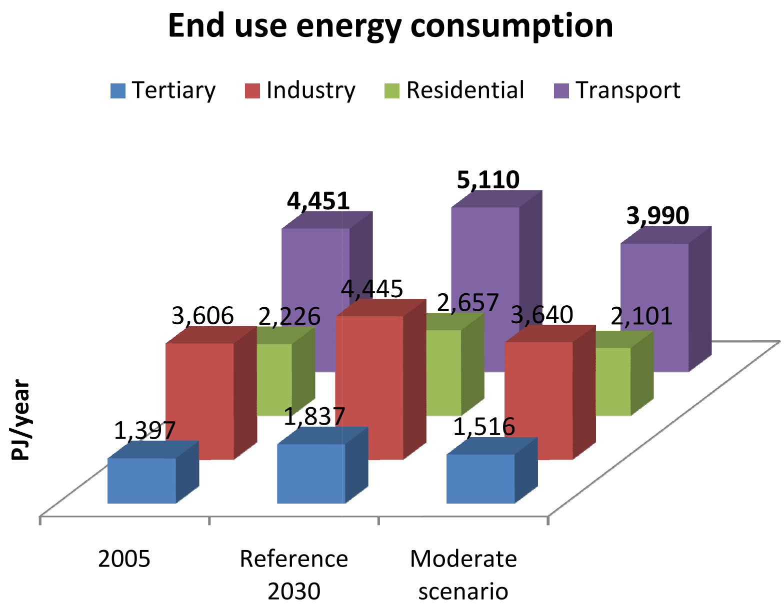


Figure 16 - End use energy consumption per sector

The energy system created in the scenario shows that by introducing additional improvements compared to the reference scenario is possible to reduce significantly the energy consumption while covering the demand for energy services. Moreover, if small changes are introduced in the transport sector great effects are made in the overall consumption pattern. As shown in Figure 16, transport and industry are the two most consuming sectors. However in the moderate scenario the difference between the sectors is reduced significantly proving the effects of combining energy savings and changes in the transport sector. Moreover, the oil consumption is reduced by almost 43% mainly due to the introduction of electric/hybrid vehicles and the diversity of fuels used mainly for cars and buses.

The Moderate Scenario however does not reach the CO2 reduction target despite all the changes described throughout this section. Transport sector still accounts for a great share (49%) of the total emissions although the other sectors managed to reduce more than 50% their shares.

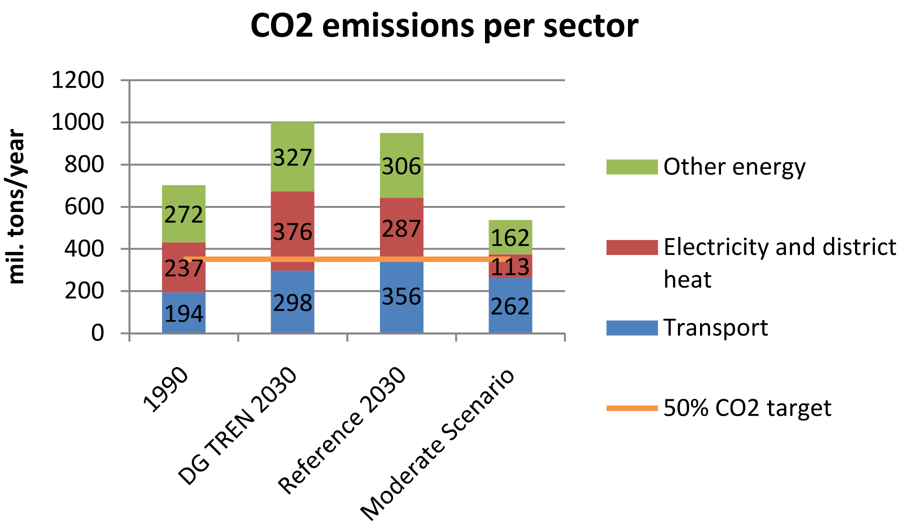


Figure 17 - CO2 per sector and target

In this section it was shown that despite many changes done in the energy sector such as doubling the share of RE or significant improvements in all the energy demanding sectors still the targets set are far from reach especially for the emissions which are directly linked to the environmental impacts such as the climate change.

In the following section the Optimistic Scenario will be presented in a way of exploring potentials for reaching both targets by making certain changes in the power and heat sector while special focus will be given in the transport sector which as shown in Figures 15 and 17 keep the energy system as presented in the moderate scenario away from the targets.

3.3 Ambitious scenario

3.3.1 Main characteristics

In the previous section the moderate scenario was presented. The overall results showed that despite the significant improvements in almost every aspect of the energy system both targets were not reached. In the optimistic scenario although that potential savings of the different sectors were kept in the same levels as in the moderate scenario, full of the available renewable sources and significant changes in the transport sector were implemented. In order to improve the performance of the energy system regarding CO2 emissions complete commissioning of all old coal and natural gas power plants was implemented.

As it will be presented a share of 50% of the transport sector will be powered by electricity. Combined with the increased share of renewable sources in power production in the overall measures taken both targets are reached in this scenario.

3.3.2 Energy demand

The energy consumption as presented in table 8 is significantly improved compared to the moderate scenario. This is due to the reduction of electricity used for heating purposes and substitution with renewable sources. Moreover significant reduction was made in the transport sector by introducing higher efficiency expectations, modal changes and a diverse mix of fuels like electrify, natural gas and biofuels substituting a large share of fossil fuels.

Table 8 - End use energy consumption per sector

End use	Consumption	GDP	Reference	Optimistic scenario
Energy consumption sectors	2005	Economic growth	2030	2030
	TJ/year	% p.a.	TJ/year	TJ/year
Tertiary	1,396,856	2.1	1,836,774	1,548,416
Industry	3,605,829	1.9	4,444,719	3,639,942
Residential - heating	2,225,602	2.0	2,656,544	2,147,952
Total	**7,228,287**		**8,938,036**	**7,336,310**

		Growth in transport work		
Transport, person	2,757,080	1.0%	3,066,748	1,231,135
Transport, gods	1,693,792	1.6%	2,042,980	1,218,395
Total incl. transport	**11,679,160**		**14,047,764**	**9,785,841**

The heating demand is characterised by significant reductions on the electricity used, weighing the share of district heating systems, solar heating and heat pumps are increased. In table 9 the contribution of different fuels for heating purposes are presented.

Table 9 - Fuel consumption per sector

	Sectors						
	Tertiary		Residential			Industry	
Fuel consumption	TJ	%	TJ	%		TJ	%
Electricity	**616066**	**40%**	**497565**	**24%**		**868434**	**24%**
Appliances	566995		416208		**Appliances**	379344	
Space heating	49071	5%	52301	3%	**Process power**	489090	15%
District heat	343497	35%	523010	30%		652120	20%
Coal	0	0%	0	0%		65212	2%
Oil	0	0%	34867	2%		391272	12%
Natural gas	294426	30%	523010	30%		1304239	40%
Biomass	49071	5%	87168	5%		195636	6%
Solar heating	245355	25%	435842	25%		163030	5%
Heat pumps	0	0%	87168	5%			
Total	2164482		**2101462**			**3639942**	

3.3.3 Savings

In the optimistic scenario the energy savings are also an important measure for reaching the targets as in the moderate. These improvements were kept however in the same levels. In this way greater focus is given on the effects of the other two key measures, renewable energy technologies and changes in the transport sector. The assumptions for efficiency improvements are shown on table 10.

Table 10 - Savings per sector

Percentage saving compared to today's level	Energy form	Efficiency improvement in reference*	Additional improvement in Moderate Scenario
Tertiary	Electricity	21%	18%
	Heating	23%	9%
Industry	Energy	19%	15%
Residential	Electricity	20%	18%
	Heating	20%	15%

3.3.4 Transport sector

On the reference and the moderate scenario transportation sector is limiting significantly the results regarding both targets. With these considerations in mind, more changes were introduced in this scenario. Electricity as powering fuel was assumed for trains, cars and buses reaching shares of 100%, 50 and 60% respectively. Modal changes were also included in higher shares increasing the use of mass means like buses and trains. In the following figures the shares for the two sectors are presented. These targets are based on the assumption that electric and hybrid vehicles are widely available as well as the supporting infrastructure.

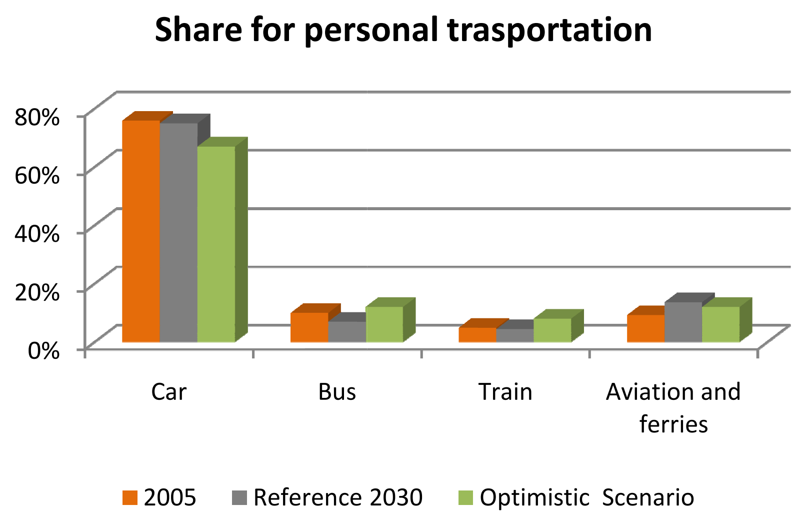


Figure 18 - Transport sector for personal transportation

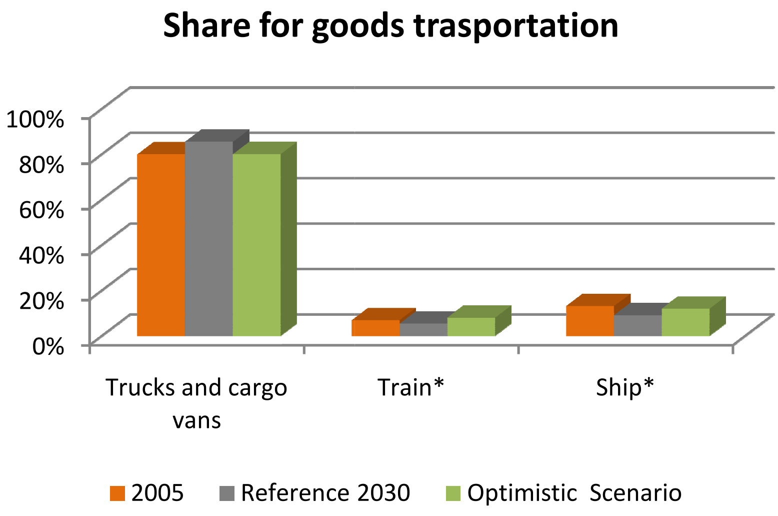
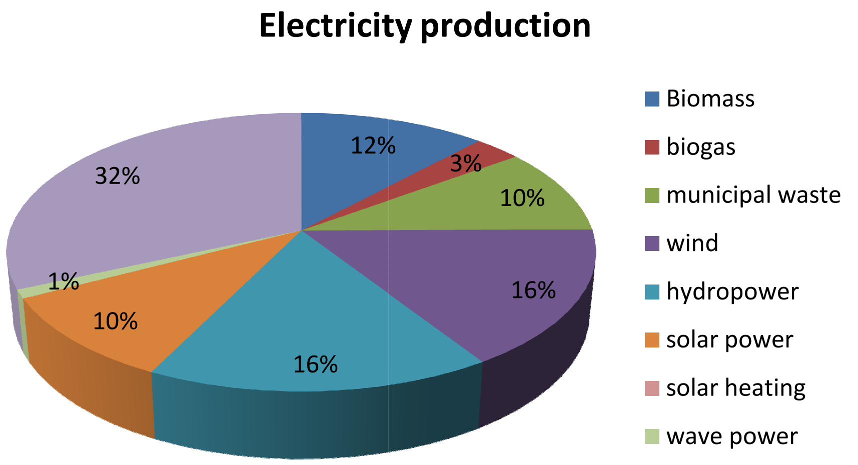


Figure 19 - Transport sector for goods transportation

3.3.5 Renewable energy

In the optimistic scenario renewable energy has even greater share exploiting fully almost all the exploitable and available resources based on the model's data. The contribution of renewable in the electricity production mix reaches 68% while in the heat production almost 43%. The fossil fuels used in the heat sector account specifically for natural gas since oil and coal have been completed removed for the power and heat sector.

As presented in figure 20 there is great diversity in the energy mix in which apart from the main contributors like wind and hydro power, solar power, biomass and municipal waste prove to be very important. In the heat sector solar heat and biomass account for more than 1/3 of the production assumed that solar systems can used for both district heating and private installations while biomass specifically for combined heat and power plants. This diversity for both sector guarantees great security of supply while reducing the oil dependency. However in the heat sector natural gas is still a major contributor.



