Mediterranean and National Strategies for Sustainable Development

Priority Field of Action 2: Energy and Climate Change

Energy Efficiency and Renewable Energy

Spain - National study

Regional Activity Centre for Cleaner Production

plan bleu

Gouvernement Catalan
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If you should consider that any point of this study could be improved or that there is any inaccuracy, we would be grateful if you would inform us of this.

Study completed in December 2006

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TABLE OF CONTENTS

0 INTRODUCTION

The Mediterranean Strategy for Sustainable Development (MSSD)

In 2005, the Contracting Parties to the Barcelona Convention adopted the Mediterranean Strategy for Sustainable Development (MSSD). The Strategy includes seven priority fields of action *in which it is essential to make real progress*. The second of these fields of action focuses on energy and climate change; notably, *improved rational use of energy, increased renewable energy use and mitigation of and adaptation to climate change*.

Specifically, the second field of action of the MSSD is further defined by the following five objectives:

- *Promote the rational use of energy*
- *Enhance the potential of renewable energy*
- *Control, stabilize or reduce, as appropriate, emissions of greenhouse gases*
- *Mainstream measures for adaptation to climate change in national development plans*
- *Increase access to electricity in rural areas, where necessary*

Furthermore, the Mediterranean Commission on Sustainable Development (MCSD), an advisory body set up in 1996 within the Barcelona System, is actively working in coordinating the implementation of the MSSD. In the schedule and working plan set by the MCSD for implementing the Strategy, the MSSD field of action focusing on energy and climate change was defined as a priority area to be tackled during the years 2006 and 2007.

Within this framework, the Regional Activity Centre for Cleaner Production (RAC/CP) works on energy and climate change jointly with the Blue Plan Regional Activity Centre, the component of UNEP/Mediterranean Action Plan leading the MSSD working group focusing on energy and climate change. This study, **Energy Efficiency and Renewable Energy. Spain - National study**, is one of the activities of the working group above.

Objectives and use of this National Study

This national study has two main objectives:

- To provide information on the country's situation and observed evolution, progress made or foreseen in terms of energy efficiency and renewable energy, tools implemented and examples of good practice. To contribute to the Mediterranean reflection, to the sharing of experiences, and to enrich the respective experiences of the countries.

- To raise awareness of the needs to get involved/engaged/committed in ambitious rational use of energy (RUE) and renewable energy (RE) development objectives, to implement specific tools and to take into consideration the relevant benefits that would arise. If needed offering assistance to countries in developing the energy section of their national sustainable development strategies and selecting monitoring indicators and enabling their energy policies to evolve positively.

1 THE COUNTRY'S ENERGY SITUATION: INDICATORS AND BASIC DATA

=> **Objective**: to present the national energy context in general, to analyze the basic energy data using the MSSD indicators to point out the main evolutions which have taken place since 1970-1980 and those possible (until 2015/2025) according to existing planning documents.

1.1 Share of the Energy Sector and Institutional Specificities

1.1.1 The energy sector's economic weight

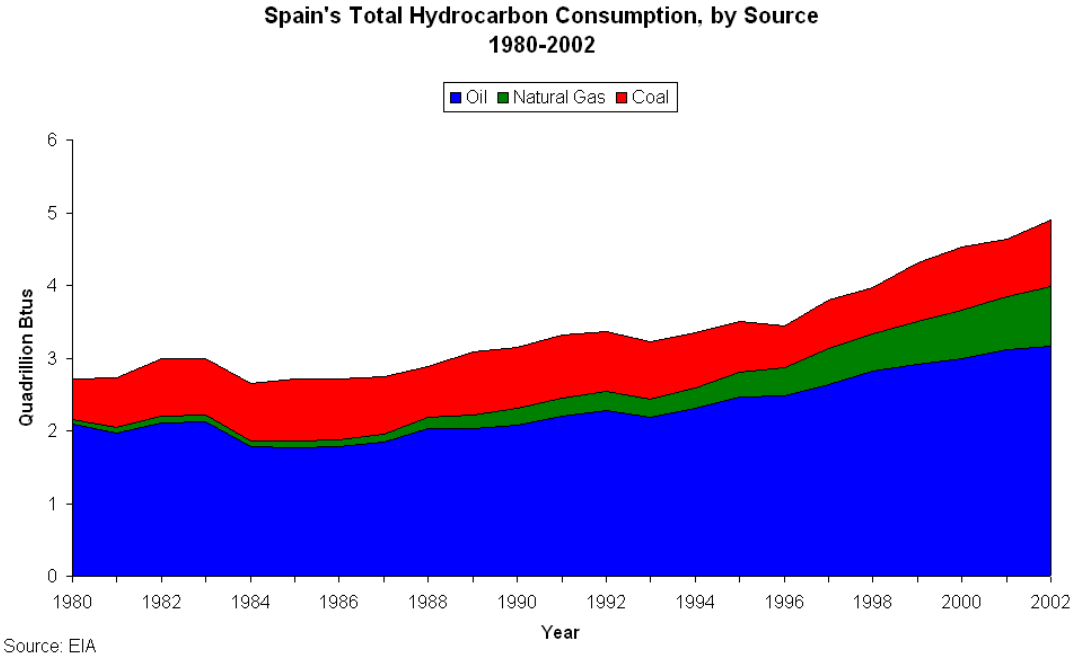
Despite recent positive performance of the Spanish economy, the country will face many economic challenges in the coming years. As mentioned above, Spain's unemployment rate has dropped significantly in the past 8 years, but it still remains above the Eurozone average of 8.8%. Spain could also lose its stream of development aid from the EU. The total aid allocated for the period 2000-2006 stands at 2.140 million € at 1999 prices. At current prices, the total financing from the Structural Funds for Spain in the period 2000-06 was 39.548 million €. The country received about 7.500 million € in EU structural funds in 2004, or about one percent of Spain's GDP. These funds have financed many of Spain's infrastructure improvements and have helped facilitate Spain's economic growth. However, even though it was once one of the poorest countries in the EU, Spain now has a per capita GDP near the EU average. With the accession of the ten mostly poor Central and Eastern European countries in May 2004, Spain might see a reduction in its structural funds receipts.

Economic growth and accelerated industrialization associated with EU membership have led to increased Spanish energy demand, up over 100% since the mid-1970s. Like many EU countries, Spain is highly dependent on imports to meet its energy requirements, with domestic energy production only meeting 24,2% of Spain's total energy consumption in 2002 and 21,1% in 2005. The Spanish government has funded additional investments in domestic energy sources, especially renewables, though the country will be dependent upon foreign energy sources for the foreseeable future.

Oil

Spain has a small amount of proven oil reserves, only 158 million barrels in 2005. The importance of oil to the Spanish economy has declined somewhat in recent years, with oil's share of total primary energy consumption falling from 77% in 1980 to 51% in 2002 and 49% in 2005. However, because the country's total energy consumption has risen dramatically over that period, Spain's oil consumption in absolute terms has increased from 990,000 barrels per day in 1980 to 1.56 million barrels per day in 2004. The total consumption of oil products in 2005 was 71.785 ktoe. Spain depends upon imports for most of its oil needs, and like most oil-importing EU countries, Russia was in 2005 one of the major suppliers (14,8%), Mexico (14.9%), Saudi Arabia (10,5%), Nigeria (11,8%) and Libya (10,2%). In 2005, Spain imported 60.243 Thousands tons of crude oil.

Graph 1. Total Hydrocarbon Consumption by source on the period 1980-2002 in Spain.



Source: EIA

Spain privatized its oil sector during the 1990s, opening all aspects to private competition. The largest oil company in the country is Repsol-YPF, created in 1999 through the merger of Repsol, the former state-owned oil company of Spain, and Yacimientos Petroliferos Fiscales (YPF), formerly-owned by the Argentine government. The combined group is one of the world's largest integrated oil operators, with activities in over 28 countries and proven oil and gas reserves of 5.4 million barrels of oil equivalent (boe). Despite its overall global presence, Latin America contains the bulk of Repsol-YPF's operations, with Argentina alone providing some two-thirds of the group's total hydrocarbon production. After Repsol-YPF, Cepsa is the second-largest oil company in Spain. Cepsa has exploration and production activities in Algeria and Colombia, with future expansion planned in Yemen and Iran.

The Spanish government privatized the country's oil transportation and storage infrastructure in the late 1990s, forming the Compania Logistica de Hidrocarburos (CLH) as a private holding company for the system. Ten oil and gas companies hold shares in CLH, the largest being Enbridge (25%), Respol-YPF (25%), and Cepsa (14.15%). Under Spanish law, no single shareholder can own more than 25% of CLH.

Spain produced only 1.234.137 barrels of crude oil in 2005 continuing with a decreasing tendency through time. The country has four active oil fields, all operated by Repsol-YPF: Ayoluengo, Boqueron, Casablanca, and Rodaballo. Repsol-YPF currently has exploration activities in the Atlantic Ocean and in the Bay of Cadiz, though preliminary results from these explorations have been disappointing.

Spain has nine oil refineries, with a total yearly production in 2005 of 120.058 Kt. The largest facility in the country is Cepsa's Cadiz refinery (240,000 barrels per day), though Repsol-YPF controls the largest refining capacity (520,000 barrels per day) of any single company. Repsol-YPF and Cepsa also have joint ownership of a bitumen plant, Asesa, located at the Tarragona refinery. Increasingly strict EU environmental guidelines have forced Spanish refineries to upgrade their facilities to reduce pollution emissions and to meet new fuel specifications. These upgrades have included the installation of new cracking and de-sulfurization capacity at all refineries in the country.

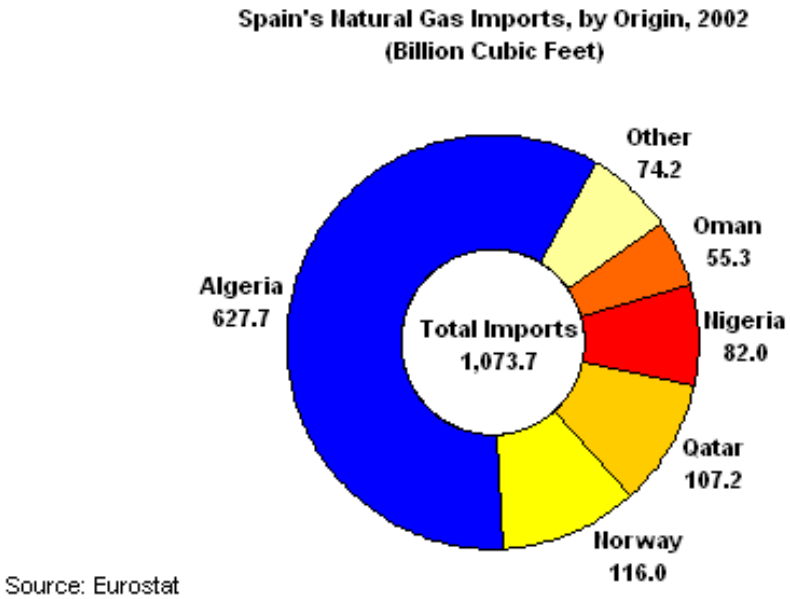
As mentioned above, CLH controls Spain's domestic oil pipeline network. The company operates over 3,500 km. of pipelines, mostly carrying refined petroleum products. The system connects Spain's coastal refineries and

import terminals to major population centers in the middle of the country. CLH also operates 38 storage facilities with 6,5 million m3 of oil storage capacity, and 28 airport storage facilities with 144.000 m3 of oil storage capacity along the pipeline system.

Natural gas

Spain has quite small proven natural gas reserves. The country's natural gas production is insignificant, only 1.856 GWh in 2005. Almost all of Spain's natural gas production comes from one offshore field, Poseidon, operated by Repsol-YPF. Gas imports in the year 2005 were 390.806 GWh having a strong increase (23%) compared to 2004.

Graph 2. Natural gas imports by origin in Spain, 2002.



Source: Eurostat

In 2002, Spain consumed 14.146 ktoe of natural gas. The final consumption of gas in 2005 was 18.133 ktoe and the total demand was 29.120 ktoe, with a strong increment on electric generation, cogeneration and combined-cycle, gas-fired turbines (CCGFT). Natural gas consumption in the country has risen dramatically since the 1980s, and Spain has one of the fastest-growing natural gas markets in the world. Between 1993 and 2002, Spain's natural gas consumption grew by 224%, driven mostly by the large-scale introduction of gas-fired power plants. Natural gas suppliers have had some difficulty keeping up with this rapid increase in demand, and several gas-fired power plants had to temporarily shutdown in late 2004 due to gas shortages. In December 2004, Spain's natural gas consumption increased by 22% from the previous year, and the country's Economics Ministry predicted that natural gas demand will grow by at least 9-12% per year until 2011.

Spain has enthusiastically supported energy market liberalization efforts by the EU, with the country implementing these reforms faster than required by EU guidelines. Since January 2003, all natural gas customers in Spain have been able to choose their supplier. Alternatively, the customers can opt to remain under regulated tariffs until full liberalization in 2007. In 1998, the Spanish government created the Comision Nacional de Energia (CNE) to oversee the deregulated market, guarantee open access to all parties, and ensure competition.

The largest natural gas supplier in Spain is Gas Natural (GN), the result of a 1992 merger between Catalana de Gas, Gas Madrid, and the gas infrastructure assets of Repsol Butano. Prior to deregulation, GN controlled all aspects of Spain's natural gas sector, including supply, transportation, and distribution. Since liberalization, however, GN has seen its influence diminish and its expansion plans curtailed by CNE. In 2002, CNE forced GN

to spin off 65% of the shares of Enagas, the private company owned by GN that controls Spain's natural gas transport system. GN now owns 5% of Enagas, the government forced GN to reduce its ownership to 5% or less by 2007. In 2001, CNE awarded 25% of the natural gas contracted to GN from Algeria's Sonatrach to six private companies in order to promote competition in the sector. Spanish electricity utilities have had the most success in gaining market share in the liberalized natural gas market, with Endesa, Union Fenosa, and Iberdrola all making significant gains.

Enagas operates the bulk of Spain's domestic natural gas transportation system. Seventy five (75%) of the company's shares float on the open market, the rest being held by GN (5%) and several other natural gas companies (25%). Enagas controls 7.533 km. of pipelines in Spain, consisting of six main trunk lines that connect Spain's liquefied natural gas (LNG) and pipeline import terminals with the country's interior. The company also maintains relevant working gas storage capacity.

Spain imports natural gas through two international pipelines. The Trans-Pyrenean pipeline, linking Calahorra, Spain to Lacq, France, began operations in 1993. This pipeline allows Spain to import natural gas from Norway via France. The second import pipeline is the 1600 km. Maghreb-Europe Gas (MEG, also called Pedro Duran Farell). MEG, completed in 1996, connects Algeria's Hassi R'mel gas field with Cordoba, Spain, via Morocco. In August 2001, Algeria's Sonatrach, part owner of MEG, awarded ABB a 75 million € contract to build a natural gas compressor station on MEG in order to increase the line's capacity. Enagas also operates two pipeline connections with Portugal, Tarifa and Tuy, through which Portugal imports natural gas from the rest of Europe and North Africa.

In July 2001, a consortium led by Spain's Cepsa and Algeria's Sonatrach agreed to build the Medgaz natural gas pipeline, a second link between Algeria and Europe. Today, the Medgaz company shares are hold by Algeria's Sonatrach (36%), Spain´s Cepsa (20%), Spain´s Iberdrola (20%), Spain´s Endesa (12%) and Gaz of France (12%). The 210 km. Medgaz link Beni Saf, Algeria to Almeria, Spain, with an eventual extension to France. In September 2002, the consortium completed a study of the line's feasibility, but delays have pushed initial construction on the project to December 2006. Medgaz should be completed by 2009. There are also plans to run a parallel power cable.

Spain’s Gas de Euskadi and France's Total constructed the Euskadour pipeline linking the LNG terminal in Bilbao, Spain to Lussagnet, France. The 19-mile pipeline runs along the Bay of Biscay and was inaugurated in 2006.

Liquefied Natural Gas (LNG)

In 2002, Spain was Europe's second largest LNG importer, behind France. Enagas operates three LNG receiving terminals in Spain: Barcelona, Cartagena and Huelva. The Bahia de Bizakaia Group, a consortium of BP, Repsol-YPF, Iberdrola, and Ente Vasco de la Energia (EVE), operates an LNG terminal at Bilbao. The consortium also owns an 800-megawatt (MW) power plant fed by the terminal.

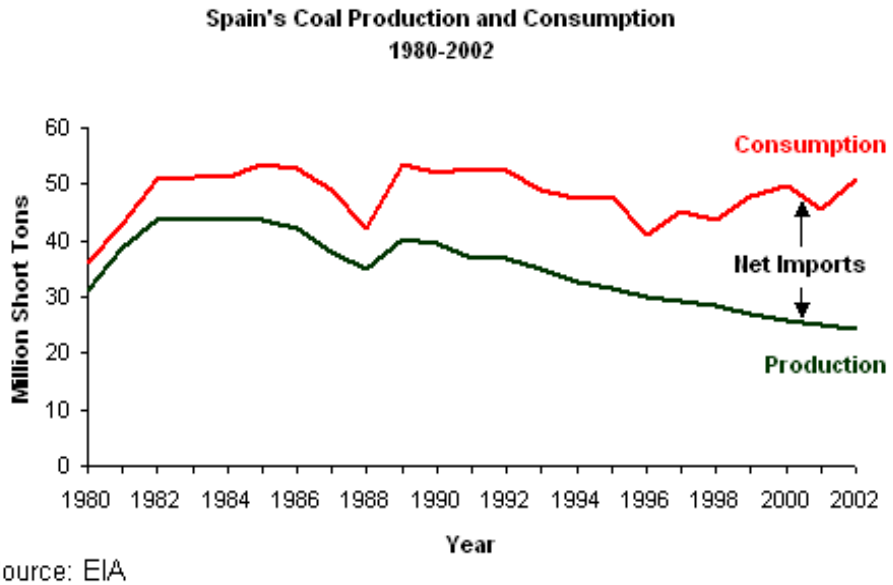
Union Fenosa, Iberdrola, and Endesa own the Sagunto LNG terminal in Valencia. The three companies use gas from the terminal to feed their gas-fired power plants in the region, and both Union Fenosa and Iberdrola plan to also construct additional power plants near the terminal. Union Fenosa and Endesa also constructed the El Ferrol LNG terminal in northwest Spain completed in 2006. The El Ferrol plant will produce natural gas using LNG supplied by Algeria's Sonatrach.

Spanish companies have invested in the development of liquefaction export terminals in foreign countries. Union Fenosa and Italy's Eni majority own the Damietta LNG export terminal in Egypt. The first such facility built in that country was Damietta. The first LNG shipment from Damietta arrived at Spain's Huelva import terminal in January 2005, with subsequent cargos promised to Union Fenosa, ENI, British Petroleum, and British Gas. Union Fenosa also has a minority stake in the construction of a third LNG plant at the Qalhat export terminal in Sur, Oman. Union Fenosa signed a 20-year contract to purchase half of the plant's output.