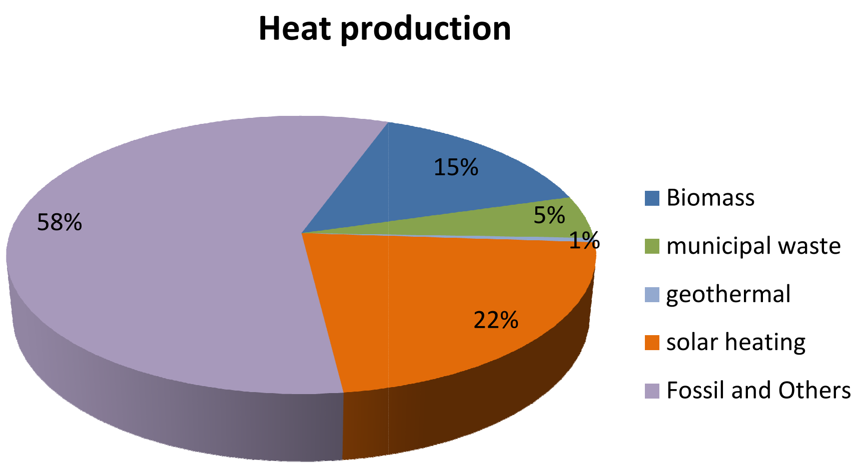
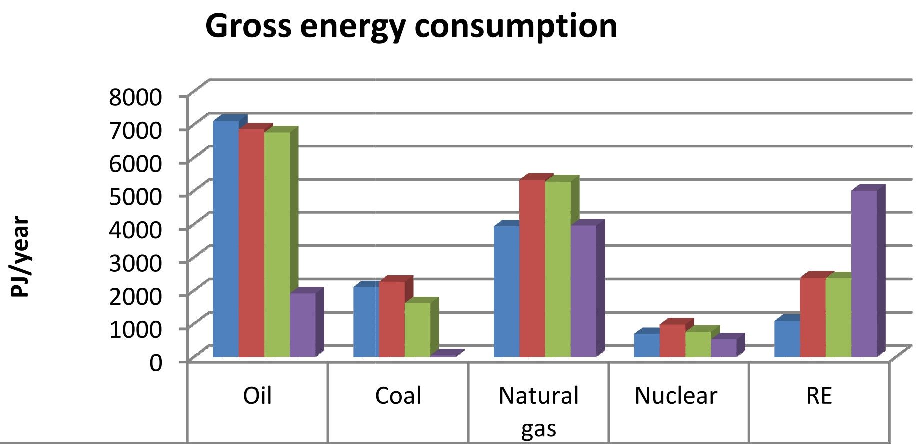


Figure 20 - Renewable technologies' contribution in electricity and heat production

Great changes are taking place in the optimistic scenario. The load shift and high share of electric powered vehicles in the transport sector lowers by more than two thirds the oil consumption compared to the 2005 levels. Moreover the high share of renewable for both heat and electricity production brings the use of coal to almost zero. It worth noticing that natural gas consumption is kept on almost the same levels as 2005. With these characteristics not only the targets are expected to be achieved but also a significant reduction on fuel import dependency.



	Oil	Coal	Natural gas	Nuclear	RE
2005	7099	2098	3925	685	1077
DG TREN 2030	6845	2258	5327	971	2382
Reference 2030	6753	1614	5275	752	2366
Optimistic Scenario	1907	38	3949	521	4999

2005 DG TREN 2030 Reference 2030 Optimistic Scenario

Figure 21 - Gross energy consumption per source

3.3.6 Scenario and targets

The optimistic scenario achieves both targets as shown in figures 22 and 24. It is notable impact of these changes on the oil consumption which was reduced almost 60% compared to the reference scenario while CO2 emissions still barely reached the target.

As shown in figure 23 the end use energy consumption was reduced dramatically. Key contributor to this was a significant change in the nature of the transport sector. Half of the car fleet is powered by electricity and better utilization of mass transportation is developed. Possibly the next step for improving this energy system could be more changes in transport sector, for example in the aviation, and perhaps additional savings in the industrial sector.

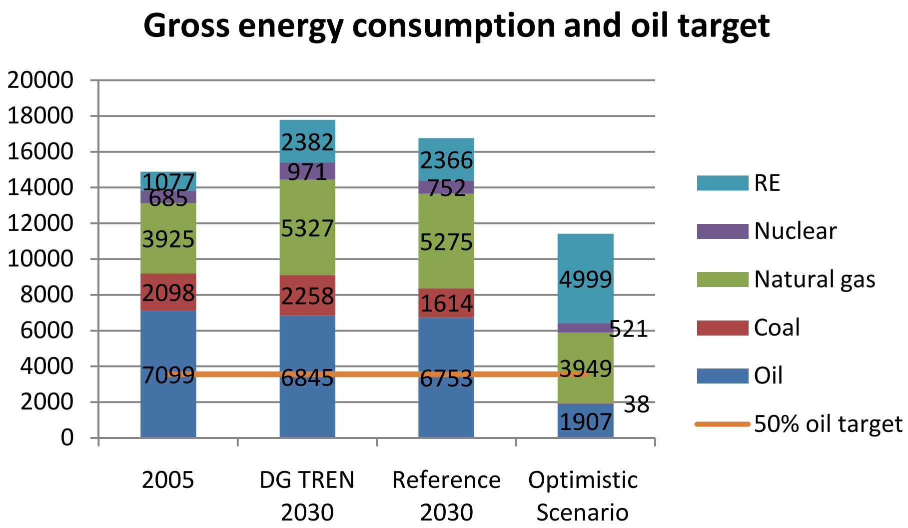


Figure 22 - Gross energy consumption and oil target

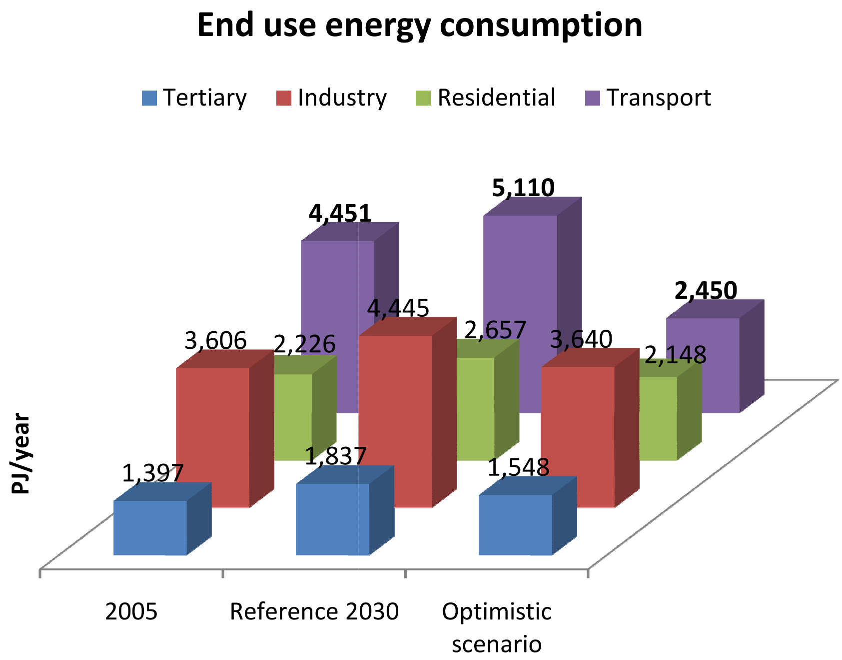


Figure 23 - End use energy consumption per sector

As expected the big changes made in the transport sector were the key to reach the CO2 targets. Possibly if great efficiencies and savings achieved thanks to technological breakthroughs, policies or market efforts these targets could be easier achieved in the given time horizon.

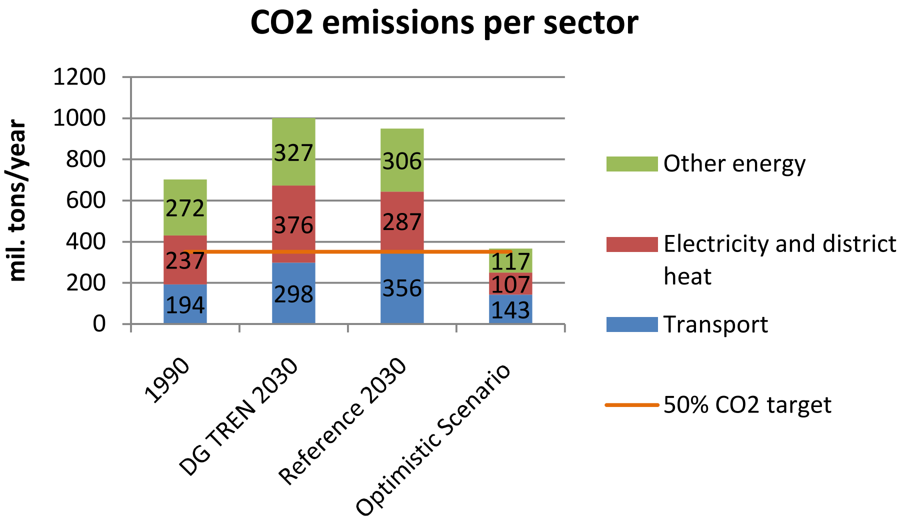


Figure 24 - CO2 per sector and target

In this scenario an energy system was presented to reach both targets for oil reduction and CO2 emissions. Throughout this chapter two more scenarios were described as an attempt to recreate the results the different paths are chosen. In the following section the three different futures are summarized leading to conclusions necessary for the creation of the roadmap in chapter 5.

3.4 Summarized results

This research is exploring different future perceptions for the energy systems in south Europe. Since the time horizon is 2030 many challenges are currently present and actions or non-actions will lead to different futures. In order to bring into surface these challenges the different energy scenarios presented in this chapter were created.

The moderate scenario compared to the reference introduces innovations and changes in the three key measures of energy savings, renewable sources in the energy mix and in the transport sector. The additional improvements compared to the expectations of DG TREN baseline vary from 9% to 18% common for both scenarios. These actions could be reached in compliance with the expectations and binding targets in European level for 2020. The effects were obvious in both scenarios as basic steps on reducing energy consumption by creating a more efficient system by regulating the demand side.

The contribution of renewable technologies in the power production was 63% and 68% for the moderate and optimistic scenario respectively almost double than the reference scenario. In the heat sector the difference was smaller since it accounted for 42% and 43%. This was due to the assumptions made especially for the optimistic scenario were all available resources and increased diversity of the provided fuels were included.

Regarding the transport sector in the moderate scenario small share of electric vehicles was included while in the optimistic that share reached 50% and smaller shares of cleaner fuels like biofuels, natural gas and full electric trains. This had a significant impact on oil consumption and CO2 emissions of the proposed system which managed to reach both targets.

The characteristics of the scenarios showed how important and necessary the changes in the current transport systems. However higher penetration of renewable energies and energy savings need to be combined in the future energy systems. Energy production from renewable sources shows its potential environmental benefits only if coupled with energy savings and lower consumption than the current trends. Additionally the diversity of the resources utilized by renewable sources will reduce significantly the dependency for import and will stabilize local economies against the volatile or high prices of fossil fuels in the future.

Through the modeling tool used certain economic projections were made for assessing the two scenarios. Due to the high level of uncertainties the results present were limited for comparing the two scenarios with the reference. In figure 25 the extra costs are presented for the system in the moderate scenario compared to the reference scenario in year 2030. The main assumptions made were a cost of 100$/barrel oil, as the reduced demand is expected to lower the current prices, and a price of 30€/ton CO2. The interest rate used was 5% and the main technology costs derive from the technology catalogue of the Danish Energy Authority as included in the model.

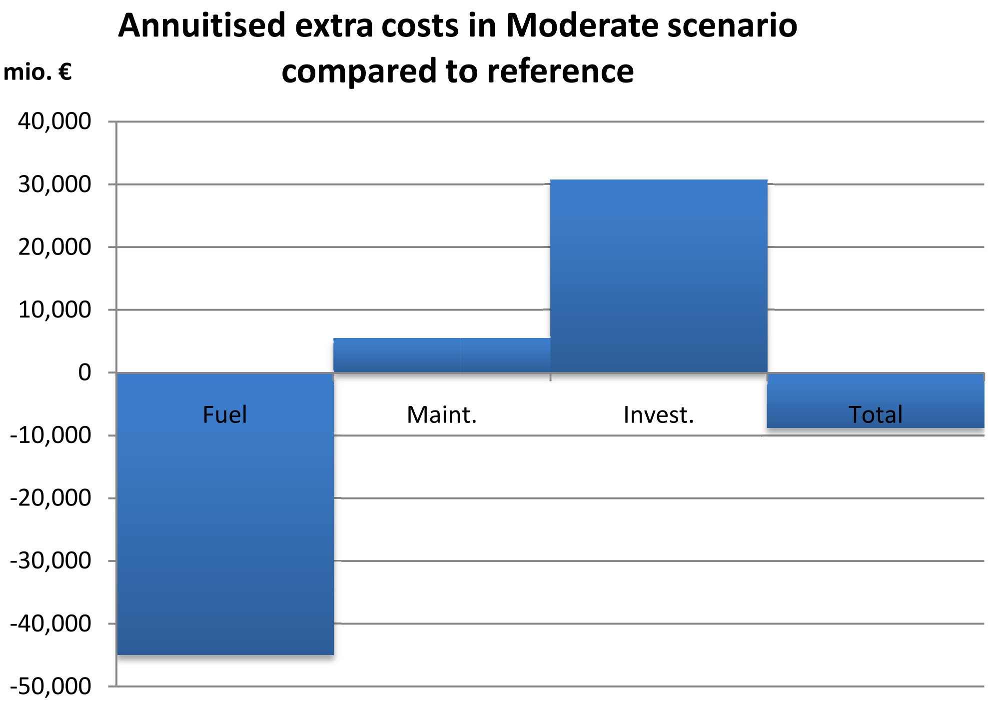


Figure 25 - Extra costs for Moderate scenario in one year

The same assumptions were made in figure 26 regarding the optimistic scenario. In this way the comparison can focus on the two scenarios comparable to the common baseline.

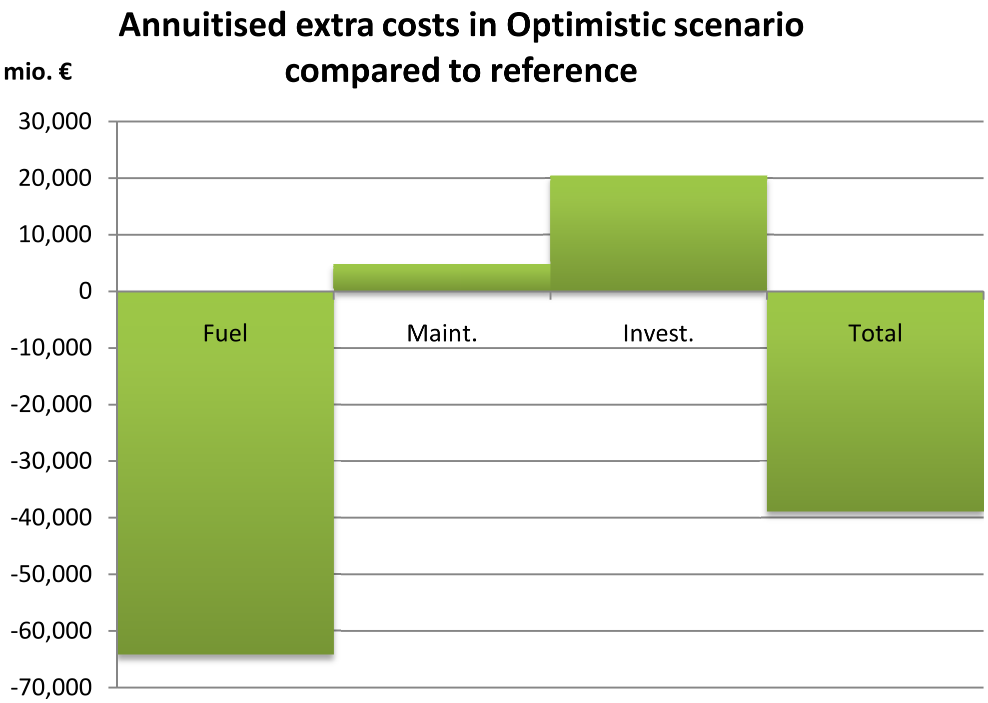


Figure 26 - Extra costs for Optimistic scenario in one year

It should be noted that these figures represent a static economic analysis where the total fuel consumption is assumed to remain in the same levels regardless price changes. Moreover there might be potential differences on the actual operational costs of such a system as well as the future energy prices. The figures represent the annual costs of the systems and have not been discounted in today's value.

Due to the significant oil and emission reductions in both scenarios large potential gains are represented. This represents a gain in the form of reduced health or environmental costs or a highest energy security or added value for the economy. It is worth noticing that the optimistic scenario showed lower investment costs compared to the moderate one and the higher gain. However as mentioned this figures should be interpreted with caution.

The creation of the two scenarios and the comparison with the reference scenario showed that is needed to focus on the promotion of the three key measures. Moreover it showed that it is possible with technology specific measures to reach ambitious targets by 2030 although will require significant investments and general changes in the current energy systems.

With the results of this chapter as point of departure the following chapter will focus on the policy aspects and changes required to promote the implementation of such energy systems as shown in the scenarios. In the following chapter the energy status in 2005 and the policy developments for the countries consisting the South region will be presented. In this way the differences in the energy status and current policies will be identified while the general policy perspectives in European level will be included.

Chapter 4 - Policies in South Europe and EU

In the previous chapter scenarios were created in order to present different views on future energy systems in 2030 for the region of South Europe. In these scenarios key measures were taken in different extent and were evaluated regarding common targets on oil consumption and the generated CO2 emissions. The main result was that with technology specific measures is possible to achieve these targets by year 2030. In this chapter the different policies in South Europe will be presented as well as some important policies in European level.

A comparison with a business as usual approach showed that several actions need to be taken. These aspects naturally form the basis for exploring what is necessary to be done by creating the necessary framework in the countries of South Europe which will facilitate these changes. As it will be shown in the following sections there are several policy forming undergoes in the general EU level. This will set binding targets for the member states including the countries of Southern Europe. The current EU policies as well as the main energy related legal framework for the Southern countries will be presented. In this way their policy differences of each country can be acknowledged while due to the general EU obligations and certain targets for 2020 are expected to put the necessary pressure for more action.

The reasoning for choosing not independently approaches for every independent country lies on many aspects such as the nature of the energy problems and the magnitude of the environmental impacts, the EU energy obligations, the future common EU energy market and the need for competitiveness as well as infrastructural needs for interconnectivity for supporting energy exchange in the region.

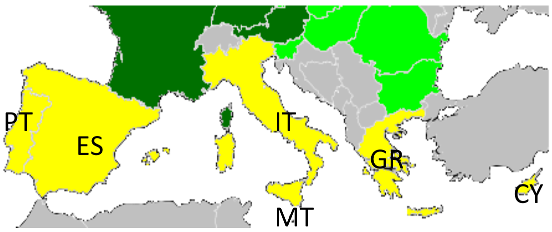


Figure 27 - South Europe

The target area of this research is the South Europe. The countries which are to be examined are Portugal, Spain, Italy, Greece, Malta and Cyprus. However, Malta and Cyprus due to their very small share compared to the other countries will not be the main issue regarding policy developments since is assumed that in the future they will apply similar policies towards achieving targets set by the European Union and from market point of view will also have penetration comparable to the other countries of the region. In this section a short presentation of each country will be done as well as the latest policy developments on energy as well as their obligations as set by European's Union current proposal for a new Directive on Renewable energy.

Cyprus and Malta are not included in the presentation due to the limited contribution to the overall energy consumption (1% of the region's consumption for both two countries combined).

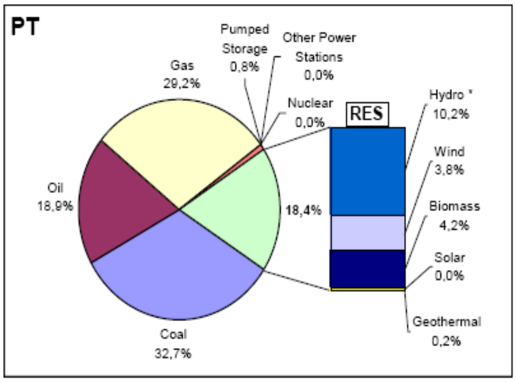
4.1 Portugal

Portugal has one of the lowest GDP of western European countries although it has a high Human Development Index. Due to lack of fossil fuels resources in local level and no nuclear power, Portugal imports almost 80% to cover its energy needs including transport.

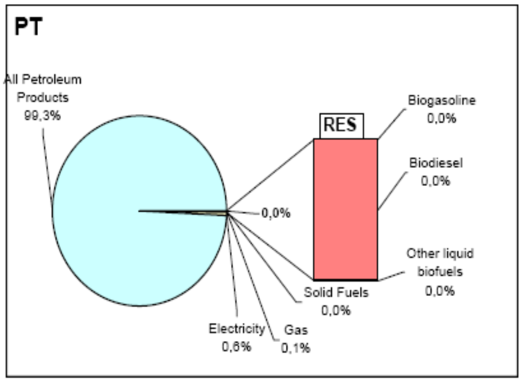
Nevertheless Portugal has been focused on the promotion of the renewable energy sector with a profound way. It has a complex policy and monitoring system. In the new Directive the indicative target for year 2020 of 31% of the gross energy consumption deriving from renewable sources applies for Portugal[21]. As in year 2005 renewable energy accounted for 20,5% as share of the final gross energy consumption. Portugal has the world's largest solar plant as well as the world's first commercial wave power plant. However, Portugal's primary energy consumption has been increasing rapidly (3,1% annual growth rate in 2005 – one of the highest in EU-25).

[21] Heer and Lagniss, June 2007 Promoting Renewable Energy Sources in Portugal: Possible Implications for China

Gross Electricity Generation by fuel (2005)



Final Energy Consumption by Fuel, Transport (2005)



Source: Eurostat

* Not including generation from hydro pumped storage, but including electricity generation to pump water to storage. Municipal Solid Waste, Wood waste, Biogas included.

In September 2006 the gradual liberalization of the Portuguese electricity market was completed. The country's present-day electricity market is comprised of the publicly regulated system *SEP (Sistema Eléctrico de Serviço Público)* with the provider EDP Distribuição (Energias de Portugal) co-existing alongside the liberalized system *SENV (Sistema Eléctrico Não Vinculado*). Providers within the liberalized system are EDP Corporate (Portugal), Iberdola and Unión Fenosa (Spain), as well as Sodesa (an association of the Portuguese Sonae Capital and the Spanish Endesa Energía). Liberalizing the power sector has clearly increased the number of competitors. However, with a market share of 49.6 percent, EDP remains the de facto market leader among the electricity providers. Additionally, EDP holds 30 percent of the transmission system operator REN and is involved to a large extent in electricity generation (via CPPE being part of the EDP group).

From policy point of view several measures have been taken to insure the uptake of the renewable energy sector. Fixed tariff system, tax reductions exist as well as subsidies (up to 40%) while a new building law obliges the installation of solar thermal systems in certain cases. Resolution No. 63/2003 defines the targets for the energy policy in Portugal.

The main three goals are of the strategy are security of supply, sustainable development and increased national competitiveness.

Moreover, the target of a minimum 39% of its gross domestic electricity consumption was set for year 2010 while also specifying targets for each renewable energy technology. Responding to the increasing oil prices the national policy was revised in

October 2005 and its result was Resolution Nr. 169/2005 which defined additional targets for year 2013 (see table 11)

Table 11 - RE capacity targets for Portugal

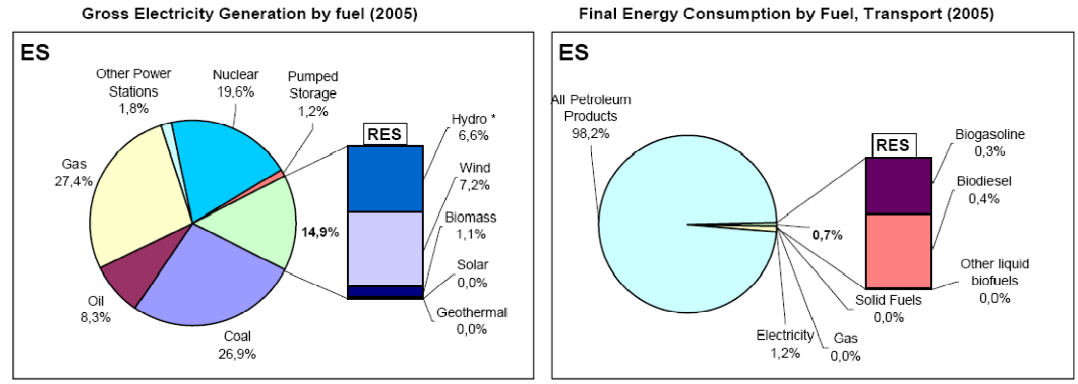
Technology	*Installed capacity in 2001 (in MW)*	*Installed capacity in 2010 (MW) (Res. 63/2003)*	*Installed capacity in 2013 (MW) (Res. 169/2005)*
Wind	101	3750	5100
Small Hydro	215	400	400
Biomass (without CHP)	10	150	150
Biogas	1	50	50
Municipal wastes	66	130	130
Wave	0	50	50
Photovoltaics	1	150	150
Large Hydro	4209	5000	5000
Total	**4603**	**9680**	**11030**

These ambitious targets have been supported by multiple financial programs mainly through the Programa de Incentivos à Modernização da Economia (PRIME). In March 2007 the government has submitted the new Operational Programme for the period of 2007-2013.

In general the policy environment for promoting an increase penetration of RE in the future energy mix has been very strong and unique in many ways since it has also promoting the local manufacturing of wind power as well as solar energy components. Additionally the limiting of the tariff period to 15 years has pushed further the pursuit of rapid commercialization and cost decline of such energy projects. It is strongly believed that Portugal will not only reach the EU targets by 2020 but possibly will exceed them.

4.2 Spain

Located in the south and north borders of Portugal Spain is the second largest country in Western Europe and has the 8th largest economy in the world and fifth in Europe based on nominal GDP. Spain is the country in Europe which has nuclear power. Its 8 nuclear reactors[22] produce almost 20% of its electricity consumption while 27% comes from coal and 27% from gas. The electricity market has been liberalized as early as 1997. Regarding renewable energy a great boom took place the last years mainly on wind power (11,6 GWe installed capacity by end of 2006) as well as in solar energy regarding solar heat, CSP and photovoltaic systems. However, Spain is far away from its obligation as set for year 2020 by European Union. In 2005 renewable energy accounted for 8,7% of the gross final energy consumption and the target for 2020 is 20%.



Source: Eurostat

* Not including generation from hydro pumped storage, but including electricity generation to pump water to storage. Municipal Solid Waste, Wood waste, Biogas included.

Since 1997 a strong support program was introduced for RE and in 2004 hydro power account for almost 50% of the green electricity. Photovoltaic seem as a promising technology with an annual increase of 54% as well as wind and biomass related technologies.

The support mechanisms are based on a feed in tariff or a premium price paid on top of the market price. However these tariffs for hydro and wind were reduced as proposed in a draft law in November 2006 while increasing the support for solar thermal electricity,

[22] http://world-nuclear.org/info/inf85.html

biomass and biogas. The new renewable energy legislation passed in May 2007 increased the tariff for renewable from biomass by 50-100% and for biogas 16-40%. Spain is the first country in the world to set obligations for installing photovoltaic systems in certain cases and the second (after Israel) for incorporating in the building code obligations for solar heating systems. The new Technical Building Code (CTE, 2006) includes an obligation for 30-70% of the domestic hot water demand to be covered by solar heat and applies to all new buildings and renovations.

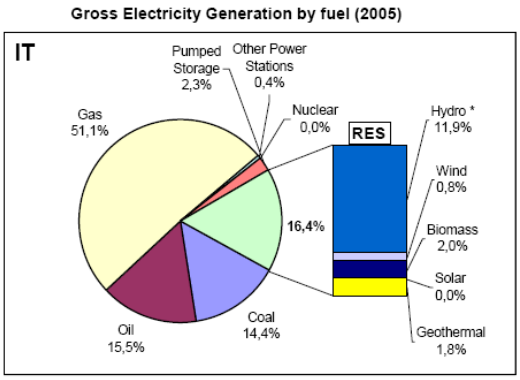
Spain has the second largest wind turbine manufacture (GAMESA) and an impressive installation growth. Within 2007, more than 3522 MW were installed reaching a total capacity of 15.145MW the second highest in Europe. The impressive growth of renewable the latest years are very promising if continued and further promoted.