Coal

Coal is Spain's most plentiful indigenous energy source, with reserves of 728 million tons (Mt). The country produced 22.035 Kt while consuming 46.075 Kt in 2002, relying on imports for the balance. In 2005, the country produced 19.354 Kt, while consuming 21.183 Kt. Overall coal consumption has remained relatively flat over the past decade, with Spain's electricity sector constituting the largest share. In the last years, coal consumption has decreased significantly due to changes in the energy policy and closedown and decrease in production in coal mines. At the same time, natural gas consumption has increased dramatically. Coal mining is spread over a number of small, isolated fields and decreasing in importance and production, including Asturias (Central and Western field), Leon (Bierzo-Villablino, Sabero and Nord), Palencia (Guardo and Barruelo), Catalonia (Pirenaica), Teruel (Teruel-Mequinenza), and Sud (Puertollano and Peñaroya). Private companies produce most of the coal in Spain, though the single-largest company is Hunosa, owned by the government through the Sociedad Estatal de Participaciones Industriales (SEPI) holding company.

Graph 3. Coal production and consumption on the period 1980-2002 in Spain.



Source: EIA

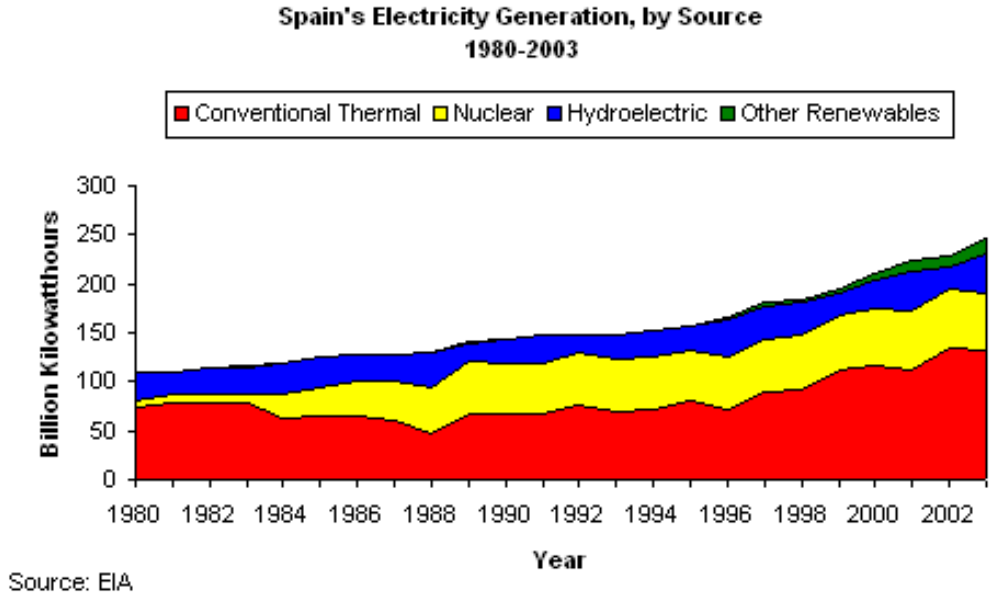
Similar to other EU members, Spain’s coal industry has struggled to remain competitive vis-à-vis imported coal and other energy sources. The Spanish government plans a gradual reduction in the size of the workforce of Hunosa through relocation, early retirement, and layoffs. It has been difficult for the government to phase out coal mining completely, because many regions of the country are dependent on the industry for employment. The Spanish government has introduced alternative plans for mining communities in conjunction with Sociedad Asturiana de Diversificación Minera (Sadim), a company that helps communities develop alternatives to coal mining.

Electricity

Spain has the fifth-largest electricity market in the EU. The country consumed 206.535 Gwh in 2002 and 273.975 Gwh in 2005. The final consumption of electricity in 2005 was 20.820 ktoe. The largest share in 2005 of Spain's gross electricity generation came from conventional thermal plants (62.6%), followed by nuclear (19,57%), other renewables (10,02%), and hydroelectricity (7,82%). The hydroelectric production has been quite smaller as expected due to lack of water resources in 2005. Both Spain's electricity generation and consumption have grown considerably in recent years, nearly double the growth rate experienced in Western Europe as a whole. On average, electricity generation and consumption in the country have grown by 4.4% and 5.1% per

year, respectively, since 1980, while generation and consumption in Western Europe over that same period has grown by 2.5% and 2.6% per year, respectively. The rising electricity consumption has strained Spain's electricity infrastructure, with several major blackouts attributed to supply shortages or transmission grid malfunctions.

Graph 4. Electricity generation by source on the period 1980-2002 in Spain.



Source: EIA

As is the case with natural gas, Spain’s government liberalized the country’s electricity sector ahead of the schedule mandated by the EU. Since January 1, 2003, all customers have been able to choose their electricity supplier. The deregulated power sector accounts for about one-third of Spain's total electricity market. In 1997, the Spanish government created the Compañia Operadora del Mercado Español de Electricidad, S.A. (OMEL) to manage the liberalized market, establish a spot market, operate the futures market, and assure the timely settlement of payments. In both the regulated and liberalized markets, most of Spain's electricity utilities integrate generation and distribution activities, though there are some small, independent operators in both activities.

Endesa is the largest power generating and distributing company in Spain, with over 22.416 megawatts (MW) of installed generating capacity in 2005. The company controls about 41% of the regulated electricity market and about 37% of the liberalized market. The largest source of Endesa’s generating capacity is coal-fired plants (42%), followed by nuclear (28%). Spain's second-largest power utility overall is Iberdrola, though the company controls the largest share (38%) of the deregulated portion of the market. Other important players in Spain's electricity sector include Union Fenosa, Hidrocantabrico, and Gas Natural.

In 1985, the Spanish government created Red Electrica de España (REE) to manage the state-owned portions of the electricity grid. Since its foundation, REE has slowly increased its control of the country's electricity transmission network through the acquisition of assets from electricity utilities. In 2002, REE purchased the transmission assets of Union Fenosa and Endesa; in 2004, REE purchased the assets of Enel Viesgo, the Spanish subsidiary of Italy's Enel. The Spanish government still owns 20% of REE through the state-owned holding company, SEPI, while Spain's large electricity utilities (Endesa, Iberdrola, Union Fenosa, and Hidrocantabrico) each own 3% stakes and 70% are free float shares. REE maintains several international connections with neighboring countries, including Portugal, France, and Morocco.

In January 2004, Spain and Portugal formally signed an agreement to create a pan-Iberian electricity market (Mibel). The new market will allow generators in the two countries to sell their electricity on both sides of the border. OMEL and Portugal's equivalent, OMIP, might merge in 2007 to create a single operator for the integrated electricity market. The election of the new Spanish government in 2004 postponed the creation of Mibel, but the Socialist government announced that it would implement Spain's part of the agreement by 2007.

Conventional Thermal

Spain's conventional thermal generating capacity contributes over half of the country's total power supply. Over the past several years, this capacity has begun to shift from an emphasis on coal towards natural gas, specifically combined-cycle, gas-fired turbines (CCGFT). Spain has promoted CCGFTs in order to increase existing generating capacity and reduce its carbon dioxide emissions. Natural gas accounted for 30% of Spain's conventional thermal capacity in 2004, and its share is likely to rise in coming years as additional CCGFTs come on-line. Iberdrola announced in late 2004 that it would build an 800-MW CCGFT in Murcia, with completion scheduled in 2007. In addition, Endesa announced the construction of two 230-MW CCGFTs for the Spanish islands of Mallorca and Gran Canaria (under construction). Union Fenosa has six CCGFTs operated by the company. As mentioned above, Union Fenosa is building a 1,200-MW power facility near its new LNG terminal at Sagunto, consisting of three, 400-MW CCGFTs built by Siemens. Construction of the Sagunto plant should be completed by 2007.

Nuclear Power

Currently, Spain has nine operating nuclear reactors. In 2005, the total installed power was 7.876 MWe which represents a 10,1% of the total installed power and a total production of 57.539 GWh. Spain decommissioned the Vandellos I reactor in July 1990, and Union Fenosa planned to close the Jose Cabrera plant, although it did not happen so far. Nevertheless, the output of the nuclear power sector in Spain has remained stable despite the closure, as upgrades and efficiency gains at existing plants replace retired capacity. Nuclear power generates a significant portion of Spain's power supply, but Prime Minister Zapatero has announced that Spain will gradually replace nuclear power with energy from renewable sources.

Renewable energy

Spain had in 2005 a total renewable energy power of 27.032 MW producing 60.096 GWh. Spain was the world's second-largest producer of wind power in 2004, behind Germany, with the energy source meeting 6% of Spain's total electricity demand. Spain has some 8,300 MW of installed wind capacity, with an additional 57,000 MW in various stages of planning, development, and regulatory approval. Endesa plans to invest over $2 billion on renewable generating capacity in Spain in the next years, adding to the wind farms already operated by the company in Portugal and Italy. The company Iberdrola is the major wind energy producer in Spain with a current total installed power of 3.728 MW. Endesa has a total installed wind energy power in Spain of 1.844 MW.

1.1.2 Spain’s energy potential saving

On November 2003, the Spanish government approved the Energy Saving and Energy Efficiency Strategy 2004-2012 (E4). This strategy document includes the past and current situation regarding RE and RUE initiatives as well as a series of renewable energy and energy efficiency measures that are and will be implemented in that period in Spain.

The Spanish government also elaborated the E4 Action Plan for the period 2005-2007. This action plan tries to solve the lack of concreteness of the Strategy by inventorying and exposing actions and measures to be taken for each economic sector, detailing objectives, deadlines, resources and responsibilities, and at the same time evaluating and monitoring the impacts of these measures.

The following section shows the potential energy saving in different scenarios set by the Energy Saving and Energy Efficiency Strategy 2004-2012 (E4 Strategy) per economic sector.

Industry

According to the E4 Strategy and taking an efficiency scenario (exposed in E4 document) as a reference, the potential final energy saving for the industrial sector is of 2.351 Ktoe by the year 2012.

Industrial sector			
	Energy objective (ktoe)	**Total investment (Million €)**	**Public support (Million €)**
Technology measures	1052	837	110
Industrial processes measures	1112	1032	258
New processes measures	188	292	113
Total	**2351**	**2161**	**481**

Source: E4 Strategy. Ministry of Industry.

Transport

The energy consumption and potential energy saving in the transport sector according to the E4 Strategy on the baseline and efficiency scenarios is the following:

		2000	**2006**	**2012**
Baseline scenario	Energy Consumption (ktoe)	32272	42384	52805
Efficient Scenario	Energy Consumption	32272	41313	48016
Potential saving	Energy saving (ktoe /year)	-	1071	4789

Source: E4 Strategy. Ministry of Industry.

El total cumulative energy potential saving for the period 2004-2012 will be 21.187 ktoe. Total public support on the period 2004-2012 will be 418 million €.

Diverse uses (Residential, Services (tertiary) and public services)

In the following table it is shown the foreseen energy savings, investments and public support associated to the specific measures:

	Annual energy saving (ktoe)	**Associated Investments 2004-2012 (Million €)**	**Public Support 2004-2012 (Million €)**
Measures on existing buildings	1094	8332	575
Measures derived from Directive 2002/91/CEE	679	5505	2
Class A Energy Efficiency appliances	409	1646	220
Public Lighting and water treatment	154	871	61
Total	**2336**	**15.354**	**858**

Source: E4 Strategy. Ministry of Industry.

Public services

The forecast for energy saving in the public services sector for the period 2004-2012 is 581 ktoe. The public investments are planned to be 61 million €. Additionally, it was added measures to improve the energy efficiency of desalination plants in Spain with a energy saving of 15,6 ktoe/year and a public support of 1,27 million €.

Energy transformation

The forecast for energy saving in the sector as well as the necessary investments are indicated in the below table. The total public support for the period 2004-2012 is expected to be 115 million €.

	2004-2012		
	Potential annual saving (ktoe)	**Investment (Million €)**	**Public support (Million €)**
Energy generation	767,5	567	21
Refineries	575,5	148	66
Co-generation	150	213	28
Total	**1.494**	**929**	**115**

Source: E4 Strategy. Ministry of Industry.

Agriculture

As a result of the E4 strategy and under the efficiency scenario, it is expected that the potential energy saving on the year 2012 will be about 348 ktoe in the agriculture and fishing sector, a cumulative energy saving on the period 2004-2012 of 1.738 ktoe, and a total public support on the period 2004-2012 of 93,5 million €.

The following table shows the energy consumption and potential energy saving in the agriculture and fishing sectors under the baseline and efficiency scenarios.

	2000	**2006**	**2012**
Baseline scenario (ktoe)	4089	4421	4920
Efficiency scenario (ktoe)	4089	4306	4572
Annual saving (ktoe/year)	**0**	**116**	**348**

Source: E4 Strategy. Ministry of Industry.

1.1.3 Institutional specificities regarding national energy planning

The Central Government through the implementing Ministry of Industry, Tourism and Trade has national jurisdiction on energy issues in Spain by the Real Ordinance 562/2004 of April of 2004 and the R.O. 254/2006 of March 3.

Within the Ministry and in the energy field, the Energy Secretariat plays a relevant role. The Energy Secretariat has the following mission:

- Elaborate norms on energy matters according to current legislation.
- Elaborate proposals on tariff regulation, energy products prices and taxes according to current legislation.
- Formulate proposals for energy saving, renewable energy promotion and development of new energy technologies.
- Elaborate and implement of measures to guarantee energy supply.

Within the Energy Secretariat, it can be found the following departments:

- General Bureau of Energy Planning; and
- Department of Energy Policy.

The Department of Energy Policy has the following Bureaus:

- Bureau of Electric power.
- Bureau of nuclear energy.
- Bureau of hydrocarbons.
- Bureau of mines.

There are other relevant institutions and departments, attributed to the Ministry of Industry, Tourism and Trade and these are the following:

- Energy Diversification and Saving Institute (IDAE). Its function is the development and promotion of the energy efficiency and renewable energy.
- Corporation for Strategic Reserve of Oil Products (CORES). This department is in charge of management and maintenance of securing a minimum reserve of oil and oil products.
- The National Energy Commission is also an important governmental body attributed to the Ministry of Industry, Tourism and Trade through the General Secretary of Energy.

Within the government, there are others Ministries and departments with roles on energy issues:

- The Ministry of Education and Science has an important role through the Energy, Environmental and Technological Research Center (CIEMAT).
- The Ministry of Environment regulates the environmental impact of all industrial activities has important bodies such as the Climate National Council.
- Finally, the Nuclear Security Council (CSN) which is the department in charge nuclear security and radiological protection.

1.2 Energy supply, demand and production: evolution and structure

1.2.1 Evolution and structure of energy demand

During the last three decades, important changes have taken place in the energy field in Spain, at the quantitative and qualitative context. The energy consumption in Spain is obviously strongly linked to the international context which had suffered deep socioeconomic transformations. The ever-changing evolution of oil prices and the distribution of energy reserves have conditioned the energy options of developed countries for decades. Recently, environmental concerns and the process of liberalization of the energy sector in Europe, has created a new European scenario for energy policies.

By the middle of the seventies, after the first great oil crisis that showed the vulnerability of western economies due to abrupt changes of oil prices, most western countries started policies to improve energy efficiency and reduce oil dependence. The second crisis (1979-80) accentuated the necessity of those policies producing reductions of energy intensity and a decrease in the weight of the petroleum in the energy balance. At the same time, nuclear energy and energy coming from coal played an increasing role as sources of energy, but in the last decade has lowered again their contribution, while increasing other sources such as gas.

In Spain, contrary to what happened in most OECD countries, an effective energy efficiency policy was not initiated until the end of the 1970s with the objective to face the changes that have taken place. Theses changes were the following:

- Important growth of the energy demand.
- Diversification of energy sources.
- Changes in the evolution of the energy intensity.
- Liberalization of the energy sector and environmental considerations.

Regarding **energy demand,** at the moment, Spain consumes more than double energy than in 1975. While in 1975, the consumption of primary energy was about 61 million toe, in the year 2000, the consumption was 125 million toe. This strong growth has had significant variations in different periods, strongly linked to the economic cycle, the demand of equipment, the effectiveness of initiatives to improve energy efficiency, etc. These variations are also related to the time period, relative prices of energy sources and energy consumption context.

From mid-1970s, an important economic and social development has taken place in Spain, with a strong expansion of the automobile, an increasing process of appliances acquisition by citizens, a great increase in heating systems and, more recently, of air conditioning in many Spanish families. All these actions have had a clear reflection in the energy consumption evolution.

In the following table, it is shown, the evolution of primary energy consumption in Spain (1973-2004) of coal, oil products, gas, hydroelectric, nuclear, exchange of energy and total (Unit: Ktoe).

Year	Coal (1)		Petroleum		Natural Gas		Hydroelectric (2)		Nuclear		Balance (3)		Total	
	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)
1973	9.875	18,2	39.455	72,9	794	1,5	2.489	4,6	1.705	3,1	-173	-0,3	54.145	100,0
1974	9.169	16,2	42.095	74,5	852	1,5	2.635	4,7	1.882	3,3	-98	-0,2	56.535	100,0
1975	10.332	17,9	42.230	73,2	941	1,6	2.244	3,9	1.966	3,4	-53	-0,1	57.660	100,0
1976	9.584	15,5	47.353	76,7	1.092	1,8	1.808	2,9	1.969	3,2	-67	-0,1	61.739	100,0
1977	10.22'7	16,5	45.714	73,5	1.184	1,9	3.413	5,5	1.700	2,7	-81	-0,1	62.158	100,0
1978	10.229	15,9	47.389	73,8	1.269	2,0	3.468	5,4	1.993	3,1	-132	-0,2	64.216	100,0
1979	10.648	16,0	49.134	73,6	1.327	2,0	3.994	6,0	1.746	2,6	-128	-0,2	66.721	100,0
1980	13.337	19,4	50.070	72,8	1.567	2,3	2.544	3,7	1.351	2,0	-119	-0,2	68.750	100,0
1981	15.178	22,4	46.439	68,7	1.765	2,6	1.894	2,8	2.494	3,7	-125	-0,2	67.644	100,0
1982	17.253	25,4	44.395	65,5	1.890	2,8	2265	3,3	2.285	3,4	-260	-0,4	67.828	100,0
1983	17.636	26,1	42.545	63,0	2202	3,3	2.335	3,5	2.778	4,1	-9	0,0	67.487	100,0
1984	18.057	25,9	40.907	58,6	1.877	2,7	2.718	3,9	6.016	8,6	199	0,3	69.774	100,0
1985	19.121	27,0	39.538	55,9	2.195	3,1	2.701	3,8	7.308	10,3	-92	-0,1	70.771	100,0
1986	18.695	25,4	40.676	55,2	2.336	3,2	2.282	3,1	9.761	13,3	-108	-0,1	73.642	100,0
1987	18.003	23,6	42.520	55,8	2.648	3,5	2.358	3,1	10.755	14,1	-132	-0,2	76.152	100,0
1988	15.248	19,3	44.282	56,0	3.440	4,4	3.035	3,8	13.151	16,6	-115	-0,1	79.041	100,0
1989	19.173	22,3	46.025	53,6	4.505	5,2	1.640	1,9	14.625	17,0	-157	-0,2	85.811	100,0
1990	18.974	21,6	47.741	54,2	5.000	5,7	2205	2,5	14.138	16,1	-36	0,0	88.022	100,0
1991	18.992	21,0	49.367	54,5	5.511	6,1	2.349	2,6	14.484	16,0	-58	-0,1	90.645	100,0
1992	19.277	21,0	50.464	54,9	5.851	6,4	1.724	1,9	14.537	15,8	55	0,1	91.908	100,0
1993	18.418	20,3	49.709	54,7	5.829	6,4	2.155	2,4	14.609	16,1	109	0,1	90.828	100,0
1994	18.018	19,3	51.894	55,6	6.479	6,9	2.425	2,6	14.415	15,4	160	0,2	93.390	100,0
1995	18.721	19,2	54.610	55,9	7.504	7,7	2.000	2,0	14.449	14,8	386	0,4	97.670	100,0
1996	15.810	16,1	55.433	56,6	8.401	8,6	3.521	3,6	14.680	15,0	91	0,1	97:936	100,0
1997	18.010	17,4	57.396	55,3	11.057	10,7	3.117	3,0	14.411	13,9	-264	-0,3	103.726	100,0
1998	18.300	16,5	61.670	55,7	11.816	10,7	3.220	2,9	15.376	13,9	293	0,3	110.676	100,0
1999	20.976	18,1	63.041	54,4	13.535	11,7	2.484	2,1	15.337	13,2	492	0,4	115.865	100,0
2000	22.137	18,2	64.663	53,2	15.223	12,5	2.943	2,4	16.211	13,3	382	0,3	121.558	100,0

Year	Coal (1)		Petroleum		Natural Gas		Hydroelectric (2)		Nuclear		Balance (3)		Total	
	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)
2001	20.204	16,2	66.721	53,7	16.405	13,2	4.129	3,3	16.602	13,4	298	0,2	124.359	100,0
2002	22.640	17,6	67.647	52,5	18.757	14,6	2.821	2,2	16.422	12,8	458	0,4	128.744	100,0
2003	21.143	16,0	69.313	52,3	21 .254	16,0	4.579	3,5	16.125	12,2	109	0,1	132.523	100,0
2004	22.205	16,0	71.054	51,4	24.671	17,8	4.120	3,0	16.576	*12,Q*	-260	-0,2	138.366	100,0
2005	22.723	16,0	71.785	50,6	29.120	20,5	3.495	2,5	14.995	10,6	-116	-0,1	142.002	100,0

1. Includes urban waste and other solid fuels for energy generation
2. Includes photovoltaic energy and wind energy.
3. Balance = International exchanges of energy (imports-exports).

Source: Energy Secretariat. Ministry of Industry.

With quite differences, the first half of the 1980s has been the period with smaller growth of **primary energy** in Spain, attaining an average increment of annual primary energy consumption of only 0,4 %. Additionally, during the first years of the 1980s, consumption reductions have occurred. The major contributors to this situation were the economic recession of the mid-1970s, more severe in Spain than in most western countries, the magnitude and persistence of high oil prices and the adoption of energy efficiency measures, all this in a context of high saving potential and profitable energy efficiency investments.

In the following table, it is shown the evolution of primary energy consumption (2000-2005) in Spain and by source type (Unit: % of total and ktoe).

	2000	2001	2002	2003	2004
Petroleum	52	52	51	51	50
Nuclear	13	13	13	12	12
Renewable	6	7	5	7	6
Coal	17	15	17	15	15
Natural gas	12	13	14	15	17
Total	**124.722**	**127.631**	**131.805**	**136.374**	**142.058**

Source: IDAE, 2005.

Between 1975 and 1990, the consumption of primary energy increased in Spain by an annual average rate of 2,7%, while in the 1990s, the rate increase was 3,1 %, specially in the last years of the decade. This increase was clearly greater than the GDP, meaning that the energy intensity was also growing.

The primary energy consumption has grown in the period 1990-2004 in Spain by 54,4%, while the GDP has grown 43,7%, which indicates that the primary energy intensity has increased significantly. On the other hand, the evolution of the types of energy has been quite different, causing a relevant structural change on the energy demand. Specifically, the electric power demand has increased 78,8% and the gas 491%, while oil demand has increased less, about 48,2%. The oil resource is increasingly demanded by the transport sector, while being substituted in other sectors by gas and electricity.

Another important change taken place in the Spanish energy panorama during the last years of the XX century is related to **diversification of energy sources.** In 1975, Spain had low diversified energy sources with an enormous preponderance of oil that covered around 70% of energy necessities. At the moment, the petroleum - that continues dominating supplies - represents a bit more than 50% of the primary energy consumption. Half of this demand is used on transport.

The effort carried out by the Public Administration on energy saving and energy efficiency initiatives in all sectors, and in particular on the industry, is attaining results. The installed cogeneration power has increased from 488 MW in 1991 to near 5800 MW in 2004. Also, the investment and support to promote renewable sources has attained, besides hydroelectric fluctuations, more than 20% of the generated electricity coming from

these sources. Public administration policies have also achieved a relevant improvement on energy efficiency in Spain.

Natural gas has evolved from being a testimonial resource – 1,5% of the consumption in 1975 - to cover about 12% of Spain's primary energy consumption in the year 2000 and 20% in 2005. Additionally, it is currently the energy source with greater growth perspectives over the mid-term. On the other hand, nuclear energy, a small energy source in 1975, represents 10,3% (2005) of the total primary energy consumption in Spain, although their relative contribution is decreasing in the last decade.

Today, coal has a weight in the primary energy consumption of about 17%, practically the same one that 25 years ago, but its evolution has lived two different stages: the first one, a strong growth until mid-1980s – period in which coal represented 25% of the energy consumption in Spain - and the second, from then that the coal contribution has been reduced gradually.

Finally, the renewable energy (at the moment represents about 6% of the primary energy consumption), has increased their absolute value contribution. In addition, their origin has diversified, especially in the last decade. Its relative contribution was greater in 1975 as consequence of the importance that hydroelectric energy and the biomass traditional uses played in the past. These sources were in the past the only practical contribution to the renewable sources in Spain. The Spanish energy polity objective of attaining 12% of the total energy consumption by 2010 coming from renewable sources is a great challenge of growth as reflected in the Renewable Energy Action Plan 2005-2010.

During this period, changes have taken place on the relative weight of the three major sectors and different paces of growth. During the second half of the 1980s, a strong economic growth took place in Europe and even greater in Spain. In the context of reduction of energy prices and entrance of Spain in the European Community, Spain increased the mean energy final consumption on 3,9 % annually, with a moderate growth on the industry consumption, a limited increase on diverse uses (residential & services) and a strong growth on the transport sector, registering an average annual increase of 7,9%.

In the following table, it is shown the final energy consumption evolution (1973-2005) in Spain of coal, oil products, gas, electricity and total (Units: ktoe and % of total).

Year	Coal		Petroleum		Natural Gas		Electricity		Total	
	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)
1973	4.029	10	30.333	75,4	763	1,9	5.124	12,7	40.249	100
1974	4.326	10,2	31.576	74,6	820	1,9	5.597	13,2	42.319	100
1975	3.955	9,5	30.993	74,4	901	2,2	5.784	13,9	41.633	100
1976	3.510	7,9	33.335	75,5	1.034	2,3	6.292	14,2	44.171	100
1977	3.522	7,5	35.916	76,2	1.136	2,4	6.557	13,9	47.131	100
1978	3.161	6,5	37.127	76,6	1.220	2,5	6.933	14,3	48.441	100
1979	3.196	6,3	39.240	76,8	1.252	2,5	7.402	14,5	51.090	100
1980	3.504	7	37.737	75,2	1.220	2,4	7.748	15,4	50209	100
1981	4.550	9,3	35.252	72,2	1.184	2,4	7.806	16	48.792	100
1982	5.545	11,3	34.477	70,3	1.178	2,4	7.865	16	49.065	100
1983	5.315	10,9	33.882	69,8	1.110	2,3	8.245	17	48.552	100
1984	5.443	10,8	34.581	68,9	1.549	3,1	8.622	17,2	50.195	100
1985	5.030	10,1	34.110	68,5	1.768	3,6	8.858	17,8	49.766	100
1986	4.783	9,4	35.221	69	2.004	3,9	9.046	17,7	51.054	100
1987	4.212	7,9	37.017	69,7	2.463	4,6	9.427	17,7	53.119	100
1988	4.237	7,6	38.328	68,9	3.153	5,7	9.876	17,8	55.594	100
1989	4.353	7,4	39.587	67,7	4.116	7	10.410	17,8	58.466	100
1990	4.271	7	40.893	67,4	4.531	7,5	10.974	18,1	60.669	100
1991	4.135	6,6	42.240	67,3	4.999	8	11.372	18,1	62.746	100
1992	3.511	5,6	42.481	67,8	5.154	8,2	11.488	18,3	62.634	100

Year	Coal		Petroleum		Natural Gas		Electricity		Total	
	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)	Ktoe	(%)
1993	3.131	5	42.998	68,4	5.130	8,2	11.569	18,4	62.828	100
1994	2.977	4,5	44.826	68,5	5.647	8,6	11.999	18,3	65.449	100
1995	2.702	3,9	46.952	68,4	6.550	9,5	12.462	18,1	68.666	100
1996	2.464	3,5	48.107	68	7.325	10,4	12.827	18,1	70.723	100
1997	2.334	3,2	50.108	67,8	8.162	11	13.331	18	73.935	100
1998	2.554	3,2	53.682	66,9	9.688	12,1	14.290	17,8	80214	100
1999	2.573	3,1	53.766	65,1	10.934	13,2	15.364	18,6	82.638	100
2000	2.546	2,9	55.628	64,1	12.292	14,2	16.306	18,8	86.772	100
2001	2.544	2,8	57.255	63,4	13208	14,6	17.292	19,1	90298	100
2002	2.486	2,7	57.642	62,6	14.224	15,4	17.791	19,3	92.143	100
2003	2.436	2,5	60.082	61,8	15.601	16,1	19.038	19,6	97.157	100
2004	2.405	2,4	61.689	61,2	16.720	16,6	19.914	19,8	100.728	100
2005	2.424	2,4	61.748	59,9	18.133	17,6	20.820	20,2	103.126	100

Note: It does not include Renewable Energy.
Source: Energy in Spain 2005. Ministry of Industry.

At the beginning of the 1990s due to economic reasons, the energy consumption growth was slow; nevertheless, this increase was above Spain's GDP growth. The economic dynamism of the second half of the 1990s was also reflected in a high growth in the final energy consumption reaching an average yearly rate of 4,9 %.

In the following table, it is shown the total consumption of final energy by sectors* (Ktoe).

	1980		1990		2000		2002		2004		2005	
	ktoe	%	ktoe	%	Ktoe	%	ktoe	%	ktoe	%	ktoe	%
Industry	24.306	48,4	25.308	40,4	34.340	38	35.634	37,3	37.623	36	38.135	35,7
Transport	14.570	29,0	22.716	36,2	32.272	35,8	34.377	35,9	37.844	36,2	38.695	36,2
Diverse uses	11.332	22,6	14.695	23,4	23.654	26,2	25.619	26,8	29.006	27,8	30.110	28,2
TOTAL	50.209	100	62.718	100	90.266	100	95.630	100	104.474	100	106.940	100

Source: Energy Secretariat. Ministry of Economy.
*includes non-energetic consumption.

In regards to sectors consumption, while in 1980 the industry absorbed about 48,4% of the energy final consumption and the transport reached 30%, in the year 2002 the industry reduced its share in more than 11% reaching 37,3%, and the transport increased its share by 6% reaching a value of 36%.

These sectors contributions are those corresponding to the final energy consumption, including consumptions for non-energetic uses, since if these are excluded; the current contribution of transport (39%) is much greater than industry (about 31%). In the industrial sector, the necessity of technological renovation due to competitiveness reasons has induced a quick penetration of efficient technologies and a reduction of energy consumption.

The elasticity of the energy price in the industrial sector contrasts with the inelasticity of the transport energy consumption in Spain, contrary to other European countries. Transport energy consumption in Spain is mainly concentrated on land transport of passengers and goods almost representing 80% of the total sector consumption. In the private transport, the vehicles increase and distance range – as a consequence of increase in mobility – is counteracted by the continuous technical improvements and lower consumption of new vehicles.

The residential sector has increased the final energy consumption from 1990 to a superior rate compared to other sectors. The increase of appliances and air conditioning has caused an important growth on electricity demand.

The energy consumption of the services (tertiary) sector is growing strongly in the last years, showing the sector relevant weight on the Spanish economy. Also, a tendency to increase the energy intensity is observed as a

consequence of more electric equipment installed (computers, air conditioning, etc.) in offices and other buildings of the services sector.

1.2.2 Evolution and structure of production

In table 4, the total installed power in Spain is detailed (as December 2005, 31st) of all power plants as well as all producers integrated in the special regime (renewable energy and other plants).

The electric production in Spain was 278.500 GWh in 2005, 4,6% above the 2004 production.

In the following table, it is shown the total installed energy power, structure and generation contribution of each energy in Spain, 2005.

Facilities	**Power (MW)**	**% Structure**	**% Power contribution**
Ordinary Regime			
Hydroelectric	16.658	21,4	6,5
Nuclear	7.876	10,1	19,6
Coal	11.934	15,4	27,5
Coke-diesel	6.843	8,8	5,5
Natural Gas	15.356	19,8	18,3
Total Ordinary Regime (OR)	**58.667**	**75,5**	**77,4**
Special Regime			
Hydroelectric	1.703	2,2	1,3
Coal	130	0,2	0,2
Coke-diesel	1.479	1,9	8,6
Wind	9.930	12,8	2,5
Urban waste & biomass	1.559	2,0	7,2
Photovoltaic	70	0,1	0,0
Total Special Regime (SR)	**19.079**	**24,5**	**22,6**
TOTAL (OR+SR)	**77.746**	**100,0**	**100,0**

Source: Energy in Spain 2005. Ministry of Industry.

The following table illustrates the evolution of the structure of primary energy production per source (in ktoe), since 1980 up to 2005.

In the following table, it is shown the evolution of national electric production 1980-2005 of coal, oil, natural gas, nuclear and hydroelectric (unit: ktoe)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1998	1997	1998	1999	2000	2001	2002	2003	2004	2005
Coal	10281	12057	12948	13154	13027	12196	13233	11493	10888	11649	11383	10436	10602	10431	9868	9734	9614	9632	9238	8586	8341	7863	7685	7144	6922	6626
Petroleum	1593	1226	1531	2976	2245	2183	1861	1640	1483	1086	795	1067	1073	874	807	652	519	371	532	300	224	338	316	322	255	166
Natural gas	32	40	45	64	204	291	367	655	833	1425	1228	1248	1122	615	753	537	413	155	98	123	148	471	467	197	197	144
Nuclear	1351	2494	2285	2778	6016	7308	9761	10755	13151	14625	14138	14484	14537	14609	14415	14449	14680	14411	15376	15337	16211	16602	16422	16125	16576	14995
Hydroelectric	2544	1894	2265	2335	2718	2701	2282	2358	3035	1640	2205	2349	1724	2155	2425	2000	3521	3117	3220	2484	2943	4129	2821	4579	4120	197
Total	15801	17711	19074	21307	24210	25399	27504	26901	29390	30425	29749	29584	29059	28684	28268	27372	28746	27686	28464	26830	27867	29404	27710	28366	28182	25425

Source: Energy in Spain 2005. Energy Secretariat. Ministry of Industry.

In the following table, it is shown the evolution of energy dependency 1980-2005 of coal, oil, natural gas, nuclear, hydroelectric and total (%).

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1998	1997	1998	1999	2000	2001	2002	2003	2004	2005
Coal	77.1	79.4	75.0	74.6	72.1	67.5	70.8	63.8	71.4	60.8	60.0	54.9	55.0	56.6	54.8	52.0	60.8	53.5	50.5	40.9	37.7	38.9	33.9	33.8	31.2	29.2
Petroleum	3.2	2	3.4	7.0	5.5	5.5	4.6	3.9	3.3	2.4	1.7	2.2	2.1	1.8	1.6	1.2	0.9	0.6	0.9	0.5	0.3	0.5	0.5	0.5	0.4	0.2
Natural gas	2.0	2.3	2.4	2.9	10.8	13.2	15.6	24.7	24.2	31.6	24.6	22.6	19.2	10.5	11.6	7.2	4.9	1.4	0.8	0.9	1.0	2.9	2.5	0.9	1.3	0.5
Nuclear	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Hydroelectric	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Total	23.0	26.2	28.1	31.6	34.7	35.9	37.3	35.3	37.2	35.5	33.8	32.6	31.6	31.6	30.3	28.0	29.4	26.7	25.7	23.2	22.9	23.6	21.5	21.4	20.4	17.9

Source: Energy in Spain 2005. Energy Secretariat. Ministry of Industry.

1.2.3 Energy consumption forecast

Spanish authorities have carried out a forecast scenario of the energy consumption, using the year 2004 as a reference year incorporating:

- The current economic and energy tendencies, presenting what is considered to be the most probable future perspective.
- Spain's National Renewable Energy Plan 2005-2010: The plan modifies the scenario due to the effects of this new Plan.
- Spain's National Saving and Energy Efficiency Strategy (E4): Modifies the scenario with the performances foreseen in the National Strategy.
- Emissions Reduction Plan of SO2, CO2 and NOx in agreement with international commitments.
- Other sectoral plans, such as the coal mining sector plan.

At international level, the scenario takes into account forecasts developed by analysts of the main socioeconomic, European integration and energy markets evolution.

The environmental objectives, coming from national policies or international commitments, represent the most outstanding influence on the types of primary energy to be used, the transformation technologies and its final energy use and the energy efficiency evolution. The energy liberalization and market policies should be compatible with these objectives. The idea is to achieve more ambitious objectives assuming new emission limits for some pollutants.

In regards to the energy consumption and security of energy supply, the scenario increases the energy dependency on imports due to an increasing role of the international market and the reduction of national energy production that are not competitive (coal). At the same time, the scenario increases the national renewable energy. On the other hand, an important change is observed in the energy intensity evolution, changing from a continuous growth to a slow down and even to a descent on the primary intensity in the future. This forecast and the increase on renewable energy moderates the growth on energy dependency.

1.2.3.1 Energy forecast description

1.2.3.1.1 Energy prices in the international market

In accordance with the international energy scenarios stated on June 2005 by International Organizations, and in particular from the European Commission, it is expected a stable growth of the oil world demand in the forecast period. Nevertheless, according to these studies, there will be enough oil supply in the long term to maintain the average price between 37 and 43 USD/ barrel in 2004 currency value, being the most probable price around 40 USD/ barrel by the year 2011.