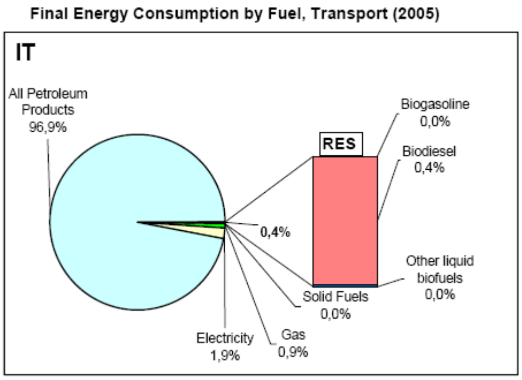
4.3 Italy

Member of the forum of the 8 most industrialized countries in the world (G8) with the 10th highest GDP in the world. It has a very developed industrial sector leading to imports for raw materials as well as energy (more than 75% of energy is imported) which are rather high Is also the 10th country with the highest amount of emissions in the world[23] in 2004.

For year 2020 Italy will be obliged by the European Directive to cover 17% of the final gross energy consumption as share of renewable consumption compared to 5,2% accounted for 2005. The Italian energy sector is heavily depended on fossil fuel, mainly gas while the renewable energy sector is dominated by large hydro plants accounting for almost 12% of the gross electricity generation.

[23] United Nations, CDIAC 2004 emission data





Source: Eurostat

* Not including generation from hydro pumped storage, but including electricity generation to pump water to storage. Municipal Solid Waste, Wood waste, Biogas included.

The main support policies set for promoting renewable energy have been:

- Priority access to the grid system is granted to electricity from RES and CHP plants.
- An obligation for electricity generators to feed a given proportion of RES-E into the power system.
- Tradable Green Certificates (which are tradable commodities proving that certain electricity is generated using RES) .The price of such a certificate stood at 109 EUR/MWh in 2005.
- A feed-in tariff for PV exists. This is a fixed tariff, guaranteed for 20 years and adjusted annually for inflation.
- National legislation is being developed, both for RES-H and for biofuels. Subsidies are already in place for bioethanol production and tax exemptions for biodiesel production.

Currently the energy market is boosted mainly due to the *Conto Energia* as modified in 19 February 2007 sets a target for photovoltaic systems and the support scheme for 3000 MW of installed capacity by 2016. Moreover, certain regions have incorporated schemes on their building codes obliging the use of solar heat and photovoltaics in certain cases.

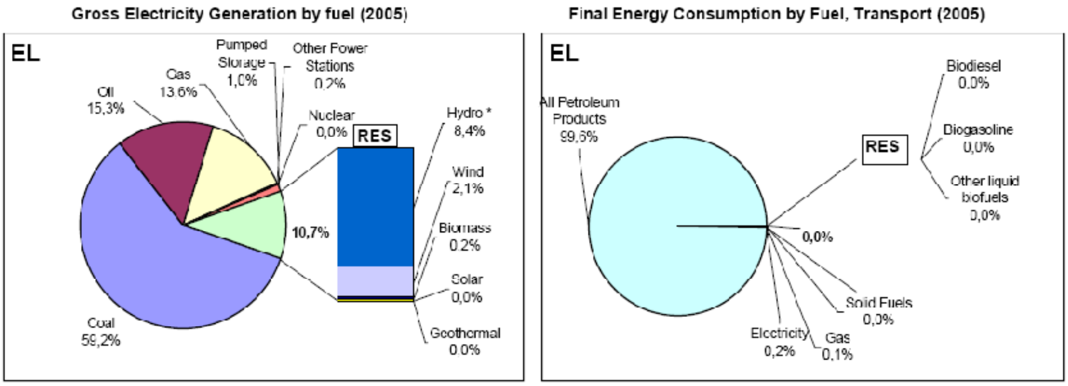
Despite strong growth in renewable energy sectors such as wind, biogas, biodiesel and an upcoming implementation of solar energy Italy is far from the targets set in national and European level. Recent political changes and barriers to implement current policies caused by complex authorization procedures contribute in the current picture. Moreover high grid connection costs discourage further potential investments on these sectors.

However, if such barriers are overcome high penetration of wind and solar technologies is expected in the future energy mix.

4.4 Greece

Greece is one of the oldest member of the European Union (since 1981) and located South east in the Balkan Peninsula. Two of the power plants in Greece (Agios Dimitrios and Kardia) are ranked 1st and 4th respectively as the most polluting power plants in Europe[24] based on a WWF report.

Greece is required to reach a share of renewable energy in the gross final energy consumption of 18% compared to 6,9% existing in 2005. Great share of electricity production is based on coal and lignite power plants while due to the high number of islands diesel generators are typically used for power production.



Source: Eurostat
* Not including generation from hydro pumped storage, but including electricity generation to pump water to storage. Municipal Solid Waste, Wood waste, Biogas included.

A new law 3468/06 was introduced in May 2006 in order to establish a favorable framework for the promotion of renewable energies. Although many economic incentives were promised as well as administrative ease still has not presented significant results[25]. The new policy provides a fixed tariff system for 20 years and financial subsidies that can reach up to 40%. However the bureaucracy and the administrative

[24] WWF , Dirty Thirty, May 2007 http://www.panda.org/about_wwf/what_we_do/climate_change/problems/cause/coal/dirty_30/index.cfm

[25] Filippidis, Policy and Market Aspects of the Greek PV sector, Denmark 2007

burdens are still discouraging and delay investments and installations. Significant changes will be required for reaching the targets set for 2020.

4.5 Policies in European level

Europe is currently working on certain policies that will define and shape the energy future for all regions. Maybe the most important is the creation of a new directive for renewable energies that is currently forwarded for approval to the Council and European Parliament. This is due to the ambitious but promising conclusions of the spring Council in 2007. In March 2007 the European leaders signed up for the binding targets for year 2020 - 20% of EU's overall consumption will come from renewable sources, 10% of biofuels in the fuel mix used and 20% reduction of CO2 emissions. Regarding renewable share all member states will have to increase it in their national energy mix by 5,5% compared to 2005 and then the additional increase depends on national GDP. For biofuels the binding targets subject to two important characterisitics of being "subject to production being sustainable" and to "second-generation biofuels becoming commercially available". For the CO2 emissions target if other industrial nations like China and USA contribute positively in a post-Kyoto framework, EU plans on extending this target to 30%. It should not be neglected that in 2001 another Directive for the promotion of electricity produced renewable energy sources has set targets of 21% share in the electricity production by 2010 – in 2006 the share was 14,65% and predictions were that the target is far from reached[26].

Regarding the energy efficiency there is a group of policies but the main is the Action Plan[27] promising to "provide to EU citizens the most energy-efficient buildings, appliances, processes, cars and energy systems in the world". In this proposal 75 specific actions in 10 priority actions are identified to be implememnted in a 6-year period. Backed by the Green Paper on Energy Efficiency presented in 2005 it was stated that Europe could reach 20% reduction of its current energy consumption by 2020, it could contribute in reducing import dependency on oil and gas imports and that energy savings are the most cost effective and quick way to reduce the CO2 emissions and reach Kyoto's obligations. In 2007, the Commission discussed the new energy and climate change package where underlines energy efficiency as priority. Also in February 2007 the

[26] http://www.euractiv.com/en/energy/report-eu-2010-renewables-target-reach/article-170201
[27] COM(2006)545, Action Plan for Energy Efficiency: Realising the Potential

Commission proposed a strategy for reducing car emissions and since June 2007 all member states delivered national action plans on energy efficiency publicly available for monitoring of the progress. In July 2007 the Parliament adapted a new ENERGY STAR regulation for stricter efficiency requirements on public procurement of office equipment. In 2008 more proposal and discussions are expected to follow while in 2009 the Directive on energy efficiency of buildings[28] will be revised.

Since 1998 a voluntary agreement between the Commission and ACEA (the European Automobile Manufacturer's Association) was made with a commitment by the manufacturers on reaching a target of 140g/km of CO2 emissions by 2008. Small developments have been made since then reaching from 1995 level of 186g/km to 161g/km in 2004. On February 2007 the new strategy proposed by the Commision – which was twice postpone – proposed binding targets of 130g/km by 2012 and 95g/km by 2020. Among other it proposed member states to promote and stimulate the purchase of fuel-efficient vehicles and to demand EU car producers to sign a good practice code on promoting more sustainable consumption patterns[29].

In this short overview it was shown that in the highest level of policy making a lot of effort are being done towards 2020 regarding renewable energy, energy savings and improvements and up to an extend on transport. However the targets set in this report are over-passing the time horizon set by European Union's policies. Considering the latest developments in EU level, the current status on the Southern countries and the requirements of the proposed energy scenarios formed the basis for the following chapter. In that chapter recommendations through a roadmap will be made in pursuit of answering the research question and concluding this research.

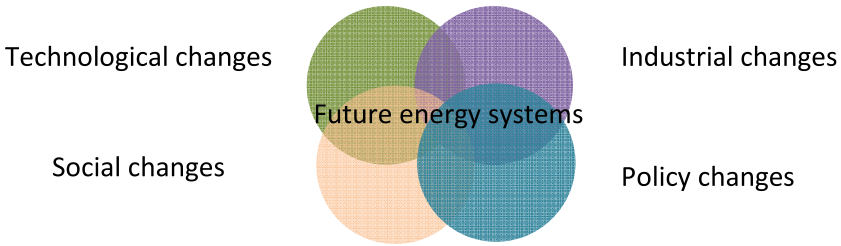
[28] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings

[29] IP/07/155, Brussels February 2007

Chapter 5 - Roadmap

Following the developments and policy status at European and country level the final part of this research is created in the form of a general roadmap. This will epitomize the necessary changes for establishing a favorable framework which will facilitate the necessary technological changes. However firstly it should be discussed why creating a roadmap is needed and which are the possibilities.

Technology roadmapping has been widely used in the corporate world as an easy to understand and predictive way to communicate future scenarios while assisting on strategic decision making and implementation[30]. Using this method is possible not only to position future developments and changes in a projected timeline but also identify the linkages between the different dimensions of the scenarios. It is widely argued that system changes and innovations are difficult to achieve due to the prevailing systems which act as barriers to the creation of new systems (Kemp and Soete 1992; Jacobsson and Johnson 2000; Unruh, 2000; Kline, 2001; Geels 2002; Carlsson and Jacobsson, 2004; Frenken et al., 2004). It is important to understand that in the creation of following roadmap four main dimensions are considered (figure XX). These dimensions are technological changes, industrial changes, policy changes and social changes (Könnölä, 2007). All of these aspects are interlinked in complex systems like the creation of the proposed future energy systems.



Future energy systems derive from the gradual development of new technologies and trends. These changes are largely driven by the industrial and market dynamics which resources define the value networks and lobbying efforts. However this system is also affected by policy changes which actively take part in the future developments by setting market conditions and controlling supply and demand. Finally social changes should

[30] Totti Könnölä, 2007, JRC, Innovation Roadmap: Exploring Alternative Futures of Industrial Renewal

mainly direct policy changes linking together the different parts for creating and future system.

In chapter 3 different energy scenarios were created and evaluated based on their performance on achieving the targets for halving oil consumption and CO2 emissions by 2030. However only the optimistic scenario succeeded in doing so. Consequently the target of the proposed roadmap and guidelines refer to achieving this specific future.

Three key measures were taken for achieving the targets and creating the optimistic scenario. Energy savings and efficiency improvements for all the different sectors set the base for reducing energy demand. A high share of renewable sources diversified the energy mix for electricity and heat production, while changes on the transport sector like including high share of electric vehicles and work load shifts. But how can these characteristics of the proposed scenario be achieved? Which different changes should be promoted and how the necessary framework be created? The following sections attempt to answer these questions by forming the roadmap for the Southern Europe.

5.1 Energy savings

In order to create an efficient energy system for the future primary focus has to be given on reducing energy consumption. Significant savings can be achieved in a cost-effective way as shown by many peer reviewed reports. As from 2006, the directive on energy performance of buildings has been implemented in the national legislation of almost all the member states. This is expected to have a major impact if intensively and actively supported by current and future policies. One example is that by just adding insulation to existing buildings in EU-25 level could reduce the heat demand by 42%[31]. European Union has created more than 30 CEN standards that currently are applied in a voluntary basis[32]. These standards could become mandatory in country or regional level by integrating them in building codes and applying them through supporting programs. Energy auditing can support and pinpoint the potential for savings in all sectors while being carried out in local level by third parties or state agencies by enforcing also the awareness of people in energy related issues. A very successful scheme on energy auditing and savings exists in Denmark for many years. An evaluation of the scheme in 2000[33] showed that more than

[31] EURIMA study – The Contribution of Mineral Wool and other Thermal Insulation Materials to Energy Saving and Climate Protection in Europe

[32] Green Paper on Energy Efficiency or Doing More with Less, Brussels 22.6.2005. COM(2005) 265 final

[33] PEEREA, In-depth Review of Energy Efficiency Policies and Programmes of Denmark, 2004

45% of owners that acquired a label after audition and recommendation for improvement actually invested on heating saving measures. Finally it should not be neglected the fact that energy savings can create a significant amount of permanent jobs. Based on an Ecofys study[34] for EU-25 the savings sector for buildings alone can create more than 250.000 permanent jobs.

Lighting accounts for almost a third of the energy use in a building and there are available technologies now that could reduce this demand by more than 50%. Since 1992 a directive exists on information of energy efficiency of a range of domestic appliances through labeling but not for all appliances. This presents an opportunity for creating mandatory labeling for all the appliances if to be sold in the south regional or national markets. More radical market control can be achieved by policies or direct political decisions as seen for the abolition of plastic bags in China by June 2008[35] and similar policies on the thickness of plastic bags in other countries. These policies did not provide any transition period and faced a problem that for many years was growing and no solutions were expected. Australian government decided in February 2007 to become the first nation to phase out the use of incandescent bulbs as of 2009 by banning them from the market. As the Minister of Environment Malcolm Turnbull cited "It's a little thing but a massive change"[36]. These examples show how immediate actions from the national government can make an effect on the market and consequently on energy and environmental issues.