The price of natural gas seems that will also stay relatively stable, since the foreseen demand increase will be covered from existing reserves. In addition, technological improvements on gas exploration and production are expected. The coal prices will continue being below those of oil and gas in the forecast period.

1.2.3.1.2 Energy prices in Spain

A parity evolution of the exchange rate €/$ is assumed in the long term meaning that growth of the primary energy prices will be similar to those foreseen on international markets. On the other hand, applied taxes to the energy price and derived products will be conditioned by the harmonization of special taxes at EU level. This means that this can produce a slight rise on the energy price in some EU countries such as Spain.

1.2.3.1.3 Demography

The demographic evolution is important to estimate the future energy consumption for several reasons: In one hand, the future working population and the potential of national economic growth, as well as for their impact on public finances and on the other hand, the growth projection of new residences, household equipment and vehicles.

The last demographic statistics and forecasts indicate that a population's significant growth has taken place in the last years, fundamentally due to the immigration phenomenon. Therefore, a relevant increase in population is expected reaching by the year 2011 near 47 million inhabitants, above forecasts used up to now, having an important incidence in the future energy demand.

1.2.3.1.4 Economic evolution

A stable growth of the economy and the world trade of goods and services is expected, including an average annual growth of 1,5% up to 2007 and of 2,9% in the following years during the forecast period in the Euro zone. This growth is considered to be compatible with suitable price scenarios of the primary energy. In the context of the Spanish economy close linked to EU economic policies, increasing growth rates are expected due to the existence of greater growth margins and the integration effect in the Euro zone. It is estimated that Spain will continue to grow above the average Euro zone, with an annual growth of 3% in the forecast period. This evolution will be parallel to the internal demand, with moderate private consumption and acceleration on investments.

1.2.3.2 Consumption of final energy

This scenario projects a smaller growth of final energy consumption than the one experienced in the last years due to saving measures foreseen in the Energy Efficiency and Saving Strategy (E4). These energy savings foreseen in the E4 are subtracted from fossil energy consumption without affecting the consumption of renewable energy. The renewable energy, in accordance with the Renewable Energy Plan, 2005-2010, will experience a significant growth compared to the previous Renewable Energy Plan.

The consumption of final energy in Spain in the forecast period and the future scenario, it is expected to grow 3% annually until 2007 and 2,4% annually in the period 2007-2011, reaching 125.193 kTn of oil equivalent (Ktoe) by the year 2011. This deceleration on the consumption growth is justified, despite an increase on the projected economic growth, due to efficiency energy improvements, the E4 strategy and other factors.

In the following table, it is shown the forecast of consumption of final energy (2005-2011) in Spain.

	2005		2007		2011		%2007/2005 annual	%2011/2007 annual	%2011/2005 annual
	ktoe	%	ktoe	%	ktoe	%			
Coal	2297	2,1	2232	2	2021	1,6	-1,4	-2,4	-2,1
Oil products	62225	58,1	64105	56,4	67028	53,5	1,5	1,1	1,2
Natural Gas	17703	16,5	19850	17,5	24263	19,4	5,9	5,1	5,4
Electricity	21054	19,7	22750	20	25063	20	3,9	2,5	2,9
Renewable energy	3750	3,5	4704	4,1	6818	5,4	12,0	9,7	10,5
Total	**107029**	**100**	**113641**	**100**	**125193**	**100**	**3,0**	**2,4**	**2,6**

Methodology: A.I.E.
Source: General Bureau of Energy Planning

It is expected that coal consumption will continue to fall to an average annual rate of 2,1% since this consumption will continue to concentrate fundamentally on the industrial sectors (iron and steel industry and cement), where an increase in capacity is not expected. Additionally, in these industries the conversion to other fuels will continue.

The final consumption of oil products will continue growing to a annual rate of 1,5% up to 2007 and to 1,1% on the period 2007-2011 due to transport demand. This growth is significantly smaller compared to the total final energy. Therefore, the oil will lose weight in the consumption structure. Nevertheless, oil will continue to be more than 50% of the total final energy consumed by the year 2011. The transport fuels will register a significant substitution by biofuels. The Renewable Energy Plan 2005-2010 contemplates the promotion of biofuels consumption, with the objective of reaching 5,83% of fuel consumption on transport.

The expansion of the national gas network will increase the availability of this energy in the whole territory while taking advantage of its performance and smaller environmental impact. It is expected that the final consumption of gas will continue growing 5,9 % annually up to 2007 and to 5,1% annually between 2007-2011. This growth is well above the final energy growth, especially up to 2007, due to the industrial and domestic-commercial demand. The gas will continue gaining weight on the consumption structure of final energy reaching 19,4% by the year 2011, coming closer to the consumption of electricity.

The demand of final electric power is expected to increase 3,9% annually between 2005 and 2007 and 2,5% on the period 2007-2011. These annual growth rates are quite close to the forecast GDP in the planning period. This evolution represents the expected one in a more developed market than the current one and it is slightly above the growth rate of the total final energy. This is due to a relevant growth on the services sector demand, a significant increase in the number of homes, an increase in residences appliances and equipment, and an increase in the industrial sector capacity whose energy consumption is fundamentally electric.

In the scenario 2005-2011, it has been considered the forecast that appears in the Renewable Energy Plan 2005-2010, extended up to the 2011. This forecast considers that Renewable Energy will reach a consumption of 6.818 Ktoe by 2011. This means that the final consumption growth will be above the final energy average growth during the forecast period.

In the forecast period in Spain and other developed countries, it is observed an increase on the transport and services energy demand and a smaller growth on the industrial demand. This trend will continue. In Spain, also, the growth of the residential sector demand will continue, especially in the first period (2005-2007).

In the following table, it is shown the consumption of final energy forecast by sectors 2005-2011.

Sector	2005		2007		2011		%2007/2005	%2011/2007	%2011/2005
	ktoe	%	ktoe	%	Ktoe	%	annual	annual	annual
Industry	39172	36,6	41422	36,5	45589	36,4	2,8	2,4	2,6
Transport	38958	36,4	41592	36,6	46429	37,1	3,3	2,8	3
Diverse uses	28898	27,0	30626	27,0	33175	26,5	2,9	2	2,3
TOTAL	**107029**	**100**	**113641**	**100**	**125193**	**100**	**3,0**	**2,4**	**2,6**

Methodology: AIE
Source: General Bureau of Energy Planning

1.2.3.3 Final energy intensity forecast

It is expected a decrease on the energy intensity (consumption of final energy/ GDP) of 2% between 2005 and 2011, moving from 175,7 to 172,1 toe/ million € (1995 prices). This evolution is an important change compared to the period 1990-2005 (total increase of 11%). This change is mainly due to the implementation of the E4 Strategy (energy efficiency improvement) together with saturation effects of some energy demand at the end of the period. The final electric intensity (electricity consumption/ GDP) lowers slightly during the period 2005-2011 (0,3%), showing an important change compared to the precedent period (27,9% of growth on the period 1990-2005).

If the consumption of final energy per inhabitant ratio is analyzed, it is found an annual growth of 1,7%, quite lower than the value registered on the period 1990-2005, 2,7 % annual growth. The electric consumption per person will grow 2% annually in this period compared to the 3,7% growth between 1990 and 2005, reaching by 2011 a value of 6.216 kWh/ capita compared to 5.504 kWh/ capita in the year 2005.

In the following table, it is shown the final energy intensity in the past and forecast (1990-2011) in Spain also showing the consumption of final energy per unit of GDP and per person.

	1990	2005	2007	2011
GDP (*109 € constant prices 1995, revised 2005)	406,3	609,2	646,3	727,5
% annual average growth GDP	%2005/90 = 2,7		%2011/05 = 3,0	
Demography (Million persons)	39,9	44,5	45,4	46,9
Coal/ GDP (toe/million € 95)	10,5	3,8	3,5	2,8
Petroleum Products /GDP	100,7	102,1	92,1	92,1
Gas/ GDP	11,2	29,1	30,7	33,4
Electricity/ GDP	27,0	34,6	35,2	34,5
Renewable Energy/ GDP	8,9	6,2	7,3	9,4
Final Energy/ GDP (toe/million € 95)	158,2	175,7	175,8	172,1
INDEX (Year 1990=100)	100,0	111,0	111,1	108,8
Final Energy/ demography (toe/ person)	1,6	2,4	2,5	2,7
INDEX (Year 1990=100)	100,0	149,3	155,4	165,7
Electric Energy / person (kWh/ person)	3199,4	5504,4	5831,2	6215,9
INDEX (Year 1990=100)	100,0	172,0	182,3	194,3

Methodology: AIE
Source: General Bureau of Energy Planning

1.2.3.4 Consumption of primary energy forecast

The consumption of primary energy in Spain will grow 2% annually between 2005 and 2011, reaching a total of 164.735 Ktoe by 2011. This rate of growth is lower than the final energy (2,6%) due to better performance of

future electric generation. In regards to energy supply, there is a significant change due to an increasing importance of natural gas and renewable energy and a decrease in the use of coal, petroleum and nuclear energy. The consumption of petroleum will overall grow slightly due to in one side, its use on the transport sector and on the other, its substitution for gas on the electric generation. Nevertheless, oil will remain as the main source of energy supply.

The coal consumption will decrease as a source of electric generation, especially from 2007 and beyond. The total demand of natural gas by 2011 will be about 40.530 Ktoe. Natural gas will be the primary energy with greater growth, a 5,1% annual increase up to 2007 and of 6 % increase between 2007 and 2011, representing 24,6% of total consumption of energy by the year 2011. It is estimated a continuous growth in gas demand along the forecast period, since some other demands will decrease in the second half of the period.

The nuclear energy will stay practically constant, meaning that its weight in the total consumption of primary energy will decrease along the forecast period. Renewable energy, including the hydroelectric power, will supply by 2011 a total of 20.552 Ktoe. This figure represents 12,5% of the total energy demand by the year 2011, as projected by the Renewable Energy Plan 2005-2010 and the energy efficiency scenario.

In the following table, it is shown the consumption of primary energy forecast (2005-2011) in Spain.

	2005		**2007**		**2011**		**%2007/2005**	**%2011/2007**	**%2011/2005**
	ktoe	**%**	**ktoe**	**%**	**Ktoe**	**%**	**annual**	**annual**	**Annual**
Coal	21350	14,6	19198	12,5	13956	8,5	-5,2	-7,7	-6,8
Petroleum prod.	72476	49,6	73690	47,9	74553	45,3	0,8	0,3	0,5
Gas	29076	19,9	32147	20,9	40530	24,6	5,1	6,0	5,7
Nuclear	15001	10,3	15874	10,3	15145	9,2	2,9	-1,2	0,2
Renewable energy	8402	5,7	13036	8,5	20552	12,5	24,6	12,1	16,1
Total	**146188**	**100**	**153945**	**100**	**164735**	**100**	**2,6**	**1,7**	**2,0**

Methodology: AIE
Source: General Bureau of Energy Planning

1.2.3.5 Electric generation

The electric generation structure will register an important change in the forecast period, continuing the process of change from traditional generation (coal and nuclear energy) to the prevalence of natural gas and renewable energy. This evolution not only implies the change of primary energy but also the technology of generation, becoming the combined gas cycle, the dominant generation technology. The introduction of natural gas in Balearic and Canary Islands (displacing the current electric generation with oil products), will have positive effects on the energy efficiency, such as the reduction of specific polluting emissions. In regards to renewable energy and the planned scenario, the forecast of renewable generation developed on the Renewable Energy Plan 2005-2010 is assumed as correct. As a whole, the renewable energy generation, assuming a normal hydraulic year, will reach 30,9% of the total gross generation by the year 2011.

In the following table, it is shown the electric generation structure (% on gross production) in the past and forecast (2000-2011) on coal, nuclear, natural gas, oil products and renewable energy in Spain.

	2000	2005	2007	2011
Coal	35,9	28,0	21,2	15,0
Nuclear	27,6	19,7	19,7	17,3
Natural Gas	9,7	26,0	27,6	7,2
Petroleum	9,9	8,9	7,2	3,6
Renewables	16,9	17,4	24,3	30,9

Source: General Bureau of Energy Planning

1.2.3.6 Primary energy intensity forecast

In regards to the consumption of primary energy in Spain, an improvement of 5,6% is expected on the energy intensity (consumption of primary energy/ GDP) between 2005 and 2011, with a value of 226,4 toe/million € 95, reaching similar levels to those of 1990. This evolution is an important change compared to the registered growth in the last decade. This improvement can be explained by efficiency of new electric generation technologies, as well as the effects of the E4 strategy.

In regards to thermoelectric generation (not nuclear), the average performance in 2000 was of 41,3%, while in 2005 was 45%. In 2011 this average thermal yield will reach about 50%, in a normal hydraulic year. In regards to total electric generation and primary energy, in 2000, 202 toe/GWh were used, 185 toe/GWh were used in 2005 and in 2011, 172 toe/GWh will be used approximately.

Analyzing the consumption ratio of primary energy per capita, a growth of 1,1% annually is expected in the forecast period, although quite smaller than the 2,4% growth occurred between 1990 and 2005.

In the following table, it is shown the primary energy intensity in the past and the forecast (1990-2011) in Spain.

	1990	2005	2007	2011
GDP (*109 € constant prices 1995, revised 2005)	406,3	609,2	646,3	727,5
% annual average growth GDP	%2005/90 = 2,7		%2011/05 = 3,0	
Demography (Million persons)	39,9	44,5	45,4	46,9
Coal/ GDP (toe/million € 95)	46,7	35	29,7	19,2
Petroleum Products /GDP	117,5	119	114	102,5
Gas/ GDP	12,3	47,7	49,7	55,7
Electricity/ GDP	34,8	24,6	24,6	20,8
Renewable Energy/ GDP	14,7	13,8	20,2	28,3
Primary Energy/ GDP (toe/million € 95)	226	239,9	238,2	226,4
INDEX (Year 1990=100)	100,0	106,2	105,4	100,2
Primary Energy/ demography (toe/ person)	2,3	3,3	3,4	3,5
INDEX (Year 1990=100)	100,0	142,8	147,4	152,6

Methodology: AIE
Source: General Bureau of Energy Planning

1.3 Impacts and risks of the observed and forecast evolutions

1.3.1 Energy dependence and Energy bill, reduction in export capacities

Spain has a strategic need to maintain certain volumes of oil and oil products due to the high contribution of oil to the energy supply. It is quite clear that Spain can not guarantee its oil supply because it does not have own oil

resources. The strong energy dependence on imports of natural gas and oil products is close to 100%. The geographical situation and international connections in energy matters forces Spain to strategically store oil products to guarantee energy supply at national level and at the same time take regulatory measures to guarantee this supply.

In the following table, it is shown the evolution of external dependence on hydrocarbons (2000-2004) in Spain.

		2000	2001	2002	2003	2004
External energy dependence	**Oil**	99,7	99,5	99,6	99,6	99,7
	Natural Gas	99,0	97,1	97,5	98,9	98,7

Source: Spain´s Electricity and Gas Energy Plan 2002-2011. Energy Secretariat. Ministry of Industry.

The increase on the internal energy demand above the GDP has produced that the energy dependency was in the year 2005 about 21,1%, as indicated in the following table:

In the following table, it is shown the degree of energy self-supply in Spain*

	1980	1990	1999	2000	2001	2002	2003	2004	2005
Coal	77,6	62,3	38,6	40,3	40,3	35,1	35,2	33,1	31,3
Petroleum	3,5	1,7	0,3	0,5	0,5	0,5	0,5	0,4	0,2
Natural Gas	2	24,6	1	2,9	2,9	2,5	0,9	1,3	0,5
Nuclear	100	100	100	100	100	100	100	100	100
Hydroelectric	100	100	100	100	100	100	100	100	100
Renewable E.	100	100	100	100	100	100	100	100	100
TOTAL	**34,4**	**36,9**	**25,5**	**26,3**	**26,3**	**24,2**	**24,2**	**23,4**	**21,1**

*Relationship between GDP and total consumption of energy.
Methodology: AIE
Source: Energy Secretariat and E4 Strategy. Ministry of Industry, 2005.

1.3.1.1 Evolution of oil products sales in Spain 2000-2004

The oil market in Spain has been characterized by an increase in demand in the last years caused by a sustained economic growth. In the following table it is shown oil products sales in Spain on the period 2000-2005.

In the following table, it is shown the evolution of oil products sales in Spain (2000-2005) (Units: thousands of m3; coke - thousands of Tn).

Products	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**
Gasoline	11250	11183	10848	10706	10271	9671
Querosene	2724	2777	2615	2748	3050	3245
Diesel	28782	30699	31810	34525	36916	38487
Querosene+diesel	31506	33476	34424	37274	39966	41732
Coke	6926	6945	7875	5875	5612	5746
TOTAL	**49682**	**51604**	**53148**	**53856**	**55849**	**57151**

Source: Spain's Electricity and Gas Energy Plan 2002-2011. Energy Secretariat. Ministry of Industry.

1.3.1.2 Forecast evolution of oil products consumption in Spain 2006-2011

In accordance with the estimates of CORES (Oil Products Strategic Reserves Corporation) Strategic Plan, the following projected data of annual oil sales for the period 2006-2011 is presented:

In the following table, it is shown the forecast of oil products consumption in Spain (2006-2011) (Units: thousands of m3; coke - thousands of Tn).

Products	**2006**	**2007**	**2009**	**2011**
Gasoline	9669	9476	9147	9147
Querosene	3360	3501	3790	4099
Diesel	39115	40366	42866	45477
Subtotal	**42474**	**43867**	**46656**	**49576**
Coke	6069	5826	5398	5078
TOTAL	**58213**	**59169**	**61201**	**63801**

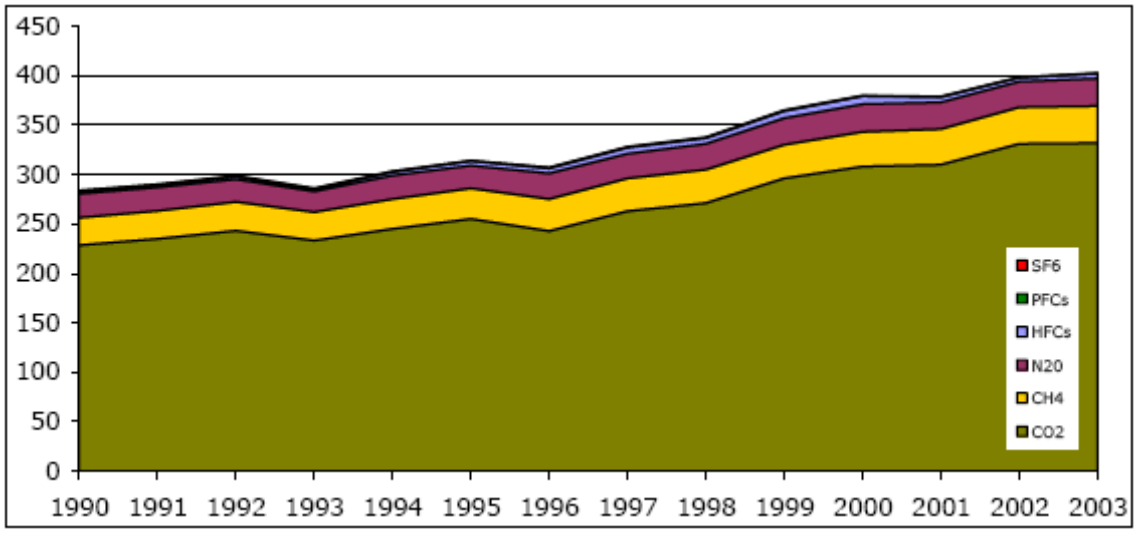
Source: Spain's Electricity and Gas Energy Plan 2002-2011. Energy Secretariat. Ministry of Industry.