5.2 Renewable energy

Renewable energy has finally received high importance in European level and will continue since it contributes on both energy security by exploiting local resources and has clearly positive environmental impacts. Some technologies like wind or hydro power have already reached a high level of maturity and an increasing market share. As proposed in the optimistic scenario a share of 68% on the electricity sector and 43% of the heat production has to derive from renewable sources. It is obvious though that even the specific targets demanded by the new Directive on renewable for year 2020 will require extended efforts and should be achieved much earlier in order to reach the

[34] Ecofys, DM 70067,'Cost effective retrofit in buildings', 2005

[35] http://blogs.wsj.com/chinajournal/2008/05/30/banned-by-beijing-plastic-bags/?mod=googlenews_wsj

[36] http://www.theaustralian.news.com.au/story/0,20867,21255580-1702,00.html

targets for 2030. Three main axis should be promoted for potentially achieving the targets. Creating the necessary framework in an extended way for "green business", efficient monitoring of the progress and public awareness are identified as such.

Spain, a world leader in wind power[37], has already reached a very high installed capacity of wind power while Portugal and Italy are expected to present an annual growth of 20% between 2006 and 2010[38]. Spain broke an EU record by installing 3522MW in 2007 only. This is due to favorable policy schemes mainly regulated through fixed tariff support and ease on the licensing procedures. However it is crucial these schemes to extend to all countries towards establishing a strong market and industry for wind power which can provide large amounts of energy in the system while investing in infrastructure and connectivity. An uprising of solar power is also reported the last year for both power and heat production. With the high potentials for all region but the limiting factor of high costs especially for photovoltaics support schemes should continue to exist focusing not only in installations but also structuring national industries. In this way costs can be reduced, jobs can be created and added valued opportunities can contribute to the regional economies. Spain and Italy have already introduced mandatory obligations for including solar heating systems in new or renovated buildings. Moreover, Greece has an already established market and soon other markets like Spain and Italy will emerge due to the increasing demand. Concentrated Solar Power is mainly promoted in Spain were more than 1GW installed capacity has been already contracted and will be built by 2010, although no such plans still exist for the other countries. Portugal already operates the first commercial wave power plant of 2,25 MW installed capacity and plans for expansion[39]. Bioenergy presents high potentials in the areas of South Europe[40] the use of these resources are very scarce and an established market has not been created. Biomass

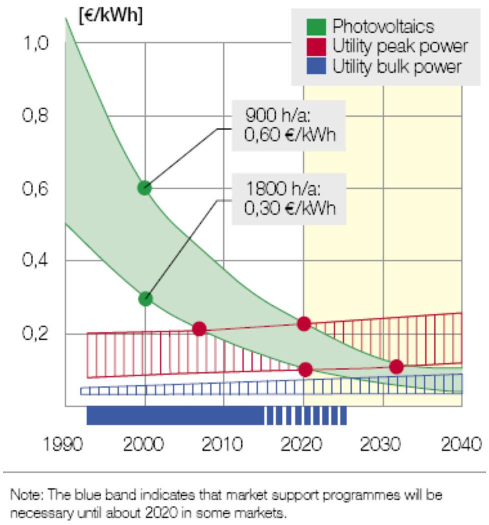


Figure 28 - Utility prices and PV generation costs, EPIA 2007

[37] http://www.ewea.org
[38] http://www.ewea.org/index.php?id=194
[39] http://www.power-technology.com/projects/pelamis/
[40] European Biomass Industry Association, "Energetic Valorisation of Forest Biomass in South of Europe", 2007

mainly for heating production has been widely developed in Nordic countries with very mature technologies and results. It is necessary local actors to become aware of these technologies and their feasibility and promote technology transfer from other EU countries. This can be supported by regional support schemes and technical support for creating the necessary infrastructure and dissemination of potential applications for district heating or personal use of biomass like wood pellets or biofuels.

However, despite the hope provided from these latest developments on technology and market still barriers exist in the general region that need to be overtaken. Fossil fuels and nuclear are still subsidized on EU and national level making difficult for cleaner technologies to compete with. Environmental costs are not fully calculated for all the energy products fully else the deployment of cleaner technologies and the phasing out of conventional ones will be much faster.

Bounding targets for the share of all Member States are expected to be set with the new Directive as shown in Chapter 5. If assumed that the countries will reach their 2020 obligations, significant increase and efforts will be required as shown in the table 12 towards 2030.The distribution between countries was created through the calculations used by EU for setting the individual targets for 2020.

Table 12 -Indicative targets towards 2030

Share of renewable sources in the gross final consumption							
	South region	Spain	Portugal	Italy	Greece	Cyprus	Malta
2005	7.4%	8.7%	20.5%	5.2%	6.9%	2.9%	0.0%
2020	18.2%	20.0%	31.0%	17.0%	18.0%	13.0%	10.0%
2030	44.0%	48.4%	75.1%	41.2%	43.6%	31.5%	24.2%

These individual targets can be utilized as reference for national strategies. If higher share will be achieved by 2020 reaching the targets for 2030 could be easier to attain and reassure a continuous growth while enjoying the multiple benefits of such diversified energy mixes much before others. In the following figure the different projected shares are shown. The 2020 scenario assume an average share of 30% achieved in the region instead of 18.2% deriving from the EU obligations.

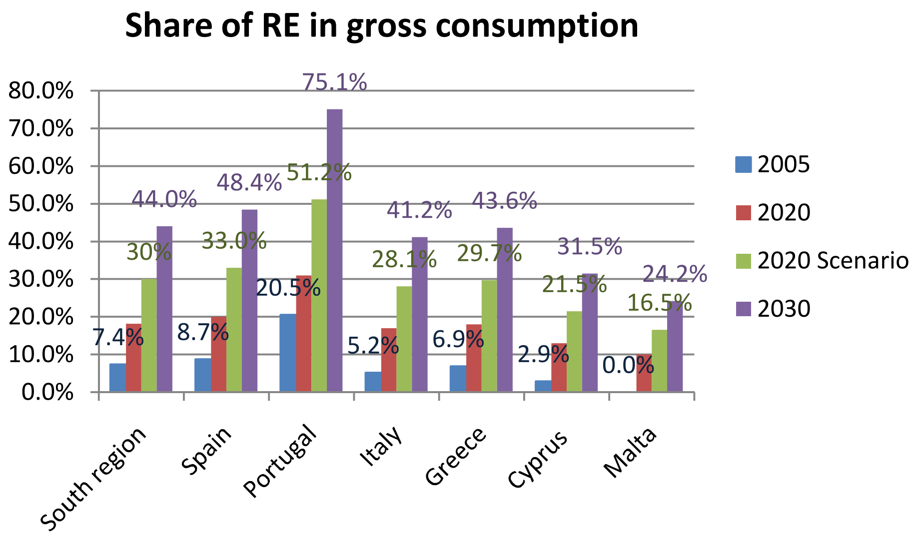


Figure 29 - Share of RE towards 2030

Nuclear energy currently exists only in Spain but unfortunately political views in Italy and Greece lately became more friendly and potential installations may be attempted in the near future. This might look as a quick way to reduce emissions but the environmental and security issues are neglected. Hopefully with the latest examples of the risks as shown with the leakages in Slovenia[41] and consequently the shutdown of the only nuclear plant will mobilize both the societies and politicians out of such focus. Moreover nuclear plants despite the recent hype on safety and the promise for large amounts of emission free energy still has very large capital costs – many times over subsidized by public money - and a rather long building time when action calls for changes now. An good example for the complications on building nuclear plants is the only currently building nuclear plant at Olkiluoto, Finland[42] which has been funded with very low interest rates by French and German state organizations and is currently already 24 months behind schedule[43], some 2 billions euros above budget and currently under investigation by the European Commission due to allegations for financing breaches of the commission's rules.

[41] http://news.bbc.co.uk/2/hi/europe/7436671.stm
[42] http://www.mng.org.uk/gh/renewable_energy/NS_nuclear_article.htm
[43] http://www.platts.com/Nuclear/Resources/News%20Features/eurogrowth08/stuk.xml

Technological changes in the renewable sector are driven by global demand and efforts on research and developments and the learning curve presents a bright future for the main proposed technologies such as wind, solar and bioenergy. Potential breakthroughs though may change dramatically the picture and present winners in this race for high share of RE heat and electricity. Industrial changes have to be reinforced on promoting country based production of renewable technologies in the paths of Germany and the uprising Spanish sector. This is necessary to be achieved in all the Mediterranean countries and political decisions can facilitate this framework. It has to be acknowledged as soon as possible from the policy makers that the costs for creating green business friendly conditions may be burden in the short term economically but can create new and increasing revenues in the long term. Pressure from the general public due to increasing environmental awareness in combination with the high prices of fossil fuels will continue till alternatives are established through concrete policy frameworks.

5.3 Transport

This sector in South Europe as well as in most of the developed world contributes significantly on the overall CO_2 emissions and environmental quality in the modern cities. However the landscape can be changed if the necessary future developments are seeing as a chance for altering the way we move and travel in more efficient and environmental friendlier ways.

> "The first two oil shocks banned oil from power generation. How fitting if the third finished the job and began to free transport from oil century's long

There are three key points exist on this roadmap regarding the changes needed for reaching the aspects of the optimistic scenario created. On the technological aspect main focus is to be given on fuel economy but mainly the rapid introduction of electric vehicles into the market. Secondly the future of the cities in the south requires different approach of urban planning. Finally the modal changes towards use of high quality public transport and other means will require promotion and effective campaigning.

Two countries of the South Europe enjoy established automotive industries. In the mainstream category of vehicles SEAT, a Spanish subsidiary of the Volkswagen Group, and Italian FIAT are global scale industries. However they have failed to present in their national markets electric vehicles and have limited themselves in presenting concept cars. Great hope lies on partnerships like the Mobil-Green car as announced in January 2008 between Portugal and Spain on developing an electric car by joining forces of two automotive industries and financed by both private and public funds[44]. What would be the impact though if regulations obliged industries to present electric vehicles right now? Such a policy scheme was introduced by the state of California in 1990 with the Zero Emissions Mandate requiring 2% of the vehicles to have zero emissions as of 1998 and 10% by 2003 of the vehicles sold within the state (Shaseen et al, 2001)[45]. This has led for General Motors to swiftly introduce in the market electric vehicles while Japanese industries begun production of other electric vehicles leading to the introduction of the very successful Toyota Prius in 1997 followed by many other industries. However severe lobbying efforts led to the removal of these cars from the streets of California by denying of renewing the leasing despite people's demand. Electric vehicles have also other benefits to present apart from oil reduction in the general energy system. Since currently energy storage for large amounts of energy is not yet available, electric vehicles could serve as independent small batteries in the form of "plug-in" vehicles, charging when electricity prices are low and regulate the demand in peak hours reducing further the need for increased plant capacities.

An integrated approach of the policy makers is required by controlling both the technologies of the vehicles and promoting behavioral changes through support programs of car sharing and modal shifts for cleaner technologies. These policies do not require guidelines from the European Union but significant resistance towards the power relations that benefit from the current status. The technologies used for public transportation towards 2030 require fully integration of clean technologies. Trains will have to be fully electric, while buses could be fueled by electricity, natural gas or biofuels since these are technologies currently available and the effects will be immediate in air quality, oil consumption and emissions. Demonstration projects can start from smaller cities and expand to the larger cities where demand is higher.

Urban planning is a key measure for shaping the future of the cities in the South. In many cases complete lack of strategic planning has led to complete lack of infrastructure for bicycles or control of the amount of vehicles. The challenges are great but reducing the transportation needs can occur if residential areas or working areas are clearly define and the work flow is regulated. The social and environmental on replanning the urban

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[44] http://www.planetark.com/dailynewsstory.cfm/newsid/46525/story.htm

[45] Shaseen,Wright,Sperling, California's Zero Emission Vehicle Mandate - Linking Clean Fuel Cars, Carsharing, and Station Car Strategies, 2001

landscape should have the highest importance in the policy making on national level down to regional and city regulations based on coherent strategies.

Modal changes can be promoted by close collaboration of governments with Medias and NGOs but require high quality services and alternatives provided to the general public. Best practices can be acquired by other cities and rapidly deployed. One good example is the bike sharing program started in Paris in 2007 called Velib[46], with 750 stations and more than 10000 bicycles available. In just few months the number of available bicycles doubled due to high demand. Of course such programs already exist in different countries but in the South only few Spanish cities have embraced it. Networks between regions and municipalities need to be strengthened in pursuit of best practices and technology transfer. It should be highlighted that modal changes require a high level of personal awareness that can be cultivated through education and information exchange. It is rather encouraging that there is political will at least in European level for exploring alternatives that are not so obvious like the use and promotion of Information Technology for example in order to reduce transportation for business and communication purposes[47]. Innovation is welcome for realizing changes in the transport sector however coherent practices and results already exist.

5.4 The big picture

In the previous parts of this chapter basic guidelines were presented regarding the realization of the three key measures of the scenario. Nevertheless an important issue should not be neglected. The policy making lines in many issues are overlapped. This although requires responsibility and political integrity in many cases especially for South Europe is been neglected or used as a mean for transferring the execution or decision duties to other levels. In the following figure and example of problem and solution accountability is presented. European Union has a very difficult task to establish common goals and strategies mainly through directives that have to be implemented in national legislations within specific time. This process however delays significantly the implementation and the actual results while in many cases is completely disregarded.