1.3.2 Greenhouse gas (GHG) emissions

This section includes the historical series of Spain's GHG emissions as well as estimates of its forecast taking into account the current projected measures & policies to reduce GHG emissions, improve energy efficiency and promote renewable energy.

Spain's economic growth and population increase forecast up to 2020 can produce a significant increase in emissions even under the most probable scenario (scenario "with measures"). However, the implementation of technological measures and policies, attain an important emissions reduction if compared with the scenario "without measures". The application of additional measures to the planned ones could allow Spain to further reduce emissions and get an important increase of GHG absorption. Total emissions in the year 2003 were 402,28 Million Tn CO2 eq. in Spain.

Graph 5. GHG emission data in Spain 1990-2003. (Units: Million Tn CO2 eq.)



Source: Progress Report Spain 2006, UNFCCC

When examining the emission contribution of each pollutant, it is necessary to highlight CO2 contribution as the dominant GHG, with more than 80%. The second and third position corresponds to methane and nitrous oxide, maintaining the methane their quota on the 9%-10% range, while the nitrous oxide between 6,6% and 8,5%, with a descent of almost 2% compared to Kyoto's Protocol baseline year (1990). Fluoride gases contributes between 1,2% to 2,3%.

Spain's GHG emission forecast 2004-2020

In order to estimate future GHG emissions, the government has used the SEP (Spain's Emission Projection) model. The chosen pollutants are not only the GHG according to the Kyoto Protocol but also those pollutants included on the Geneve Convention. The forecast period goes from 2004 up to 2020. All productive sectors and generating emission activities are included in the SEP model.

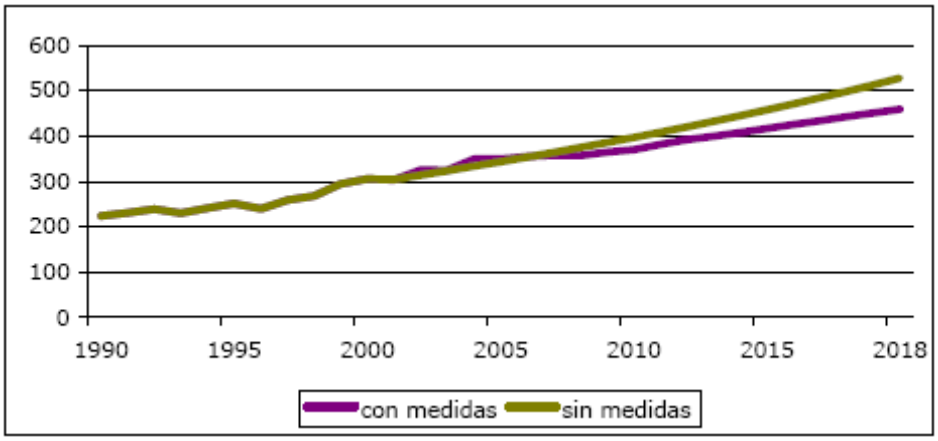
The emission forecast has two scenarios: scenario "without measures" and scenario "with measures". Scenario "without measures" seeks to reflect future emissions in case all factors and current trends are maintained without applying any measures. Scenario "with measures" seeks to reflect the most probable forecast assuming planned and approved measures, actions plans, strategies as well as legislation.

The SEP model shows for the scenario "with measures", a growth of total GHG emissions reaching 60,3% by the year 2012 and 84.8% by the year 2020 above Kyoto's Protocol baseline year (1990) - Kyoto's objective for Spain is +15% above 1990 levels by the year 2012 -. The scenario "without measures" shows a growth of total GHG emissions of 83,1% in 2012 and 131,4% increase in 2020 above Kyoto's Protocol baseline year (1990). All values have been expressed in millions of equivalent tons of CO2 (MTn CO2 Eq.).

When analyzing each pollutant, it can be observed that methane emissions decrease significantly on the period 2008-2012, to smaller values than the Kyoto objective. This evolution is quite similar for HFC, N2O and PFC emissions. On the other hand, SF6 is expected to decrease compared to the year 2000 (baseline) but on the period 2008-2012, SF6 might be 115% above 1990 emission levels.

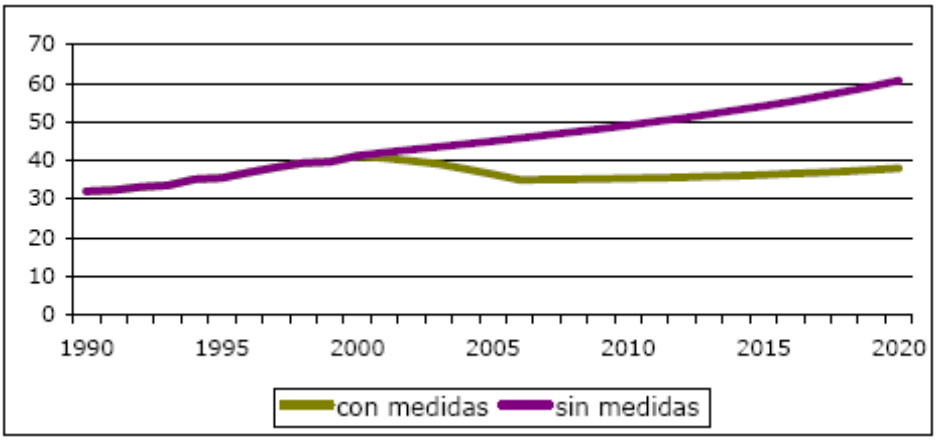
In the CO2 case, the emissions trend is clearly increasing in the analyzed period. It is necessary to highlight the prospects of economic growth and population increase as critical factors that explained this expected CO2 emissions evolution in Spain.

Graph 6. CO2 emissions and forecast emissions (without -- and with -- measures) (Million Tn)



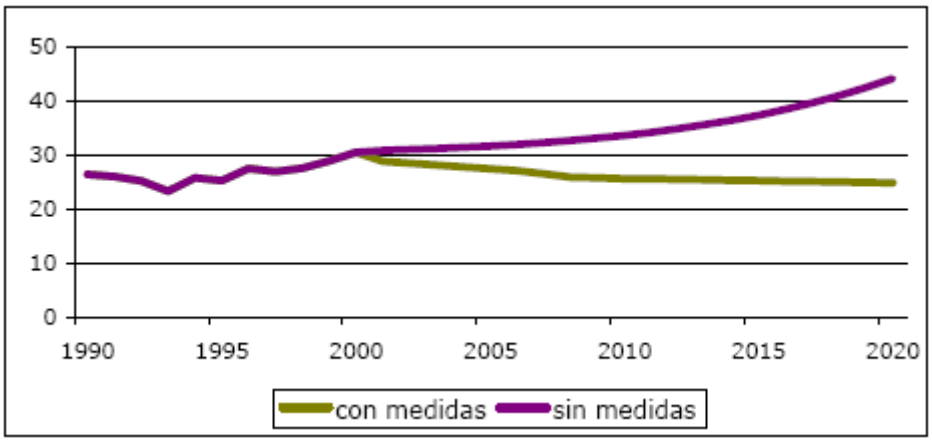
Source: Kyoto Progress Report Spain 2006, UNFCCC

Graph 7. CH4 emissions and forecast emissions (with -- and without -- measures) (MTn CO2 Eq.)



Source: Kyoto Progress Report Spain 2006, UNFCCC

Graph 8. N2O emissions and forecast emissions (with -- and without -- measures) (MTn CO2 Eq.)



Source: Kyoto Progress Report Spain 2006, UNFCCC

Last update

On **February 13th, 2007**, a draft version of the **Spanish Climatic Change and Clean Energy Strategy 2012** was presented by the government to be subjected to public consultation and revision by the National Climate Commission and other governmental bodies. A small introduction and a summary of the contents of this strategy is presented below:

In the year 2004, total GHG emissions reached in Spain 427,9 Million tons of CO2-equivalent. This quantity represents a 48 % increase compared to emissions baseline year (1990), almost 33 points above the Kyoto Protocol commitment. In addition, it is worth to mention that the year 2005 was characterized by scarce water resources and therefore, an abnormally low renewable hydroelectric production, a low contribution of nuclear generation and a high price of natural gas. Given the weight of the generation sector regarding emissions in Spain, the circumstances of the year 2005 favored the growth of total emissions.

Therefore, emissions evolution shows the difficulties that Spain is encountering to conjugate the economic convergence with the European Union while limiting GHG emissions. This Strategy seeks to attain the following objectives simultaneously:

- Attain Spain's international commitment ratified by the Kyoto Protocol;
- Preserve the Spanish economy competitiveness and employment;
- Maintain economic and budgetary stability; and
- Secure energy supply.

The National GHG Emissions Assignment Plan (PNA) 2008-2012, approved by the Real Ordinance 1370/2006, establishes the execution plan by the Government to attain Kyoto's objectives.

This PNA has relevant changes compared to the previous National Assignment Plan 2005-2007. In the PNA 2005-2007, it was established an emissions stabilization objective of +40% by 2007. Analyzing current Spanish emissions evolution, it is quite necessary to revise again Spanish plans.

Despite this negative trend, according to emission projections carried out by the Madrid Polytechnic University, with the already adopted measures, the average emissions increase on the period 2008-2012 will be about +50 % (without these measures the increment would overcome +70 %).

Taking a look at this data, the Spanish government has established the emissions growth objective for the period 2008-2012 up to 37% above the baseline year (1990). This level is 22% above the Kyoto objective (+15%). In order to attain this objective, it is planned a 2% reduction obtained from carbon sinks and the rest (20%) by means of Kyoto flexibility mechanisms (acquisition of carbon credits).

As a result of this situation, the central government and all remaining governmental bodies should identify and set up additional emission reduction measures, take measures for carbon absorption from forests, study potential geologic CO2 storage and its legal framework and plan for acquiring necessary carbon credits. The objective of this Strategy is in fact to provide a framework to develop public policies to meet those goals promoting active participation from the central government and all remaining governmental bodies and other stakeholders.

Also, given the necessary and important actions to be implemented by Spain related to the Protocol Flexible Mechanisms, this strategy shows necessary measures to assure its viability, optimizing the potential of these mechanisms as international cooperation tools, promote sustainable development in host countries and support international activity of Spanish companies.

1.4 Financing and investment needs

On September 2002, the Spanish government approved the National Electricity and Gas Plan 2002-2011. This Plan seeks to further develop the natural gas and electric systems for the horizon 2002-2011. Nevertheless, the time lapsed showed significant differences between demand growth forecasts and current situation making necessary to revise and upgrade the Plan, this time with a horizon of 2005-2011 while maintaining the same criteria as the previous document.

In the following table the cost estimate for the electric system (as December 2004) for the period 2005-2011 is presented.

In the following table, it is shown the total cost of electric infrastructure (2005-2011) in Spain.

	Electric Network Cost (million €)	**Electric substations cost (million €)**	**Total Cost (million €)**
Total	1897,41	1943,74	3841,15

Source: National gas and electric planning revision 2005-2011. Ministry of Industry.

In the following table, it is shown the annual investment for natural gas during the period 2005-2011.

In the following table, it is shown the total annual investments on gas infrastructure (2005-2011) in Spain.

	Total natural gas infrastructure investment (million €)							
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Total 2005-2011**
Gas pipelines	176	288	484	505	323	168	41	1984
Gasification plants	328	331	395	455	368	289	143	2309
Gas compression stations	57	56	88	123	104	9	-	438
Underground storage	2	41	332	419	224	70	83	1171
Total	**563**	**716**	**1300**	**1503**	**1018**	**536**	**267**	**5902**

Source: National gas and electric planning revision 2005-2011. Ministry of Industry.

The financing needs with regard to RUE and RE will be presented in the following sections of this document.

2 RATIONAL USE OF ENERGY (RUE) - RENEWABLE ENERGIES (RE): POLICIES, TOOLS, PROGRESS, RESULTING EFFECTS, CASE STUDIES

=> **Objective**: to analyze the evolution of the in-country RUE and RE since 1980, the policies, the tools, their existing methods of development, difficulties encountered, efficient leverage and the resulting effects in terms of the country's development (economic, social and environmental).

2.1 RUE and RE Policies

The world energy consumption will increase in the first two decades of the present century about 50% - between 44% and 56%, in accordance with the recent forecasts developed by the main international institutions. The fossil fuels will continue dominating the energy system with a contribution of 85% and therefore, a decrease on world reserves and an increase on global emissions.

The European Union is currently increasing its energy consumption, imports of energy products and therefore its external energy dependence. At the same time, the EU is observing that current tendencies lead to a remarkable growth of that import dependence.

In Spain, during the last 25 years the energy consumption has duplicated – moving from 68 million toe in 1978 to more than 136 million in 2003, and more than 141 million toe in 2004 -. Also, although the country presents a smaller energy consumption per capita than the average in the European Union, Spain has experienced during the last years, a notorious energy intensity growth in terms of final and primary energy.

Likewise, the energy dependence of Spain – greater than 75% in the last years -, greater than the European Union and most of the western countries, constitutes a structural deficiency. This dependence is also a source of commercial deficit and a factor of great uncertainty, keeping in mind the geopolitical distribution of oil and gas reserves.

Based on the EU Renewable Energy White Book, published in 1997 with the objective of achieving a 12% of the total demand of energy coming from renewable sources by 2010, the Spanish National Law of the Electric Sector proposed the same objective. In accordance to that commitment, at the end of 1999, the Spanish government approved the Renewable Energy Plan 2000-2010.

As a result renewable sources evolution since the approval of that Plan, the growth on energy consumption – more than expected by the Plan - and the later forecasts developed, the Plan was revised producing the development of the Renewable Energy Plan 2004-2010 that increases significantly renewable energy objectives in order to guarantee the global contribution of renewable energy to 12% by 2010.

The EU Directive 2003/30/EC on biofuels development sets the establishment of national objectives of biofuels and other renewable fuels use to 2% by 2005 and 5,75% on transport use by 2010. This Directive has been transposed to the Spanish legislation (Real Ordinance 1700/ 2003), by which specifications on gasoline, diesel, coke fuel, oil liquefied gases and biofuels are set.

2.1.1. Rational use of energy (RUE) policies

The Energy Saving and Energy Efficiency Strategy in Spain 2004-2012 (E4) was approved on November 2003 and includes a series of renewable energy and energy efficiency measures that are and will be implemented in that period in Spain.

The Spanish government has also elaborated an Action Plan during the period 2005-2007. This action plan tries to solve the lack of concreteness of the Strategy by inventorying and exposing actions and measures to be taken for each economic sector, detailing objectives, deadlines, resources and responsibilities, and at the same time evaluating and monitoring the impacts of these measures.

The opportunity of implementing energy efficiency measures and a specific Action Plan is fully justified considering, among other, the following current conditions:

- High external energy dependence, 80% for Spain and about 50 % on average in the EU, which generates inflationary risks and macroeconomic imbalances especially in the current and future oil price rise scenario.

- High annual rates of growth in the energy demand (above GDP growth), producing a growth on energy intensity contrary to the existent decreasing tendency in the EU.

- Need to have a tool to plan energy demand that complements the electricity and gas supply planning.

- Difficulty to attain the national objective of 12% of total consumption coming from renewable energy, in absence of measures holding the strong growth on energy consumption.

- Since the energy is responsible for 78% of greenhouse total emissions, there is an urgent need to adopt active measures to promote energy efficiency and attain CO2 emission reduction objectives planned at the National Plan of Emission Right Assignment 2005-2007 (PNA).

It is estimated that the present Action Plan 2005-2007 will generate a primary energy saving of 12 million equivalent tons of petroleum and a reduction of CO2 emissions of 32,5 million tons.

Energy efficiency objectives by sectors

The Action Plan 2005-2007 implements the objectives of the Energy Saving and Efficiency Strategy in Spain 2004-2012 (E4). The primary energy saving potential identified by the Strategy is about 15.574 ktoe/ year by the year 2012 as a result of implementation of planned actions. The following Table 18 shows potentials savings by sectors, excluding potential primary energy savings coming from less demand of final energy consumption (savings on electric power generation and refineries).

In the following table, it is shown the E4 Strategy, in particular the summary of sectoral objectives.

	Energy Consumption 2000 (ktoe)	**Base Scenario 2012 (ktoe)**	**Base scenario Growth 2012/2000 (% annual increase)**	**Efficiency scenario 2012**	**Energy Saving Potential (ktoe)**	**Efficiency scenario growth 2012/2000**
Industry	34.340	48.840	3,0%	46.489	2.351	2,6%
Transport	32.272	52.805	4,2%	48.016	4.789	3,4%
Construction	14.491	23.584	4,1%	21.811	1.773	3,5%
Public Services	591	808	2,6%	654	154	0,8%
Residential & Offices	3.462	4.687	2,6%	4.278	409	1,8%
Agriculture	4.089	4.920	1,6%	4.572	348	0,9%
Energy Generation	125.175	180.673	3,1%	162.866	1.494	2,2%
TOTAL	**214.420**	**316.317**	**3,3%**	**288.686**	**11.318**	**2,5%**

Source: Energy Saving and Efficiency Strategy in Spain 2004-2012 (E4).

Note: The saving potential corresponding to the sector of energy transformation is related to technology measures. Therefore, it is not accounted the energy saving coming from smaller energy demand of final use sectors.

The greatest saving potential is shown on the transport sector with a 42% of the total saving potential. The industrial and construction sector are also quite relevant in terms of saving potential. The Action Plan 2005 - 2007 centers its efforts in the previously identified sectors, so that the greatest saving volume foreseen on the Action Plan is also expected in the transport sector. Taking a look at the annual savings forecast by the Plan, 3.156 ktoe out of the total 7.179 ktoe corresponds to this sector (44% of the total).

2.1.2. Renewable energy (RE) development policies

Spain has maintained for 30 years a notorious growth of energy intensity. Spain's growing and excessive external energy dependence (around 80% in the last years) - and the need to preserve the environment, has forced the development of effective measures for an efficient energy use and the use of clean sources. Therefore, the substantial growth of the renewable sources, in addition to an important improvement of the energy efficiency, responds to economic, social and environmental reasons and a clear strategy.

The Renewable Energy Plan (PER) 2005-2010 constitutes a revision of the Renewable Energy Plan in Spain 2000-2010. With this revision, the national commitment of at least 12% of total energy consumption coming from renewable energy sources by 2010 is maintained as well as meeting other objectives such as 29,4% of electric generation from renewables and 5,75 % of biofuels use on the transport sector.

The Renewable Energy Plan 2005-2010 uses as baseline year 2004. The following table shows real production data of renewable energy in 2004, as well as the consumption of primary energy.

In the following table, it is shown the Renewable Energy Plan 2005-2010 and the synthesis of Energy and Renewable Energy Scenarios.

	Energy production in terms of Primary Energy (ktoe)			
	2004	**2010**		
		Renewable Energy Scenarios		
		Current	**Probable**	**Optimistic**
TOTAL ELECTRIC AREAS	5.973	7.846	13.574	17.816
TOTAL THERMAL AREAS	3.538	3.676	4.445	5.502
TOTAL BIOFUELS	228	528	2.200	2.528
TOTAL RENEWABLE ENERGY	9.739	12.050	20.220	25.846
Energy Scenario: Trend-Tendency				
Primary Energy Consumption (ktoe)	141.567	166.900	167.100	167.350
Renewable Energy / Primary Energy (%)	6,9%	7,2%	12,1%	15,4%
Energy Scenario: Efficiency				
Primary Energy Consumption (ktoe)	141.567	159.807	160.007	100.257
Renewable Energy / Primary Energy (%)	6.9%	7,5%	12.6%	16,1%

Source: Renewable Energy Plan 2005-2010

According to expected trend (tendency) energy scenario, the renewable energy under a probable scenario reaches 12,1%. In case of a smaller technological development (current scenario), the production stays well below the plan commitment reaching 7,2% while the optimistic scenario surpass the plan by attaining 15,4%.

In regards to the Plan objective of electricity generation coming from renewable energy (29,4% by the year 2010), in the probable scenario, the objective is reached, attaining 30,3% of gross electricity consumption by the year 2010.

In regards to biofuels consumption forecast, the probable scenario set in the RE Plan -2,2 million toe by 2010 -, it would represent 5,83% of the total gasoline and diesel consumption for transport by 2010, slightly above the EU Directive objective on biofuels set on 5,75% in 2010.

2.1.2.1 Objectives by sectors and by type of energy

An exhaustive analysis (on the Renewable Energy Plan 2005-2010) was carried out by the Spanish government based on possible energy scenarios and their adaptation to the existent commitments, mainly as regards to covering primary consumption (12%) and electric production (29,4%) coming from renewable sources by 2010, biofuels consumption (5,75 % by 2010) and associated environmental impacts (emissions of CO2 avoided up to 2010, mainly).

Wind energy

Wind energy is the area that has experienced greater developments in Spain as a result of important private sector initiatives, a market with excellent prospects in the next future. The wind sector has registered an important growth in the last years of more than 1.600 MW annually.

Due to these reasons, the Plan objectives related to wind energy seeks for an increment of 12.000 MW in the period 2005-2010, summing up by 2010 an installed total power of 20.155 MW. The plan proposes a series of measures to attain this objective.

We should notice the remarkable positive effects of new wind power installations promoted by the Real Ordinance 436 / 2004, of March 12, relative to the electricity production special regime.

The following table shows the total increase including the Spanish autonomous communities or regions contribution:

	Situation 2004 (MW)	**Planned increase on 2005-2010 (MW)**	**Total Power 2010 (MW)**
TOTAL YEAR 2010	8.155 MW	12.000 MW	20.155 MW

Source*: IDAE*

Hydroelectric Energy

The hydroelectric energy constitutes one of Spain's main sources of electricity, with a long history and tradition that has allowed conforming a technologically mature and consolidated sector with relevant resources available. During decades, the hydroelectric energy has increased its capacity although the global contribution as electric power is diminishing. At the moment, the hydroelectric energy faces important administrative barriers to its further development and advances more slowly as foreseen.

The global objectives of the E4 Plan proposed in terms of increment of installed power during the period 2005-2010 are as follows:

	Power increase (MW)
Mini-hydroelectric (less than 10 MW)	450
Hydroelectric between 10 & 50 MW	360

Source: Renewable Energy Plan 2005-2010

Solar Thermal Energy

The sun is a source of abundant energy that it is called to play a much greater role in Spain than at the present moment. During the last years, the thermal solar energy has registered a low growth in contrast with the Spanish government objectives. However, with the approval of the Construction Technical Code, the thermal solar energy might experience an important future development in Spain. Additionally, the favorable solar conditions in the country and the prospects on developing solar thermal energy in new housings are in favor of this potential growth.

One of the general objectives of above mentioned Plan is to increase the solar thermal surface by 4.200.000 m2 in the period 2005-2010. The installed solar thermal surface by the year 2004 was 700.433 m2.

The Autonomous Spanish Communities have also elaborated specific plans for renewable energies. These plans, for thermal solar energy, have different temporal horizons, although most of them refer to the year 2010 as the period of their specific plans.

The foreseen annual evolution of new installed panels in the period 2005-2010 is as follows:

	2005 (m2)	**2006 (m2)**	**2007 (m2)**	**2008 (m2)**	**2009 (m2)**	**2010 (m2)**	**TOTAL 2005-2010 (m2)**
Pre-assembled panel installation	33.000	41.000	101.000	185.000	215.000	265.000	840.000
Installation by modules	115.000	170.000	430.000	815.000	880.000	950.000	3.360.000
TOTAL	**148.000**	**211.000**	**531.000**	**1.000.000**	**1.095.000**	**1.215.000**	**4.200.000**

Source: Renewable Energy Plan 2005-2010

This growth on installed surface is predicted based on implementing specific measures and proposals to eliminate the existent barriers in the thermal sector. The measures are exposed in other sections of this document.

For these increments of installed surface, the total energy produced by year is shown in the following table. This summary is based on the type of installation. The resulting energy production is based on the predicted installed surface from 2005 until 2010.

	2005 (toe)	**2006 (toe)**	**2007 (toe)**	**2008 (toe)**	**2009 (toe)**	**2010 (toe)**	**TOTAL 2005-2010 (toe)**
Pre-assembled panel installation	2.551	5.720	13.528	27.828	44.448	64.932	159.006
Installation by modules	8.890	22.031	55.270	118.269	186.293	259.728	650.480
TOTAL	11.441	27.751	68.798	146.097	230.741	324.660	809.486

Source: Renewable Energy Plan 2005-2010

Thermoelectric Solar Energy

The thermoelectric solar energy contains a group of differentiated technologies that are characterized by applying a solar concentration with the purpose of reaching high temperatures that allow electric generation. Their application can end up in the future constituting a competitive energy generation, with the advantage of being renewable and the associated environmental benefits. The thermoelectric solar energy is a technology that at the moment in Spain is at an initial stage of development for commercial development. The positive factor is that Spain has very favorable solar conditions with important technological projects and research development. It is also necessary to highlight the financial support from the government and the interest from companies on the technological development and promotion of projects. There are prospects and several initiatives exist from the public and the private sector to increase installed capacity up to 500 MW.

The reasons for this projection are as follows:

- Existence of favorable solar resources in Spain.
- Existence of knowledge and previous experiences that configure Spain as a leader in these technologies.
- High interest of private sector promoters to carry out commercial projects and technological research.

On the other hand, the Royal Decree 436/2004 and other legislation have stimulated the development of new projects. At the moment, there are energy projects, some implemented, some under study, for a total energy power of about 500 MW. With the attainment of these objectives and the industrial development, Spain plans to become a world leader in this technology, research, investigation and development of commercial projects.

The foreseen annual evolution of new energy power to be installed on the period 2005-2010 is as follows:

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTAL 2005-2010**
Annual Power (MW)	-	10	40	150	150	150	500

Source: Renewable Energy Plan 2005-2010

The planned growth of the thermoelectric power in the period 2005-2010 will be only possible if the government takes the necessary legislative steps and changes to eliminate the limitation to 200 MW in order to obtain the financial support considered in the Royal Decree above mentioned.

The following table reflects the annual energy results predicted and produced by thermoelectric plants:

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**TOTAL 2005-2010**
Annual Production (MWh)	0	25.960	129.800	519.200	908.600	1.298.000	2.881.560

Source: Renewable Energy Plan 2005-2010

As it can be observed, the foreseen objective of 500 MW will produce 1.298 GWh by the year 2010 and a total of 2.882 GWh in the period 2005-2010.

Photovoltaic Energy

The electric power production coming from photovoltaic panels presents great industrial, environmental, social and other type of advantages, etc. Among them, the installation of photovoltaic solar energy as wide as possible will contribute to improve future technological developments with the objective of competing with other types of electric generation. In the last years, the development of photovoltaic energy has been smaller as expected by the government and below plans. However, it is expected a strong growth in a near future.

The development of the photovoltaic energy has different barriers such as economic which limit its development. There are several reasons that can surpass these barriers and launch the development of this technology. These reasons were already presented on the previous section on thermoelectric energy. Also, the new legislation of the R.D. 436/ 2004 represents an important improvement on the potential development of this technology.

This Plan sets a new objective of photovoltaic power increase to 363 MWp on the period 2005-2010, assuming that planned measures will be implemented. The installed photovoltaic power was in 2004 of 34 MW. The Autonomous Communities have also elaborated specific energy plans for the renewable energy.

The foreseen annual evolution of this energy to be installed on the period 2005-2010 is as follows:

Year	2005 (MW)	2006 (MW)	2007 (MW)	2008 (MW)	2009 (MW)	2010 (MW)	TOTAL 2005-2010 (MW)
Isolated	1	1,5	2	2,5	3,5	4,5	**15**
P<100 KW fixed	13	19	32	47	47	47	**205**
P<100 KW with sun search	5	6	11	17	28	45	**112**
P>100 KW fixed	-	-	1	5	10	15	**31**
TOTAL	**19**	**26,5**	**46**	**71,5**	**88,5**	**111,5**	**363**

Source: Renewable Energy Plan 2005-2010.

The forecast of produced energy by this technology on the period 2005-2010 is shown, by type of installation, in the following table:

Year	Annual Ratio (kWh/kW)	2005 (MW)	2006 (MWh)	2007 (MWh)	2008 (MWh)	2009 (MWh)	2010 (MWh)	TOTAL 2005-2010 (MWh)
Isolated	1.000	1.000	2.500	4.500	7.000	105.000	15.000	40.500
P<100 KW fixed	1.250	16.250	40.000	80.000	138.750	197.500	256.250	728.750
P<100 KW with sun search	1.644	8.222	18.089	36.179	64.135	110.180	184.182	420.987
P>100 KW fixed	3.142	0	0	3.142	18.852	50.272	97.402	169.668
TOTAL		**25.472**	**60.589**	**123.821**	**228.737**	**368.452**	**552.834**	**1.359.905**

Source: Renewable Energy Plan 2005-2010.

Biomass

The heterogeneity is the fundamental characteristic of the biomass energy, having many different types of materials that can be employed as fuels for many different uses. This resource characteristic makes difficult to approach and analyze this area from one perspective only, because there are many combinations, types of biomass and technologies for energy use.

In the last years, the biomass has experienced sensibly smaller evolution as planned by Spain and its planning documents. Important barriers persist in Spain, and the Renewable Energy Plan 2005-2010 seeks to surpass these barriers.

Regarding the biomass electric generation, the growth objective on the period 2005-2010 is 1.695 MW. The biomass electric generation by the year 2004 in Spain was 344 MW. This development is based on three measures:

- The start up of a co-combustion program, to implement combined combustion of biomass and coal in 19 existent power plants in Spain, having to modify the Law 54/1997 of the Electric Sector.

- A sensitive increment of fiscal retribution to electric generation coming from biomass.

- The already existent Biomass Commission whose operation is expected to "energize" the biomass sector.

In regards to the thermal biomass, the increment objective by 2010 ascends to 582,5 ktoe. To meet this goal, one of the planned measures is to improve the biomass supply logistics with a new and free financial support to investment projects.

The following table presents the biomass growth objectives (primary energy) according to the Renewable Energy Plan 2005-2010 for each fuel and application.

	OBJETIVES (toe)
Resources	
Forest waste	462.000
Agriculture Waste (wood)	670.000
Agriculture Waste (herbaceous)	660.000
Forest Companies Waste	670.000
Agriculture companies Waste	670.000
Energetic Crops	1.900.300
Applications	
Thermal Applications	582.514
Electric Application	4.457.786
TOTAL	
Primary Energy	5.040.300

Source: Renewable Energy Plan 2005-2010.

The following table shows the biomass growth objectives (in terms of electric power) according to the Renewable Energy Plan 2005-2010.

PER 2005-2010: objectives (MW)	
Micro-production	
Per resource type	
Forest waste	60
Agriculture waste (wood)	100
Agriculture waste (herbaceous)	100
Forest companies waste	100
Agriculture waste companies	100
Energetic Crops	513
TOTAL Micro-production (MW)	**973**
Co-combustion (MW)	
Total co-combustion (MW)	722
Total electric generation with biomass	
TOTAL (MW)	**1.695**

Source: Renewable Energy Plan 2005-2010.

The foreseen annual evolution on biomass electric generation on the period 2005-2010 is the following:

Year	2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
Annual Biomass Electric Power (MW)	10	40	95	210	285	333	973
Annual Co-Combustion Power (MW)	0	50	125	125	200	222	722

Source: Renewable Energy Plan 2005-2010.

As a consequence of the Plan, the biomass electric power will be of 1.695 MW by 2010 and 11.822,6 GWh of electric production.

Finally, regarding the biomass thermal uses, the annual increment planned on the period 2005-2010 is the following:

Year	2005	2006	2007	2008	2009	2010	TOTAL 2005-2010
Domestic Biomass Use: Thermal capacity (toe/year)	69,8	348,8	1011,4	2476,1	4464,0	6.786,7	15.156,7
Industrial Biomass Use: Thermal capacity (toe/year)	0	348,8	1.220,6	2.092,5	3.487,5	5.036	12.185,3

Source: Renewable Energy Plan 2005-2010.

This growth in the biomass area is conditioned by the development of a biomass market to supply domestic users as well as the development of specific legislation that regulates this biomass introduction, fuels, facilities, etc.

Biogas

The potential energy use of biogas has its starting point with four types of biodegradable wastes: ranching waste, Waste Water Treatment Plants (WWTP) waste, industrial effluents and the organic fraction of urban solid waste. Although the planned objectives were quite modest, in the last years their growth has been quite superior to the initially expected. In accordance with the registered evolution and the Renewable Energy Plan 2005-2010, the planned objective of power installed is 94 MW, with an electricity production by 2010 of 592 GWh and in terms of primary energy, an additional 188 ktoe.

Biofuels

The good prospects of biofuels from the beginnings of this decade, the favorable fiscal reform taken place in Spain, the existence of an industrial sector in expansion, and the approval of the EU Directive 2003/30 - already transposed to the Spanish legislation - are good reasons to expect a very positive evolution of biofuels in Spain. The National Plan 2005-2010 has the objective of supplying by 2010, 5,75% of fuels quota for transport with biofuels and other renewable fuels. This trend and new legislation has required the definition in the Plan of more ambitious objectives, assuming those defined in the mentioned Directive, moving to an energy objective by 2010 of 2,2 million toe.

The following table shows the sector situation in 2004, the objectives for 2010 of the previous Renewable Plan and the objectives of the new Renewable Energy Plan 2005-2010.

Situation 2004 (toe)	Objectives Previous plan (toe)	Objectives Plan 2005-2010 (toe)
228.200	500.000	2.200.000

Source: Renewable Energy Plan 2005-2010.

The following table shows the energy objectives proposed for each biofuel and resource application (primary energy) during the period 2005.2010.

Energy objectives 2005-10 (toe)	
Resources	
Biomass and Cereals	550.000
Wine Alcohol	200.000
Pure Vegetable Oil	1.021.800
Used Vegetable oil	200.000
Applications	
Bioethanol	750.000
Biodiesel	1.221.800
TOTAL	
Primary Energy (toe)	1.971.800

Source: Renewable Energy Plan 2005-2010.

2.1.2.2 Measures for monitoring RE and RUE Policies

The monitoring and control is a necessity for any plan to be implemented. In the case of the Energy Saving and Efficiency Plan and the Renewable Energy Plan 2005-2010, both promoted by the Spanish government, its important objectives and energy policies must be accurately monitor in harmony with EU energy policies and objectives and acquired international environmental commitments and treaties.

The main objective of monitoring the Plan is the systematic and periodic evaluation of different energy efficiency and renewable areas, in accordance with the established objectives, as well as the analysis of the barriers that persist. Also, it is important to formulate proposals that allow overcoming them. The idea is on one side, to evaluate the evolution of objectives from a quantitative point of view and, on the other, analyze the qualitative evolution of each one of the areas. The energy, environmental, technological, industrial, socioeconomic aspects are taken into consideration as well as those that, on the short or long term, can hinder objectives attainment.

The different plans use different information sources from different institutions, companies, manufacturers, associations of companies, etc. Special relevance deserves the information coming from the Autonomous Communities, the Energy National Commission, the Ministry of Industry, Trade and Tourism, the Ministry of Economy and Finance, the Ministry of Agriculture, the Ministry of Environment, as well as IDAE.

The Renewable Energy Plan 2005-2010 has an Office of the Plan, managed by the IDAE, whose President is the General Secretary of Energy of the Ministry of Industry, Tourism and Commerce.

In order to monitor the plan, the working group meets twice a year (first and last trimester) participating the Energy General Secretariat, the IDAE and other Ministerial Departments that are collaborating on the different plans, as well as the Autonomous Regions.

2.2 Instruments and measures to be taken in favour of RUE and RE

2.2.1 Tools and measures in favor of rational use of energy (RUE)

The Action Plan 2005-2007 proposes many different measures by sectors. These measures are the following:

Industrial Sector

The Action Plan 2005-2007 in the industrial sector proposes the following measures:

1. Voluntary agreements. The Action Plan proposes voluntary agreements between private sector associations and the government in the attainment of energy objectives.

2. Energy audits. This measure includes co-financing by the government of energy audits providing 75% of the total cost and up to 276 audits carried out in high-priority facilities including the chemical, steel and iron industry, food and drinks, tobacco and non-metallic minerals.

3. Programs of public aid. The Plan seeks to define financial support lines to finance energy saving and energy efficiency projects in the industrial sector.

The following table shows a summary of planned governmental investments, public support, energy savings and CO2 emissions avoided as a result of the implemented measures.

MEASURES	Investment (Thousands €)	Public Aid (Thousand €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005-2007	2007	2005-2007
1. Voluntary agreements	0	0				
2. Energy audits	4.029	3.022				
3. Public aid support	485.150	108.190	673	1.014	1.620	2.442
TOTAL INDUSTRY	**489.179**	**111.212**	**673**	**1.014**	**1.620**	**2.442**

Source: Renewable Energy Plan 2005-2010.