[46] http://www.velib.paris.fr/

[47] Wijkmann, STOA dinner debate, Strasburg April 2008

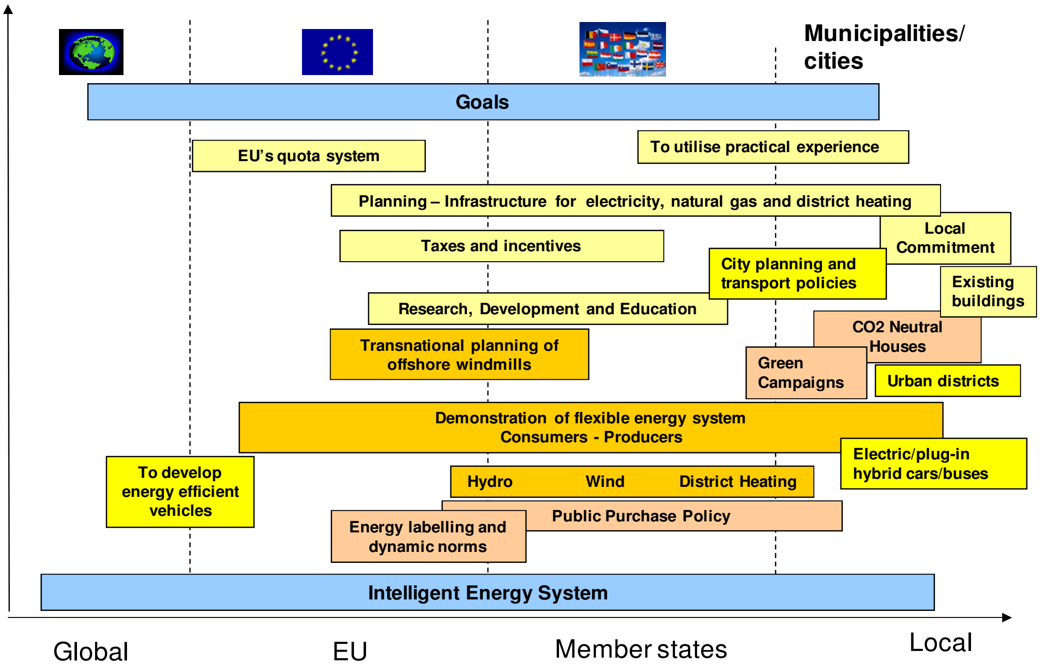


Figure 30 – Goals and actions with overlapping responsibility areas

A concrete example is Greece regarding the lack of implementation of the European Directives especially on environmental related policies. Until July 2007 based on report published by WWF Greece[48], 13 Directives have not been implemented in the national legislation and were past the deadline period. Of course this show possibly the importance given in the political agenda of the government which has led periodically Greece at the European Court – since 1992 to nowadays 31 cases where brought to Hague while 27 are still pending. With these conditions political will, public demand and common understanding are necessary elements since environment should be put in the highest position in the agenda regardless political interests. It is vital in order to achieve not only the targets of the scenario but firstly the EU targets for 2020 to overcome these complications and rapidly deploy the proposed Directives. Else the current differences on development and progress between the countries in South Europe will continue to exist and extrapolate in the future.

In the near future a common energy market for whole Europe will be established. The first step has been made by the market opening of the energy markets in all European countries (in Greece will begin in July 2008). This will increase apart from the competition

[48] WWF Hellas, «Δεσμεύσεις χωρίς εφαρμογή: Η περιβαλλοντική νομοθεσία στην Ελλάδα, July 2007

inside the countries, the collaboration and expansion of utility and energy companies in every part in Europe hopefully will improve current infrastructure, energy savings and grid quality and availability. The southern countries although interconnected to an extent, yet no common energy market exists. If such a market was created, based on practices-examples like Nordpool[49] existing for the Nordic countries, new incentives would be created for attracting investments in both infrastructure and energy projects. Maybe this could also a key for bringing the governments as well as businesses closer in the general Mediterranean region towards solving energy and environmental problems while sharing best practices and why not energy products as well.

Creating a roadmap which begins from a discouraging current status to a vision for better future energy systems in south Europe has been a difficult task. Although many paths may exist towards 2030 the complexity and the need for changes in multiple levels was stressed out in this chapter and the overall report. Three basic areas need to be expressed in political, market and personal level. An increasing share of renewable energy in the energy mix needs a favorable and supporting environment while at the same time discouraging and phasing out any old and polluting technologies. The new ideas and concepts can redefine the business landscape of southern Europe as currently established in countries like Germany or Denmark. Energy savings can dramatically reduce consumption in all energy dependent sectors. This approach requires also the active participation and mobilization of the general public. The transport sector calls for large changes in technology, urban planning and personal choices. The actions or non actions taken from now on can have different time horizon and real costs which will affect the future energy systems and not only.

[49] http://www.nordpool.dk/nordpool/group/index.html

Conclusions

Energy has penetrated in every aspect of modern life. It covers human needs in forms like light, heat or powering transportation and contributes in general prosperity and quality of life. However a combination of increasing demand for energy and the sources used to cover this demand since the beginning of the industrial revolution has led to several complications faced in the global scale. The present energy systems in the majority of the developed world are heavily dependent on fossil fuels while their availability in national level is not sufficient. The scarcity of these resources has created global markets and prices which consequently affect every aspect of modern life. The nature of these energy systems apart from the high level of dependency has created another problem. The way we create and consume energy comes with severe environmental impacts. Air quality, water quality, soil intoxication, toxic waste, deforestation and biodiversity loss are just few of the impacts directly connected to energy. These effects came under a greater “umbrella” since the global agreement on the scale of the so called “climate change” phenomenon and the risks presented in the near future. The different pieces of this puzzle called for action in different levels. The past years some steps were made, from the Kyoto Protocol and the EU directives down to national legislations or regional policies. However more efforts are required and calling for changes still.

The research conducted and presented in this report focused in a group of countries located in south Europe. Two ambitious targets were selected which assumed will positively contribute in both fossil fuel dependency and the environment impacts. From technology point of view it was shown that it is possible to shape the current energy systems of this region into new and more efficient ones that will achieve both targets. Additionally guidelines on how to create this future energy systems were presented as a roadmap. In this way it was presented a potential path that may lead South Europe to reduce by 50% the oil consumption based on 2005 levels and the CO_2 emissions of the energy systems compared to the 1990 levels.

On the demand side is necessary to reduce the consumption without risking the quality and availability of the energy uses. This can be done with increased efficiency improvements throughout all end use sectors. More insulated buildings, efficient lighting, less energy consuming devices, reduction of stand-by consumption or implementation or strict efficiency standards are few of the ways that can have significant impact.

In order to reduce the environment impacts and dependency on fossil fuels cleaner technologies and local sustainable resources were implemented in the proposed energy systems. A high share of renewable sources and almost complete exclusion of oil and coal in the power and heat production were needed. The diversity in the energy mix will reduce the need of primary sources imports although natural gas will continue to play a major role used in high efficient power plants and heating devices. District heating and cooling should be greatly promoted and used although there will be high need for infrastructural developments. Due to the excellent resources in the region solar power could be a reasonable choice despite the high costs of today's market mainly for photovoltaics. Transportation is sector that nowadays has the highest oil consumption and consequently dependency. Radical changes are required as presented in the energy scenarios. The vehicle fleet will be powered by different fuels like biofuels, natural gas and of course locally produced electricity. The mass transportation should also be powered by these fuels while with careful urban planning combined could support modal changes away from inefficient methods of transport.

In order these changes to be realized, strong political decisions are required to shape the rules of the markets. A favorable framework should be created for the ones positively contributing in these strategies in combination with a discouraging environment for the ones who don’t. The necessary changes should be put in high priority in a long term agenda in which future governments should be realistically committed to. Voluntary agreements and market initiatives are welcome in the process. However, in few cases the desired results were delivered. Policy makers should express the actual environmental costs in clever and innovative ways even by reaching the allowed limits of the open market. Markets should adapt to the new challenges and the reevaluate their social responsibility in a broader perspective. The opportunities laid ahead may create new leaders while the current ones will require transforming the nature of even their core products.

Finally the contribution and the necessary changes will have to exist in personal level. Whether it is a politician, a major executive or a farmer the ethics, accountability and demand for a brighter future should affect us in our everyday life and the choices we make. After all, we all live in this beautiful blue planet.

The world can cover every man’s need but cannot cover every man’s greed.
Mohandas Karamchand Gandhi, 1869 - 1948

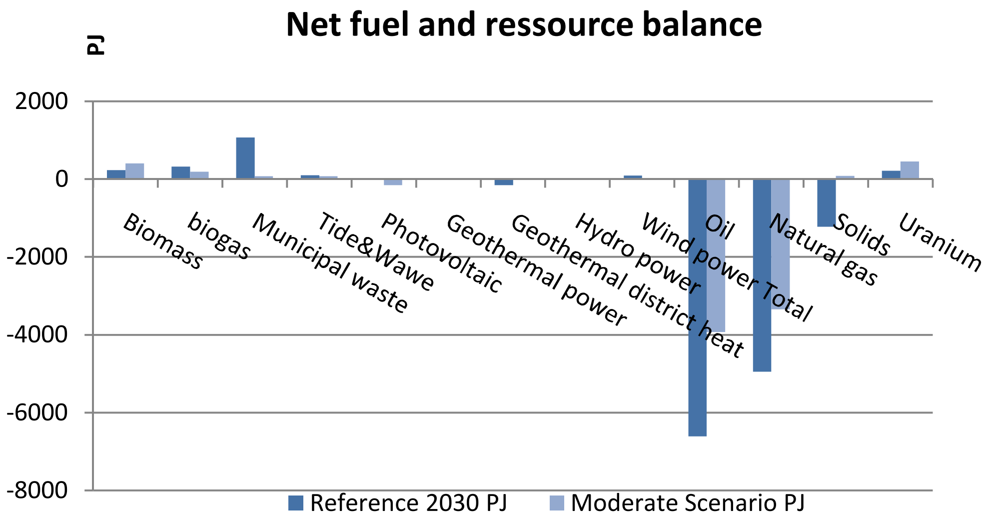
Appendix

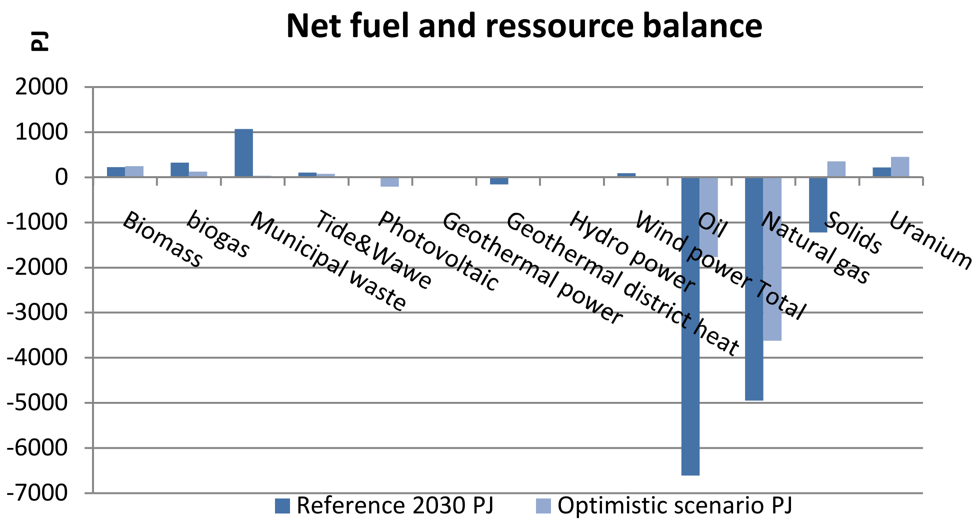
Installed capacity in the three scenarios in year 2030

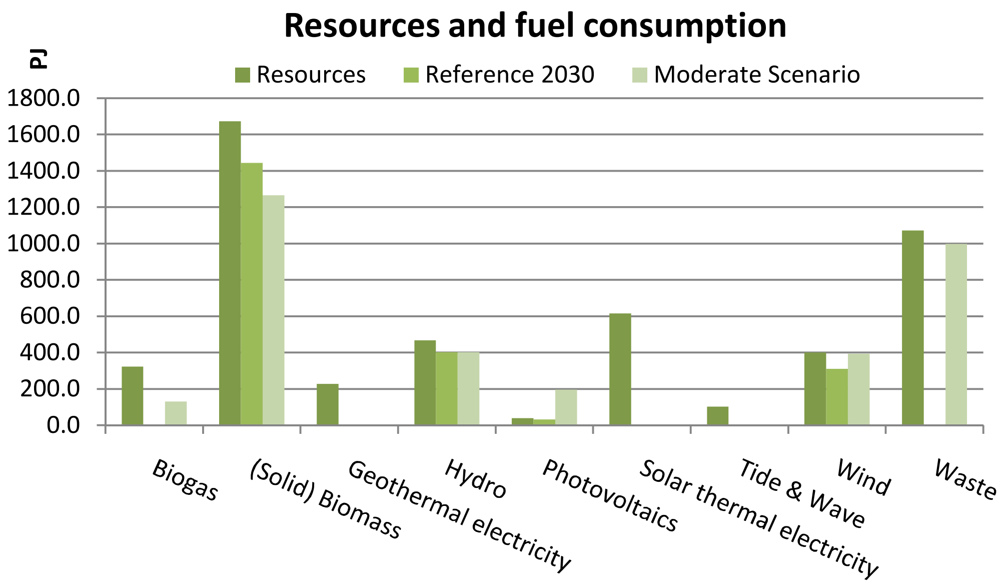
Installed capacity and operation hours for different technologies							
		Reference		Moderate		Optimistic	
		Operating hours	MW	Operating hours	MW	Operating hours	MW
Electricity	oil	4,000	19,813	4,000	-	4,000	-
	Coal	8,736	10,785	4,000	(18)	8,492	653
	ccgt	8,627	29,854	8,717	20,690	4,315	43,660
	gasturbine	8,627	-	8,717	-	4,315	-
	micro CHP	8,627	-	8,717	-	4,315	-
	Wind, onshore	1,919	21,500	1,919	29,500	1,919	30,700
	Wind, offshore (incl. net)	3,738	12,000	3,738	14,000	3,738	13,500
	Hydro	3,311	33,794	3,311	33,794	3,311	33,794
	Biomass (Straw,woodwaste)	8,736	9,072	8,524	8,372	8,598	10,863
	Biomass (Energy crops)	4,000	-	4,000	-	4,000	-
	biogas	4,000	-	8,640	1,815	8,682	2,712
	Waste	4,000	-	8,736	8,976	8,722	8,999