Transport sector

The Action Plan 2005-2007 includes 15 measures in the Sector contained under three themes: modal change, more efficient use of transport and improvement of vehicles energy efficiency. The Plan predicts also, an important potential of CO2 emissions reductions due to a fast penetration of biofuels on the land transport sector (3,8 Million tons of CO2 avoided in the period 2005-2007).

The following table shows a summary on investments, public support, energy savings and avoided CO2 emissions as a result of measures on the transport sector.

Action Plan 2005-2007. Transport planned measures

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktnCO2)	
			2007	2005-2007	2007	2005-2007
1.- Urban mobility plans	807.326	52.326	307	589	856	1.640
2.- Enterprises transport plans	147.000	17.000	150	300	419	835
3.- Greater contribution of land transport	3.500	3.500	36	62	101	172
4.- Greater contribution of train	6.600	6.600	488	710	1.358	1.976
5.- Greater contribution of maritime transport	1.800	1.800	45	80	129	230
6.- Transport infrastructure management	3.400	3.400	904	1.262	2.517	3.512
7.- Management of land transport routes	8.600	8.600	134	288	387	829
8.- Air fleets management	3.300	3.300	52	90	58	100
9.- Efficient vehicle driving	5.800	5.800	224	411	624	1.144

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktnCO2)	
			2007	2005-2007	2007	2005-2007
10.- Efficient buses and trucks driving	2.700	2.700	224	502	645	1.443
11. – Efficient flight of air fleets	1.600	1.600	43	75	47	83
12.- Renew land transport fleets	11.200	11.200	192	384	553	1.105
13.- Renew of air fleets	300	300	18	31	20	34
14.- Renew marine fleets	200	200	13	19	38	58
15. – Renew private vehicles	9.820	9.820	324	475	903	1.322
TOTAL TRANSPORT	**1.013.146**	**128.146**	**3.156**	**5.277**	**8.655**	**14.483**

Source: Renewable Energy Plan 2005-2010.

The responsibility in the execution of planned measures corresponds, mainly, to the Ministries of Development, Ministry of Industry, Tourism and Trade, Ministry of Economy, Ministry of Interior and having a smaller role, the Ministry of Environment and the Ministry of Health and Consumption. The Autonomous Regions and local entities participate through collaboration agreements with the central government.

Construction sector

The construction sector includes buildings (the thermal facilities (heating, air conditioning and production of sanitary hot water) and the lighting facilities). The analysis of the sector includes energy consumption coming from buildings (domestic and services – tertiary - sectors). The office equipment and appliances are not included because they belong to the residential and office equipment sector.

The legal measures taken in the construction sector have as basis the Directive 2002/91/EC of energy performance of buildings. The EU Directive has been transposed to the Spanish legislation through the Royal Decree 314/ 2006 of approval of buildings technical code, which establishes the obligation of implementing energy efficiency requirements for new buildings and for existent ones subject to rehabilitation works. Additionally, it seeks the energy certification of buildings and the periodic inspection of boilers and air conditioning systems.

The Plan distinguishes between measures devoted to new buildings and existent ones. For each type plans to create specific financial support from the government for insulation building renovation, renovation of building thermal facilities and lighting upgrades in the domestic and services (tertiary) sectors.

The following table shows a summary of investments, public support, energy savings and CO2 avoided emissions by planned measures in the construction sector.

Action Plan 2005-2007. Construction Sector

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005-2007	2007	2005-2007
1. Insulation building renewal	1.116.774	73.060	127	199	348	544
2. Improvement of buildings energy efficiency	1.553.411	101.625	224	350	585	913
3. Improvement of existing building lighting	624.804	40.875	491	765	1.328	2.069
4. Normative measures to transposed the EU Directive 2002/91/EC	1.542	861	191	191	463	463
TOTAL BUILDINGS	**3.296.531**	**216.421**	**1.033**	**1.505**	**2.724**	**3.989**

Source: Renewable Energy Plan 2005-2010.

The responsibility in the execution of the previous measures corresponds to all governmental bodies, from the Central government (through the Ministry of the Housing and the IDAE) to the Autonomous Communities and Local Administrations.

Public services sector

The measures proposed by the Action Plan 2005-2007 (and for the E4 Plan) considers energy consumption from public lighting - highways, streets and ornamental lighting - and water supply, water purification and wastewater treatment plants.

The Plan proposes a series of actions including:

- Development of specific legislation on public lighting and public infrastructure.
- Development of economic instruments and financing.
- Development of good public communication and outreach instruments.

The following table shows a summary of investments, public support, energy savings and CO2 avoided emissions of different measures in the public services sector.

Action Plan 2005-2007. Public Services Sector Measures

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005-2007	2007	2005-2007
1.Improvement of the current outdoor public lighting energy efficiency	231.456	15.142	63	110	171	296
2. Improvement of the new outdoor public lighting energy efficiency	14.751	965	6	10	15	26
3. Improvement of the energy efficiency of current water supply, water purification and wastewater treatment plants.	73.020	4.777	22	39	60	105
4. Improvement of the energy efficiency of new water supply, water purification and wastewater treatment plants.	54.967	3.596	19	32	50	87
TOTAL PUBLIC SERVICES	**374.194**	**24.480**	**110**	**191**	**297**	**515**

Source: Renewable Energy Plan 2005-2010.

The responsibility of the execution of these measures corresponds, ultimately, to Local Entities. The Central government will sign through the Ministry of Industry, Tourism and Trade and the IDAE agreements with the Spanish Federation of Municipalities and Counties (FEMP) and ENERAGEN.

Residential and office equipment sector

The residential and office equipment sector includes the necessary actions for the consumption reductions of appliances (of all types), air conditioners of domestic use (up to 12 kW of power), kitchens, ovens and office equipment in general (in the domestic sector and others).

The measures in the Action Plan 2005-2007 include increasing the penetration of high energy efficiency

appliances, in particular, those labeled as A-class or superior. The proposed measures affect new and existing equipment and are as follows:

1. Plan for appliances renewal.
2. Salespersons and buyers training and awareness.
3. High efficient equipment in new housings.
4. Equipment and efficient use of energy in the public Administration plan.

The following table shows a summary of investment, public support, energy savings and CO2 avoided emissions of the measures for the residential and office equipment sector.

Action Plan 2005-2007. Residential and office equipment sector measures

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005-2007	2007	2005-2007
1. - Plan for appliances renewal.	631.110	213.000	310	465	832	1.248
2.- Salespersons and buyers training and awareness	206.450	375	100	200	270	540
3.- High efficient equipment in new housings	2.214	36	2	2	5	5
4.- Equipment and Efficient Use of Energy in the Public Administration Plan.	493.514	O	239	239	644	644
TOTAL EQUIPMENT	**1.333.287**	**213.411**	**650**	**905**	**1.751**	**2.437**

Source: Renewable Energy Plan 2005-2010.

The responsibility in the execution of measures corresponds to the Ministry of Industry, Tourism and Trade, with the collaboration of the IDAE, National Institute of Consumption, Autonomous Communities and Local Administrations.

Agriculture and fishing sector

The energy consumption of the agriculture and fishing sector corresponds, fundamentally, to the use of agricultural machinery and watering systems. The efforts to introduce approaches of energy efficiency in the sector and measures proposals in the Action Plan 2005-2007 are devoted, therefore, to these uses.

The Plan proposes the following measures:

1. Communication / promotion campaign of the efficient use of energy in agriculture.
2. Renewal plan of tractors.
3. Legislation promoting changes in the efficiency of watering systems.

The following table shows a summary of investment, public support, energy savings and CO2 avoided emissions of measures in the agriculture sector.

Action Plan 2005-2007 Agriculture sector measures

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005-2007	2007	2005-2007

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005-2007	2007	2005-2007
1. Communication / promotion campaign of efficient use of energy in agriculture.	441	441	-	-	-	-
2. Renewal plan of tractors	347.000	22.956	25	47	71	136
3. Legislation promoting changes in the efficiency of watering systems.	162.000	0	13	16	28	37
TOTAL AGRICULTURE	**509.441**	**23.397**	**38**	**64**	**99**	**173**

Source: Renewable Energy Plan 2005-2010.

The responsibility of measures included in this sector corresponds to the Ministry of Agriculture and the Ministry Industry, Tourism and Trade through the IDAE.

Energy Transformation Sector

The Energy transformation sector includes three subsectors, quite different from each other: refineries, electric generation and cogeneration.

It is important to point out that, regarding the objectives outlined by the Energy Saving and Energy Efficiency Strategy 2004-2012 (E4), the Action Plan increases the objective related to electric power production by cogeneration during the period 2005-2007 to reach a total of 1.150 MW at the end of 2007, 750 MW more than those proposed by the E4 strategy itself.

The Action Plan 2005-2007 proposes the following measures for this sector:

1. Set up a Commission to monitor the E4 strategy.
2. Viability studies (financing up to 75% total cost and 100 studies).
3. Energy audits (financing up to 75% total cost and 190 audits).
4. Development of cogeneration in Spain.

The Action Plan proposes the introduction of the Directive 08/2004/EC to facilitate the economic profitability of new cogeneration plants.

The following table shows a summary of investment, public support, energy savings and avoided CO2 emissions of taken measures on the energy transformation sector.

Action plan 2005-2007. Measures for the energy transformation sector

PLANNED MEASURES	Investment (Thousands €)	Public Aid (Thousands €)	Primary Energy Saving (ktoe)		Avoided CO2 emissions (ktCO2)	
			2007	2005 -2007	2007	2005 -2007
1. - Commission (Refineries and generation)	310.646	90	914	2.135	2.136	4.990
2.- Viability studies (Cogeneration)	1.500	1.125				
3.- Energy Audits (Cogeneration)	51.280	1.710	52	105	81	164
4.- Greater potential of cogeneration	541.000	3.000	553	811	2.230	3.270
TOTAL ENERGY TRANSFORMATION	**904.426**	**5.925**	**1.519**	**3.051**	**4.447**	**8.424**

Source: Renewable Energy Plan 2005-2010.

The responsibility of the previous measures corresponds to the Ministry of Industry, Tourism and Trade.

Communication strategy

The Action Plan 2005-2007 proposes communication measures as a strategy to affect citizens behavior with regard to energy saving and energy efficiency.

The Action Plan proposes the following measures or institutional communication campaigns:

1. Advertising campaigns for responsible energy consumption awareness of citizens
2. Advertising campaigns on wise use of transport.
3. Advertising campaigns for the residential and services sector to promote wise use of the energy at home.

Obstacles for RUE Development

There are several obstacles for the RUE development. Some weaknesses have also been detected on the Action Plan 2005-2007 and these are:

A) The Action Plan is not adapted to the National Assignment Plan (PNA) 2005-2007 of CO2 rights emissions as a result of the entry into force of the Kyoto Protocol. The Action Plan 2005-2007 seeks to comply only with Spanish energy policies objectives and it does not have as a main objective to reduce emissions demanded by the PNA 2005-2007. Nevertheless, the Action Plan measures avoid the emission of 32,4 Mt of C02 during the period 2005-2007.

The PNA 2005-2007, approved by the RD 1866/2004, included besides the above-mentioned 32,4 Mt reduction, an additional CO2 reduction of 52 million tons during the period 2005-2007 in the transport, residential and commercial, and public sectors. These 52 million tons should be added to the 32 million tons objective of the E4.

B) The Plan of Action 2005-2007 requires a public effort that can be affected by highly energy intensive policies developed by different Ministries in Spain such as transport, infrastructure, land use planning and urban development. Urban development around the most important cities in Spain and expensive transport infrastructures is causing an increase in traffic, difficult to compensate with energy saving promotion and communication measures. Collective transport (especially transport by train), no transport if possible or “zero emissions” transport must be incorporated into urban development policies.

With the objective to reduce emissions, the Action plan 2005-2007 proposes that all policies, programs and public initiatives should be evaluated to measure its global impact on energy consumption and avoided CO2 emissions, or proposes to conduct a study on energy optimization in order to guarantee that public policies elaborated in different Ministries do not significantly affect the Spanish energy policy.

2.2.2 Tools and measures in favor of renewable energy (RE) and obstacles

The Renewable Energy Plan 2005-2010 and its Action Plan proposes many different measures by sectors. These measures also seek to surpass existing obstacles and barriers. These barriers and some of these measures will be implemented under the Action Plan and other plans are the following:

Wind energy

Barriers / Obstacles	Measures	Responsibility	Calendar
Wind energy transport infrastructure is not sufficient.	Development of energy transport networks.	REE (Spanish Electric Network Company)	2006-2010
	Revise planning of gas and electricity sectors.	REE and Ministry of Industry	2006
Deficient energy connection legislation, low access to electric network and deficient operational conditions (O.M. 05/09/1985).	New Royal Decree facilitating connection to energy with special regime (renewable).	Ministry of Industry	2006
Inadequate management of wind power production.	Establishment in REE of an unique centre of operations for the "Special Regime" Energy.	REE and Ministry of Industry	2005-2006
	Development of coordination canters for wind power facilities or facilities located in a specific territory.	REE and utilities	2006-2007
	Expand application time to solicit financial incentives to upgrade old wind turbines.	Ministry of Industry	2005
Limit of current bonus and rates until total wind power reaches 13.000 MW.	Maintenance of Royal Decree 436/2004 but increasing the legal limit to 20,000 MW.	Ministry of Industry	2005

Source: Renewable Energy Plan 2005-2010

Hydroelectric energy

Barriers / Obstacles	Measures	Responsibility	Calendar
Existence of public hydroelectric infrastructure without use	Promoting public bids to exploit governmental hydroelectric infrastructure.	Ministry of Environment	2005-2010
	Hydroelectric use of ecological flows		
Deficient connection legislation, access to electricity networks and operational conditions (O.M. 5/09/1985)	New Royal Ordinance on access to electric network and operational conditions.	Ministry of Industry	2006

Source: Renewable Energy Plan 2005-2010

Solar Thermal Energy

Barriers / obstacles	Measures	Responsibility	Cost (€)	Calendar
Lack of solar thermal energy use in the construction sector.	Approval of the Construction Technical Code during 2005 which effects will be seen on the period 2008-2010.	Approval: Ministry of Housing Implementation: City Councils	-	2005
Diffusion of solar thermal technology need to city councils	Support the approval by Municipalities of Solar Thermal energy Ordinances by informing City Councils.	IDAE	Pending	2005.2010

Barriers / obstacles	Measures	Responsibility	Cost (€)	Calendar
Insufficient profitability if solar thermal is not supported with public financial aid.	Public financial support to promote investments for an amount of 348 millions € during the period for 2005-2010. This budget will come from the central government and autonomous communities. Maintenance of current conditions of the public financial line ICO IDAE.	Ministry of Industry and Autonomous Communities	348 M	2005-2010
Need to spread awareness among potential users.	Carry out solar thermal awareness campaigns and training for citizens.	IDAE	Pending	2005-2010

Source: Renewable Energy Plan 2005-2010

Solar thermoelectric

Barriers / obstacles	Measures	Responsibility	Cost (€)	Calendar
Limit of tariffs and rates until reaching 200 MW of power generation.	Maintenance of current conditions of the R. D. 436/2004, but increasing the legal limit up to 500 MW. Maintenance of conditions of the R.D. 2351/2004.	Ministry of Industry	559 M	2005-2010
Need for public support for first projects in Spain.	Promote public financial support to first projects in Spain.	Autonomous Communities, EU	6,2M	2005-2010
Deficient planning and valuation for initial projects, producing more expensive projects.	Support to carry out demonstration projects.	IDAE	Pending	2005-2010

Source: Renewable Energy Plan 2005-2010

Photovoltaic energy

Barriers / obstacles	Measures	Responsibility	Cost (€)	Calendar
Insufficient profitability.	Maintenance of fiscal bonus set on the Real Ordinance 436/2004.	Ministry of Industry	499,4 M	2005 - 2010
Difficulties to develop new projects due to lack of public financial support.	Modification of the IDAE financial line, maintaining support for isolated facilities only.	IDAE	42,6 M	2005 - 2010
Lack of photovoltaic energy use in the construction sector.	Approval of the Construction Technical Code.	Ministry of Housing	--	2005

Source: Renewable Energy Plan 2005-2010

Biomass

Barriers / obstacles	Measures	Responsibility	Cost (€)	Calendar
Absence of bonus for co-combustion.	Support to the coal / biomass co-combustion technology. (Modify article 27 of Law 54/1997 and the R.D. 436/2004).	Ministry of Industry, Ministry of Economy, National Energy Commission, Utilities	283,15 M	2005-2010
Lack of good performance and economic viability of biomass power plants.	Modify article 30 of the Law 54/1997 to increase biomass bonus.	Ministry of Industry, Ministry of Economy, National Energy Commission	Budget included on the modification	2005-2010

			proposal of R.D. 436/2004	
Lack of good performance and economic viability of biomass power plants.	Modify the Royal Decree 436/2004.	Ministry of Industry, Ministry of Economy, National Energy Commission	776,8 M€	2005-2010
Competition of biomass thermal domestic applications with other fuels.	Grants up to 30% on equipment for domestic biomass use.	Ministry of Industry, Autonomous Regions	213,03 M€	2005-2010
Availability of biomass coming from forest in quantity, quality and price.	Develop the Fourth Additional Provision of the Law 43/2003 of woodlands.	Ministry of Environment, Department of Biodiversity	--	2005-2010
Absence of adequate biomass pre-treatment and high costs of biomass resources (from forest and agriculture).	Public financial support to the acquisition of biomass collection machinery, transport and treatment.	Ministry of Agriculture, Ministry of Environment	71,01 M€	2005-2010

Source: Renewable Energy Plan 2005-2010

Biogas

Barriers / obstacles	**Measures**	**Responsibility**	**Cost (€)**	**Calendar**
Lack of information for potential biogas producers coming from ranching waste.	Inform potential biogas producers about existent technologies and other affected stakeholders.	Ministry of Industry	Not evaluated	2005-2010

Source: Renewable Energy Plan 2005-2010

Biofuels

Barriers / obstacles	**Measures**	**Responsibility**	**Cost (€)**	**Calendar**
Widespread fiscal exemption during at least 10 years for biofuels.	Extend the current fiscal incentives at least during the first ten years of a project life.	Ministry of Finance	2.855 M€	2006
Need to breakaway agriculture products for biofuel production from mandatory EU CAP (Common Agriculture Policy) agricultural products quota reductions.	Develop all the possibilities that the CAP (Common Agriculture Policy) offers, in particular those referring to European and national support to produce energy crops.	Ministry of Agriculture, Ministry de Economy	No additional cost	2005-2010
High market prices of oil for food purposes, greater of what it can be used for energy purposes.	1. - Develop logistics to collect used vegetable oils. 2. - Develop and select new oleaginous species adapted to Spain's agronomic conditions.	Ministry of Agriculture, Ministry of Environment, Autonomous Regions	1. Without cost 2. Pending to evaluate	2005-2010

Source: Renewable Energy Plan 2005-2010

2.3 Energy efficiency evolution

In Spain, during the last 25 years the energy consumption has duplicated – moving from 68 million toe in 1978

to more than 136 millions in 2003, and to more than 141 million toe in 2004 -. Also, although Spain presents smaller energy consumption per capita than other EU countries, contrary to what it is happening in most of countries, Spain shows a notorious growth on the energy intensity, in terms of final energy and primary energy.