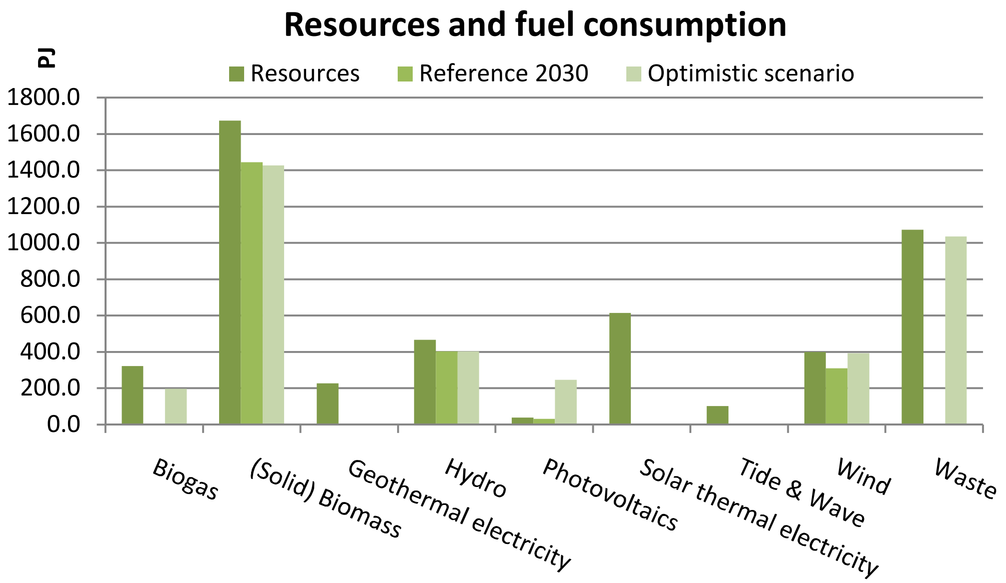
	PV	1,595	6,213	1,595	39,343	1,595	49,227
	Nuclear	8,736	9,072	4,000	13,723	8,736	6,290
	geothermal	4,000	3,715	4,000	-	4,000	-
	Wave power	4,147	-	4,147	1,891	4,147	1,893
	natural gas incl. CO2-storage	4,000	-	4,000	-	4,000	-
	Coal incl. CO2-storage	4,000	-	4,000	-	4,000	-
	biomass incl. CO2-storage	4,000	-	4,000	-	4,000	-
	old. Coalpower	8,736	10,206	8,065	4,376	4,000	-
	old. Gas power	7,556	7,867	4,000	5,881	4,000	-
District heating - boilers	Natural gas	4,000	20	1,359	70,646	1,980	95,616
	Biomass (Straw,woodwaste)	4,000	3	3,893	6,744	4,474	11,037
	Biomass (Energy crops)	4,000	-	4,000	-	4,000	-
	Waste	4,000	-	4,023	2,040	4,620	3,563
	Geothermal	4,000	0	3,998	205	4,599	358
	Heatpumps	4,000	-	4,000	-	4,000	-
	Electric boiler	4,000		4,000		4,000	
	Oil	4,000	7	4,000	-	4,000	-
	Coal	4,000	5	4,000	-	4,000	-
	Solar heat	1,595	10	1,595	20,582	1,595	45,423

Resources in the scenarios

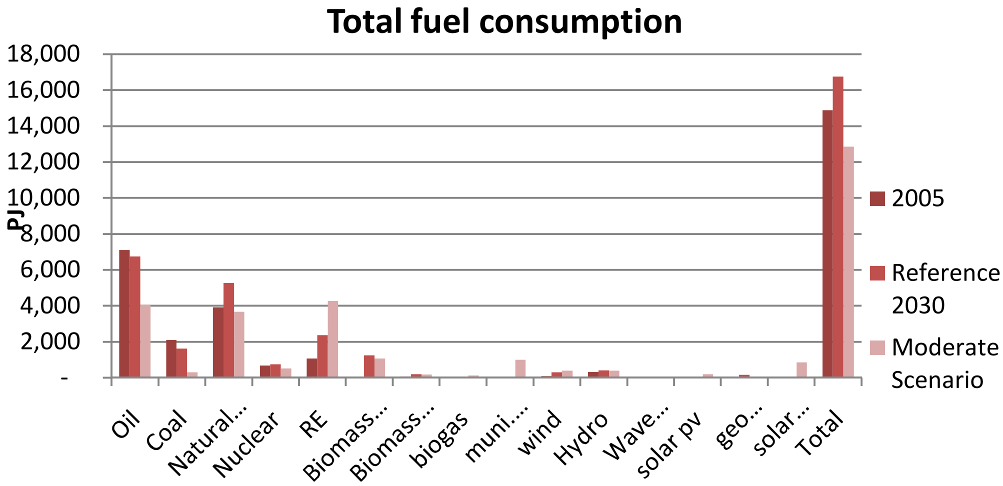


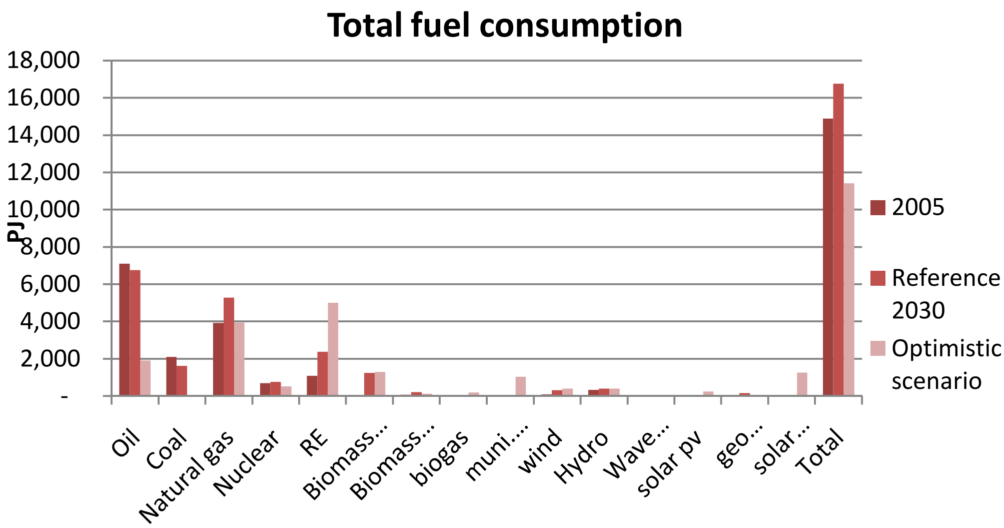



Resources and fuel consumption
PJ
Resources
Reference 2030
Moderate Scenario
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Biogas
(Solid) Biomass
Geothermal electricity
Hydro
Photovoltaics
Solar thermal electricity
Tide & Wave
Wind
Waste


Resources and fuel consumption
PJ
Resources
Reference 2030
Optimistic scenario
1800.0
1600.0
1400.0
1200.0
1000.0
800.0
600.0
400.0
200.0
0.0
Biogas
(Solid) Biomass
Geothermal electricity
Hydro
Photovoltaics
Solar thermal electricity
Tide & Wave
Wind
Waste

Fuel consumption





Energy Savings

Tertiary

		Reference				TertiaryStep1		Saving Step1	
End use		Saving	costs	lifetime	ann. costs	Saving	costs	lifetime	ann. costs
Non heating*	2005	%	€/GJ	year	€/GJ/year	%	€/GJ	year	€/GJ/year
Lighting	42%	26%	0	15	0.00	19%	85	10	10.48
Cooling	10%	11%	0	15	0.00	22%	85	10	10.48
Electrical motors	8%	9%	0	10	0.00	13%	85	10	10.48
Electronics	16%	23%	0	10	0.00	16%	85	10	10.48
Pumping	5%	26%	0	10	0.00	17%	85	10	10.48
Air conditioning/ventilation	8%	24%	0	10	0.00	28%	85	10	10.48
Other use	11%	15%	0	10	0.00	5%	85	10	10.48
Electricity demand excl. heat	**100%**	**21%**	**0**	**13**	**0.00**	18%	85	10	10.48
Share of electr. used for heat	29%					0%	0	0	0.00
Space heating		**23%**	**0**	**30**	**0.00**	9%	83	15	7.62

Residential

		Reference_North				ResidentialStep1		Saving Step1	
End use		Saving	costs	lifetime	ann. costs	Saving	costs	lifetime	ann. costs
Non heating	2005	%	€/GJ	year	€/GJ/year	%	€/GJ	year	€/GJ/year
Lighting	23%	25%	0	10	0.00	25%	85	10	10.48
Refrigerators/freezers	24%	11%	0	10	0.00	10%	85	10	10.48
Washing/cooking	14%	23%	0	10	0.00	21%	85	10	10.48
Standby	16%	25%	0	10	0.00	20%	85	10	10.48

Dryers	4%	25%	0	10	0.00	23%	85	10	10.48
Air-cond	2%	21%	0	10	0.00	15%	85	10	10.48
Other use	16%	18%	0	10	0.00	16%	85	10	10.48
Electricity demand excl. heat	**100%**	**20%**	**0**	**10**	**0.00**	18%	85	10	10.48
Share of electr. used for heat	27%					0%	0	0	0.00
Space heating		**20%**	**0**	**40**	**0.00**	15%	83	40	4.61

Industrial

		Reference 2030				IndustryStep1		Saving Step1	
Industries share of energy consumption		Saving	costs	lifetime	ann. costs	Saving	costs	lifetime	ann. costs
	2005	%	€/GJ	year	€/GJ/year	%	€/GJ	year	€/GJ/year
Steel	16%	23%	0	15	0.00	13%	85	15	7.80
Chemical/petrochemical	13%	29%	0	15	0.00	13%	85	15	7.80
Pulp and paper	6%	22%	0	10	0.00	14%	85	10	10.48
Sum Energy Intensive Industries	**36%**	**25%**	**0**	**14**	**0.00**	**13%**	**85**	**14**	**8.28**
Non-metallic minerals	22%	22%	0	10	0.00	14%	85	10	10.48
Food and Tobacco	9%	22%	0	10	0.00	19%	85	10	10.48
Construction	1%	17%	0	10	0.00	16%	85	10	10.48
Mining	1%	17%	0	10	0.00	16%	85	10	10.48
Machinery	8%	15%	0	10	0.00	18%	85	10	10.48
Ferrous metal	4%	15%	0	10	0.00	18%	85	10	10.48
Transport equipment	2%	15%	0	10	0.00	18%	85	10	10.48
Textiles and leather	5%	22%	0	10	0.00	14%	85	10	10.48
Wood industry	12%	15%	0	10	0.00	10%	85	10	10.48
Sum Other Industries	**64%**	**19%**	**0**	**10**	**0.00**	**15%**	**85**	**10**	**10.48**
Total/Average	**100%**								

Transport

Reference scenario

Share of Transport work		Reference 2030	Moderate		Reference 2030	Moderate
	2005	2030	2030	2005	2030	2030
Person				Utilisation	Utilisation	Utilisation
mio.person km	1,823,800	2,366,000	2,366,000			
Car	76%	75%	69%	39%	33%	33%
Bus	10%	7%	10%	28%	35%	35%
Train	5%	4%	6%	40%	42%	60%
Aviation and ferries	9%	14%	14%	50%	50%	60%
Bike etc.	0%	0%	1%	100%	100%	100%
	100%	100%	100%			
		Reference 2030	**Moderate**		**Reference 2030**	**Moderate**
	2005	2030	2030	2030	2030	2030
Goods				Utilisation	Utilisation	Utilisation
mio.tonnes km	540,000	794,800	794,800			
Trucks and cargo vans	80%	85.5%	81%	30%	30%	30%
Train*	7%	5.4%	8%	50%	50%	50%
Ship*	13%	9.1%	11%	40%	40%	40%
Air transport		0%	0%	80%	80%	80%
	100%	100%	100%			

Reference 2030	Distribution of transport work									
2030		Electricity	Gasoline	Diesel	Natural gas	Etha nol	Metha nol	Bio-diesel	Hydro gen	Total
Persons	TJ	%	%	%	%	%	%	%	%	%
Car	2,222,249	0%	46%	45%	0%	4%	0%	5%	0%	100%
Bus	31,822	0%	0%	90%	5%	0%	0%	5%	0%	100%
Train	33,656	60%	0%	40%	0%	0%	0%	0%	0%	100%
Aviation and ferries	779,020	0%	100%	0%	0%	0%	0%	0%	0%	100%
Total	**3,066,748**	**13,614**	**1,894,185**	**957,784**	**1,591**	**96,971**	**0**	**102,602**	**0**	**3,066,748**
		Electricity	Gasoline	Diesel	Natural gas	Etha nol	Metha nol	Bio-diesel	Hydro gen	Total
Goods	TJ	%	%	%	%	%	%	%	%	%
Trucks and cargo vans	1,973,554			96%		0%	0%	4%	0%	100%
Train*	5,788	60%		40%		0%	0%	0%	0%	100%
Ship*	63,637			100%		0%	0%	0%	0%	100%
Air transport	0		100%			0%	0%	0%	0%	100%
Total	**2,042,980**	**2,316**	**0**	**1,961,721**	**0**	**0**	**0**	**78,942**	**0**	**2,042,980**
		Electricity	Gasoline	Diesel	Natural gas	Etha nol	Metha nol	Bio-diesel	Hydro gen	Total
	TJ	%	%	%	%	%	%	%	%	%
Transport total consumption	**5,109,728**	**0%**	**35%**	**59%**	**0%**	**2%**	**0%**	**4%**	**0%**	**100%**
	1.25	15,931	1,894,185	2,919,505	1,591	96,971	0	181,545	0	5,109,728

General technology improvement in the period

Reference 2030	18%	25%	22%	22%				
2030	Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen
	MJ/Pkm or Tkm with same utilisation as in base year							
Car	0.33	1.17	0.98	0.98	1.17	1.17	0.98	0.50
Bus	0.15	0.23	0.24	0.24	0.23	0.23	0.24	0.20
Train	0.23	0.00	0.51	0.00	0.00	0.00	0.51	0.30
Aviation and ferries	0.00	2.42	2.52	2.52	2.42	2.42	2.52	4.00
Trucks and cargo vans	1.64	2.79	2.90	2.90	2.79	2.79	2.90	1.50
Train*	0.09	0.00	0.20	0.00	0.00	0.00	0.20	0.30
Ship*	0.00	0.84	0.88	0.88	0.84	0.84	0.88	0.20
Air transport	0.00	7.50	7.80	7.80	7.50	7.50	7.80	3.00

Moderate scenario

Moderate Distribution of transport work

2030		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
Persons	TJ	%	%	%	%	%	%	%	%	%
Car	1,664,290	10%	35%	45%	0%	5%	0%	5%	0%	100%
Bus	39,929	5%	0%	75%	10%	5%	0%	5%	0%	100%
Train	24,409	80%	0%	20%	0%	0%	0%	0%	0%	100%
Aviation and ferries	579,286	0%	100%	0%	0%	0%	0%	0%	0%	100%
Total	**2,307,914**	**74,309**	**1,255,791**	**789,755**	**4,082**	**98,539**	**0**	**85,437**	**0**	**2,307,914**
		Electrici	Gasolin	Diesel	Natural	Ethan	Methan	Bio-	Hydrog	Total

		ty	e		gas	ol	ol	diesel	en	
Goods	TJ	%	%	%	%	%	%	%	%	%
Trucks and cargo vans	1,607,039	5%		85%	0%	0%		5%	5%	100%
Train*	6,511	80%		20%						100%
Ship*	68,775	0%		100%	0%			0%	0%	100%
Air transport	0		100%			0%				100%
Total	**1,682,325**	**52,481**	**0**	**1,497,645**	**0**	**0**	**0**	**83,915**	**48,284**	**1,682,325**
		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
	TJ	%	%	%	%	%	%	%	%	%
Transport total consumption	**3,990,238**	**7%**	**29%**	**56%**	**0%**	**2%**	**0%**	**4%**	**2.0%**	**100%**
		126,790	1,255,791	2,287,400	4,082	98,539	0	169,352	48,284	3,990,238

General technology improvement in the period

Scenario 1	25%	35%	30%	30%				
2030	Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen
	MJ/Pkm or Tkm with same utilisation as in base year							
Car	0.30	1.01	0.88	0.88	1.01	1.01	0.88	0.50
Bus	0.14	0.20	0.21	0.21	0.20	0.20	0.21	0.20
Train	0.21	0.00	0.46	0.00	0.00	0.00	0.46	0.30
Aviation and ferries	0.00	2.10	2.26	2.26	2.10	2.10	2.26	4.00
Trucks and cargo vans	1.50	2.42	2.61	2.61	2.42	2.42	2.61	1.50
Train*	0.08	0.00	0.18	0.00	0.00	0.00	0.18	0.30
Ship*	0.00	0.73	0.79	0.79	0.73	0.73	0.79	0.20
Air transport	0.00	6.50	7.00	7.00	6.50	6.50	7.00	3.00

Optimistic scenario

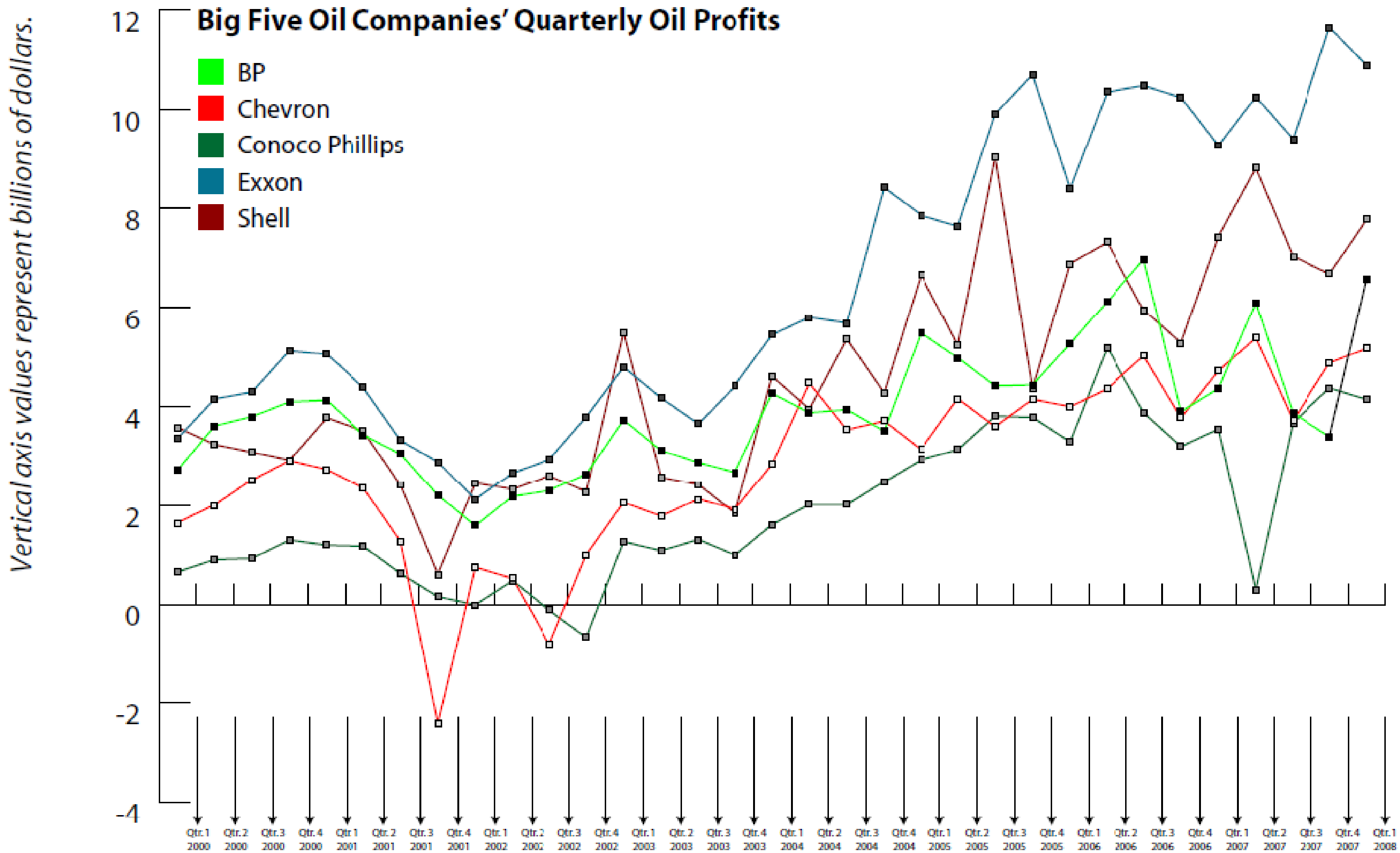
Share of Transport work		Reference 2030	Optimistic		Reference 2030	Optimistic
	2005	2030	2030	2005	2030	2030
Person				Utilisation	Utilisation	Utilisation
mio.person km	1,823,800	2,366,000	2,366,000			
Car	76%	75%	67%	39%	33%	50%
Bus	10%	7%	12%	28%	35%	35%
Train	5%	4%	8%	40%	42%	65%
Aviation and ferries	9%	14%	12%	50%	50%	70%
Bike etc.	0%	0%	1%	100%	100%	100%
	100%	100%	100%			
		Reference 2030	**Optimistic**		**Reference 2030**	**Optimistic**
	2005	2030	2030	2030	2030	2030
Goods				Utilisation	Utilisation	Utilisation
mio.tonnes km	540,000	794,800	794,800			
Trucks and cargo vans	80%	85.5%	80%	30%	30%	40%
Train*	7%	5.4%	8%	50%	50%	60%
Ship*	13%	9.1%	12%	40%	40%	60%
Air transport		0%	0%	80%	80%	80%

Optimistic	Distribution of transport work									
2030		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
Persons	TJ	%	%	%	%	%	%	%	%	%
Car	743,170	50%	10%	30%	0%	5%	0%	5%	0%	100%
Bus	38,009	60%	0%	20%	10%	5%	0%	5%	0%	100%
Train	24,358	100%	0%	0%	0%	0%	0%	0%	0%	100%
Aviation and ferries	425,598	0%	100%	0%	0%	0%	0%	0%	0%	100%
Total	**1,231,135**	**226,189**	**549,470**	**330,472**	**4,899**	**64,210**	**0**	**55,895**	**0**	**1,231,135**
		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
Goods	TJ	%	%	%	%	%	%	%	%	%
Trucks and cargo vans	1,164,006	10%		80%	0%	0%		5%	5%	100%
Train*	4,371	100%		0%						100%
Ship*	50,018	0%		100%	0%			0%	0%	100%
Air transport	0		100%			0%				100%
Total	**1,218,395**	**75,903**	**0**	**1,044,567**	**0**	**0**	**0**	**62,159**	**35,766**	**1,218,395**
		Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen	Total
	TJ	%	%	%	%	%	%	%	%	%
Transport total consumption	**2,449,530**	**22%**	**20%**	**49%**	**0%**	**2%**	**0%**	**4%**	**2.4%**	**100%**

General technology improvements in the period

Optimistic	25%	35%	30%	30%				
2030	Electricity	Gasoline	Diesel	Natural gas	Ethanol	Methanol	Bio-diesel	Hydrogen
			MJ/Pkm or Tkm with same utilisation as in base year					
Car	0.30	1.01	0.88	0.88	1.01	1.01	0.88	0.50
Bus	0.14	0.20	0.21	0.21	0.20	0.20	0.21	0.20
Train	0.21	0.00	0.46	0.00	0.00	0.00	0.46	0.30
Aviation and ferries	0.00	2.10	2.26	2.26	2.10	2.10	2.26	4.00
Trucks and cargo vans	1.50	2.42	2.61	2.61	2.42	2.42	2.61	1.50
Train*	0.08	0.00	0.18	0.00	0.00	0.00	0.18	0.30
Ship*	0.00	0.73	0.79	0.79	0.73	0.73	0.79	0.20
Air transport	0.00	6.50	7.00	7.00	6.50	6.50	7.00	3.00

Historical quarterly profits of the big oil companies



Totals include profits of companies merged since 2000 with the Big Five oil companies. See underlying data at www.oilwatchdog.org/articles/?storyId=10827

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Acknowledgements

Firstly, I would like to thank Karl Sperling who supervised me through my final thesis on my Master Studies at University of Aalborg. His constructive comments and the excellent collaboration were catalytic for this research. The project was conducted while performing an internship at EA EnergyAnalyses A/S in Copenhagen, Denmark. For giving me this chance I would like to thank Mr. Hans Henrik Lindboe for the great impression, atmosphere and discussions made during my stay at EA as well as the partners for their trust and shared knowledge. Special thanks to Mr. Helge Ørsted Pedersen who with his own unique way and intuition helped me and gave me the chance to follow the project of Future Energy Systems in Europe and experiencing a meeting at the European Parliament seeing modern energy politics in action. Anders Kofoed-Wiuff has been a ”mentor” as my supervisor at Ea always smiling and willing to share my craziest questions, news and ideas. Kim Frithjof Mygind, intern at Ea, made a lot of work with the STREAM and always with a smile helped in the long days at work. I would like to thank a lot Kenneth Karlsson from RISØ National Laboratory, which being the “natural father” of the STREAM taught me how to use and how scenarios can be made fun. Walter J. Sanchez, student assistant at Ea, contributed in reminding me that philosophy is essential when it comes to energy and environmental issues and for this I thank you a lot. Moreover I would like to thank all the people at Ea for contributing the most into making excellent working conditions and a great atmosphere to work in.

Since my master studies come to an end – and most likely my academic and student life as well – there are some people that I have to express my deep appreciations from the Department of Development and Planning at university of Aalborg. Mr. Frede Hvelplund, Professor, has been the image of the professor I always had in my mind – serious but with sincere and clever sense of humor, wise in a druidic way and with the best lectures I attended since the beginning of my university life. Poul Alberg Østergaard, Lektor, was the first person I approach when I was about to change my studies and with his welcome set the base for me to reach the point I am today. His lecture were full of information while his examination skills were rather painful but constructive. Bernd Möller and George Salgi who as supervisors on the previous semesters helped me the most and for that I thank them both a lot. Giovanni Nappi and Kristian S. Livijn gave me both hard and great times working with them and I am sure that our paths will meet again.

My family has always been there for me supporting and tolerating me sometimes beyond human limits. I would like to thank my sister Nikoletta Filippidou which as my alter ego showed me how fantasy, creativity, logic, science and emotions can be combined. See you in a white beach in Oman or an Earthship near by.

Last but not least, I would like to thank Lucia Margheritini not only by supporting me in any humanly possible way but for keeping me dreaming and chasing the dreams with me. I would not have done so many things without you.

"Human progress is neither automatic nor inevitable. We are faced now with the fact that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history there is such a thing as being too late…We may cry out desperately for time to pause in her passage, but time is deaf to every plea and rushes on. Over the bleached bones and jumbled residues of numerous civilizations are written the pathetic words: Too late"

Martin Luther King Jr. '*Where do we go from here: chaos or community*'