The energy intensity indicator best allows progress in energy efficiency to be measured. This indicator's evolution since 1970-1980 should be described. If possible, energy intensity progress should be quantified for the main sectors of use: industry, households, services sector (tertiary/ /residential); plus if possible transportation. It will allow observing if a decoupling between economic activities and energy consumption is noticeable. The efficiency of energy production, conversion and transportation must also be closely monitored.

Regarding the **energy demand,** at the moment, Spain consumes the double energy as in 1975. While in 1975, the primary energy consumption was about 61 million toe, in the year 2000 was 125 million. This strong growth had significant variations depending on the economic cycle, the demand of equipment, the effectiveness of the energy efficiency measures and the relative energy prices.

Between 1975 and 1990, the consumption of primary energy has increased in Spain by an annual mean rate of 2,7%, while in the 1990s, the rate increase has been of 3,1 %, especially in the last years of the decade. This increase has clearly been greater than the GDP, meaning that the energy intensity has also been growing as reflected in the following graph.

The evolution of the **primary energy intensity** from 1980 in Spain (relationship between the energy consumption, including the necessary for generation, and the GDP) shows two stages with different tendencies. First, between 1980 and 1988, it shows a significant ratio reduction from 238 to 220 toe/million € (1995 constant prices). However, since 1988, it shows an increase exposing that the year 2000 ratio is similar to those ratios by the year 1980.

The main reasons that explain this particular evolution have, fundamentally, a socioeconomic origin. Spain registers average energy consumption per capita lower than the European average. During the last years, the economic development has greatly improved the quality of life and citizen’s mobility, with unavoidable impacts on the energy consumption. Indeed, if sectoral components of this growth are analyzed in recent years, from the end of the crisis of 1993 until the present time, the greatest increase in the consumption have occurred on the residential sector and the private transport, sectors linked to the “quality of life” but with relatively small repercussions on GDP growth.

Among the explanatory factors of this evolution, it should be considered the following:

- The improvements reached on family appliances and residences thermal comfort favoring increases on the energy consumption.
- The important increase on the automobile use (above the European average) and transport infrastructure improvements have produced greater mobility and therefore, greater consumption of fuels.
- The urban growth registered in metropolitan areas has also contributed to an increase in domestic energy consumption (bound to the residence type) and associated to transport necessities.
- The energy low prices as a result of energy market liberalization don't impede but add certain complexity to the adoption of measures to improve energy efficiency. The energy low cost does not condition the purchase of low efficient equipment, reducing the profitability of company’s investments on energy efficiency.
- In the last years, a displacement of the consumption of fuels is detected in favor of electricity. This tendency implies an increase on the energy generation and therefore, an increase on the primary energy intensity above the final energy intensity, despite improvements on power plants efficiency and the greater power generation with renewable energy and cogeneration.

In addition to these considerations explaining the energy intensity growth in Spain, it is also noticeable to indicate, in the context of the European countries, that Spain presents an intermediate level. The energy intensity indicator shows a tendency of convergence toward EU average values (around 0,20 ktoe/ECU95), in coherence with the socioeconomic evolution commented before.

At the end of the 1980s, the tendency of the primary energy intensity in Spain has been changing and, from 1988, with the exception of some years, their evolution has been of a slight growth. The consumption of final energy in Spain has increased between 1980 and 2002 in 90,5%, meaning an average annual growth of 3,6% or 1 % above GDP growth rate. This implies that the energy intensity has reached a value of 1,38.

In regards to the **final energy intensity**, the final energy intensity evolution in Spain has moved from 0,144 kep/ ECU95 in 1985 to 0,14 in 1990, 0,142 in 1995 and 0,145 in 2000. On the other hand, the final energy intensity evolution in the EU, has moved from 0,158 in 1985 to 0,14 in 1990, 0,136 in 1995 and 0,129 in 2000. It should be mentioned that the data is based on the conversion of Spanish currency to constant 1995 ECU using the exchange rate.

Looking at the same data but at purchasing power parity, the final energy intensity in Spain was 0,12 kep/ECU95 in 1985, 0,115 in 1990, 0,118 in 1995 and 0,12 in 2000. In the EU, the final energy intensity was 0,155 in 1985, 0,14 in 1990, 0,137 in 1995 and 0,128 in 2000. In both cases, the final energy consumption does not include non-energy use consumption because if this energy is not included, this indicator better reflects the energy efficiency evolution in the final consumption sectors.

In the year 2000, Spain's final intensity has been very similar to 1985, with some value oscillations through time. Similarly, the EU has reduced its final energy intensity significantly and, in a greater measure between 1985 and 1990. During the 1990s, Spain has increased its final intensity about 3% while the EU has reduced it about 8%. The decreasing tendency shown by the EU indicator is common to other EU members such as France, Germany, Ireland or the United Kingdom.

Spain equals the EU average final intensity in 1990 while reaching 13% by the year 2000 overcoming the EU average values. Considering the purchase power parity, the final intensity in Spain stays below the EU, although with tendency to converge.

The evolution of the energy intensity is usually measured by the relationship between energy consumption and the GDP (ratio of energy intensity) which have been decreasing in developed European countries from the 1980s. However, the opposite tendency is observed in Spain that can be explained by the important economic development registered in the last years, greater than the EU average. Another factor that explains the Spanish energy intensity evolution is the maintenance of energy prices in low levels from 1985 until the end of the 1990s, which has caused smaller investments on energy efficiency, less profitable in low prices scenarios.

The primary energy consumption has grown in the period 1990-2004 in Spain by 54,4%, while the GDP has grown 43,7%, which indicates that the primary energy intensity has increased significantly. On the other hand, the evolution of the different types of energy has been quite different, causing a great structural change of the demand. Specifically, the electric power demand has increased 78,8% and the gas 491%, while that of petroleum has increased less, about 48,2%. This last energy is progressively concentrated on transport, while being substituted in other sectors by gas and electricity.

Additional information on the evolution of energy efficiency and energy intensity is showed in section 1.2 of this study.

2.4 Renewable energy evolution

In 1998 when the Renewable Energy Development Plan 2000-2010 was created the consumption of renewable energy was 7,2 million toe with a total primary energy consumption in Spain of 114 million toe. This means that the renewable sources contribution represented only 6,3% to the total energy consumption.

The above mentioned Development Plan established some objectives including a renewable energy consumption of 16,6 million toe by the year 2010. This goal implies that the total energy consumption contribution would be 12%. As reflected by the Development Plan, during the period 1999-2004, the global consumption of renewable energy had increased in Spain in 2,7 million annual toe by 2004, a significant growth, although insufficient to reach the ambitious objectives set by the Plan.

The renewable energy growth presented important disparities. The wind energy continued to register important developments with a consolidated group of companies with own technology and excellent market expectations. Biofuels and biogas attained important level of development but these technologies could be more developed if additional fiscal reform was taking place.

The hydroelectric energy continued finding important administrative barriers with a slow development, as foreseen. During the period 1999-2004, the solar areas were developed well below plans to attain objectives. Additionally, the solar thermal energy and photovoltaic energy required in order to truly advance of the Construction Technical Code approval. On the other hand, biomass development on the period 1999-2004, was experiencing much lower advance as the planned one. Since the Development Plan was approved until the year 2004, biomass attained only 9% of the total planned objective by the year 2010. In addition, The R.D. 436/2004 did not contribute to a significant advance on biomass use coming from energy crops and agricultural and forest waste. According the Development Plan, these crops and waste are supposed to contribute with 90% of the supplied biomass.

Therefore, as presented in section 2.1.2 of this study, it was necessary to revise the old Plan to be truly effective, establish new scenarios and attain objectives. For this reason, the Spanish government developed the Renewable Energy Plan 2005-2010 to attain general objectives.

2.5 Existing or expected effects and benefits of RE and RUE

Renewable energy (RE) benefits

In this section, the positive effects of RE are presented (based on the Renewable Energy Plan 2005-2010) in three aspects: energy diversification, environmental benefits – only evaluated the avoided C02 emissions on energy consumption and electricity production from renewable - and socioeconomic benefits.

Energy diversification benefits

For a country like Spain, with very high external energy dependence, the diversification of energy sources and limiting the external energy dependence contribute to higher economy stability and contributes to reduce the significant commercial deficit.

It is important to point out that the energy balance (exports minus imports) of Spain, between 2000 and 2003, has deficit of about 15.000 million € annually. During the 2004, the energy deficit was more than 17.500 million €. This figure represents 29% of negative commercial balance of the national economy during 2004 and equals

2,2% of Spain's GDP.

The energy diversification of the Plan supposes an important reduction on future energy imports. By the year 2010, if the development of renewable sources was not taking place, the cost of imports to cover this renewable production would be more than 3.500 million € annually.

Environmental benefits

Although the environmental benefits of using renewable energy are many, in this section, it is only evaluated the avoided CO2 emissions contribution as the main GHG. The following table contains the forecast of avoided CO2 emissions by 2010 thanks to the renewable energy development between 2005 and 2010 as well as its economic valuation.

In the following table, it is shown the forecast of avoided CO2 emissions by the year 2010 in Spain.

Renewable sources	**Avoided CO2 emissions (compared to a Natural Gas Combined Cycle on electric generation) (t CO2/ year) (1)**
Electricity Generation	
Hydroelectric (> 50 MW)	-
Hydroelectric (Between 10 and 50 MW)	255.490
Hydroelectric (< 10 MW)	472.812
Biomass	7.364.191
Biomass power plants	2.524.643
Co-combustion (1)	4.839.548
Wind	9.649.680
Photovoltaic energy	205.654
Biogas	220298
Solar thermoelectric	482.856
TOTAL ELECTRIC ENERGY	18.650.981
Thermal uses	
Biomass	1.788.326
Solar thermal of low temperature	996.710
TOTAL THERMAL ENERGY	2.785.036
Biofuels (Transport)	
TOTAL BIOFUELS	5.905.270
Total avoided CO2 emissions by 2010 (Tons/ year)	27.341.287
Economic valuation of the non-emitted CO2 (million of €) (CO2 price considered: 20 US dollars) (2)	547

Source: Renewable Energy Plan 2005-2010.
(1): In the case of co-combustion, the avoided emissions are calculated compared to coal electric generation.
(2): Economic valuation of avoided C02 emissions thanks to the Plan by 2010.

Also, it has been calculated that the total emissions avoided by the Plan until the year 2010 are 77 millions tons of C02 and therefore, the economic valuation of these avoided emissions at the same price of C02, is up to 1.540 million €.

Socioeconomic benefits

The Renewable Energy Plan produces many different socioeconomic benefits such as contributing to economic stability; reduce the commercial deficit, improvement and modernization of industry, employment generation and contribution to regional development. In accordance with the IDAE database, there are more than 1300

registered companies working on renewable energy at the moment in Spain.

In connection to the labor market, an evaluation of the net employment has been made on the different renewable energy areas for the period 2005-2010. It is quite difficult to estimate this variable, but it seems that the future plan and related activities will produce about 100.000 net employments.

RUE Plan Benefits

In general, it can be said that the Action Plan 2005-2007 of the Energy Saving and Energy Efficiency Strategy (E4) 2004-2012 will have positive socioeconomic and environmental benefits. Basically, energy saving and reduction of GHG emissions are globally very positive compared to the public and private resources that the Plan commits.

Reduction of energy consumption and energy imports: smaller external energy dependence

The Action Plan 2005-2007 has the objective of saving 12.006 ktoe of primary energy, the equivalent to 8,5% of the total primary energy consumption of the year 2004 and about 20% of oil imports - 88 million oil barrels of the 435 millions barrels imported in 2004 -.

The annual energy saving, if all planned measures are implemented, is 7.179 ktoe/ year, which will be about 4,7% of the energy consumption by the year 2007 – assuming an annual rate increase of primary energy consumption of about 2,8% -.

In the following table, it is shown the cumulative and annual primary energy savings by sectors (ktoe) in Spain.

	2005	**2006**	**2007**	**Total 2005-2007**
Industry	29	241	532	803
Transport	466	1.521	2.957	4.944
Construction	17	213	494	724
Office and domestic equipment	10	69	201	280
Public services	7	18	34	59
Agriculture and fishing	7	16	29	52
Total final use	536	2.078	4.248	6.862
Energy transformation	407	1.125	1.519	3.051
Primary energy savings derived from savings on final energy	95	585	1.412	2.093
Total primary energy savings	**1.039**	**3.788**	**7.179**	**12.006**

Source: Energy saving and Energy Efficiency Strategy 2004-2012 and Action Plan 2005-2007.

Looking at the Plan energy savings, near 45% corresponds to fuels in the transport sector. In terms of final energy, the smaller consumption of fuels from vehicles represents 70% of potential savings set at the Plan. These savings and the oil saving of the industry, domestic and tertiary sectors, contribute about 90% of the forecast total savings in terms of final energy. Considering that 99% of all energy consumption is coming from imported oil products, the Action Plan has a great and direct impact on the energy dependence of Spain and on Spain's self supply.

In the following table, it is shown the economic benefits derived from primary energy savings (€) in Spain.

	2005	**2006**	**2007**	**Total 2005-2007**

Industry	12.260.284	100.692.487	222.471.794	335.424.565
Transport	164.500.329	536.920.602	1.043.835.778	1.745.256.709
Construction	11.371.813	144.644.268	341.710.366	497.726.446
Office and domestic equipment	11.001.145	73.269.761	215.109.766	299.380.672
Public services	7.476.506	19.225.302	36.314.459	63.016.267
Agriculture and fishing	2.347.241	6.183.537	12.551.457	21.082.234
Total final use	208.957.317	880.935.956	1.871.993.619	2.961.886.892
Energy transformation	134.615.250	372.093.750	502.409.250	1.009.118.250
Total primary energy	**343.572.567**	**1.253.029.706**	**2.374.402.869**	**3.971.005.142**

Source: Energy saving and Energy Efficiency Strategy 2004-2012 and Action Plan 2005-2007.

Reduction of environmental impacts due to smaller energy consumption

The measures contemplated in the Plan will allow to reduce the CO2 emissions in 19,6 Million Tons (Mt) per year at the end of the period 2005-2007. The total avoided emissions are 32,5 Mt of the total avoided 190 Mt forecast by the Plan.

In the following table, it is shown the annual and cumulative avoided CO2 emissions by sectors (Thousands of Tons).

	2005	**2006**	**2007**	**Total 2005-2007**	**2012**	**TOTAL 2004-2012**
Industry	89	733	1.620	2.442		
Transport	1.407	4.421	8.655	14.483		
Construction	92	1.173	2.544	3.989		
Office and domestic equipment	90	596	1.751	2.437		
Public Services	61	157	297	515	42.315	190.051
Agriculture & Fishing	20	53	99	173		
Total Final Use	1.760	7.134	15.145	24.038		
Energy Transformation	937	3.039	4.447	8.424		
TOTAL	**2.697**	**10.173**	**19.592**	**32.462**		

Source: Energy saving and Energy Efficiency Strategy 2004-2012 and Action Plan 2005-2007.

In this case, the avoided CO2 emissions have been valued at 10 €/ ton. The derived environmental benefits of the Action Plan 2005-2007 is about 423,2 M€. The annual benefit is 195,9 M€ by 2007 as a result of the implemented measures.

Competitiveness improvement and employment creation

The Energy Saving and Energy Efficiency Strategy 2004-2012 (E4) has the objective to reduce the global energy intensity in 7,2% during this period. This reduction means, at micro-economic level, smaller energy consumption per production unit and therefore, a smaller cost of production. Under the EU Program SAVE, it was conducted an evaluation study about the impacts on employment of the Spanish energy efficiency public policies. This study for Spain exposed that approximately, for each million of € invested on energy efficiency, 10 to 20 new employments were created in Spain. The E4 Strategy and the Action Plan 2005-2007 will have effects on the competitiveness of industrial companies and will create new business opportunities. Certain regulations will demand qualified specialists, new professional degrees and will create of employment of quality.

Other impacts: improving the quality of life and traffic security

The Action Plan 2005-2007 avoids the emission of 32 million tons of CO2 and other pollutants such as S02, NOx or particles. The Action Plan 2005-2007 generates an improvement on the quality of life, a reduction in the

emission of pollutants - fundamentally, the private vehicle -; reduction of the negative impacts of climatic change on economic activities, human health and ecosystems. Additionally, it creates employment; technological innovation; reduces vehicle traffic, improves the air quality besides many other positive effects.

2.6 Renewable Energy (RE) Financing

Renewable Energy (RE) financing

A financial analysis is a fundamental part when starting any plan. Therefore, due to the importance of the Renewable Energy Plan for the period 2005-2010, securing financing is absolutely necessary.

Economic-financial analysis of the investment Plan

The total necessary investment to reach the energy objectives is about 23.599 million € on the period 2005-2010. This will require private sector financing of about 4.719 million € and the remaining financing will come from the financial market (18.198 million €). The public support will provide about 681 million €.

Financing source	Investment (Thousands of €)	%
Promoters	4.719.728	20,0
Financial market	18.197.974	77,1
Public aid	680.939	2,9
TOTAL	**23.598.641**	**100**

Source: Renewable Energy Plan 2005-2010.

Public support required by the Plan

There are three differentiated categories under public support, one public support is a direct investment and the other two are related to the exploitation of resources.

a) Public support to invest. This support contemplates a direct financial help that is giving away in order to improve the project financial conditions. This direct investment is about 681 million €, going primarily to the solar thermal energy, the biomass facilities for domestic use, the photovoltaic solar energy and in smaller measure, the solar thermoelectric energy.

b) Fiscal incentives to biofuels use. This public support provides full fuel tax cut on biofuels. This exemption represents about 2.855 million € in the period 2005-2010 in public support to bioethanol and biodiesel.

c) Bonus to electricity generation with renewable sources. This public support is given only to solar photovoltaic and solar thermoelectric energy. This bonus support might be complemented with direct investments. The total amount of bonus during the period 2005-2010 for generation facilities will be 4.956 million €, many of them correspond to wind energy facilities. It is expected a 62% increment of electric generation coming from wind energy by 2010.

The application of bonus to renewable energy in this Plan will increment the electric tariff at an average annual constant rate of about 0,696 %. The previously mentioned bonus on electricity generation are, obviously, a public decision based on the government legal capacity and the costs of such bonus are paid by the final energy consumers through the electric tariff or rate.

Among the different types of public support, we should also mention the Financial Line ICO-IDAE whose peculiarity resides in combining different public incentives in one instrument of clear financial profile by

proving financing public funds and direct incentives and investment to reduce the investment final cost.

2.7 RUE Financing

The total cost of the Action Plan 2005-2007 is 7.920 Million € compared to the necessary 26.063 Million € for the whole period of the E4 Strategy 2004-2012. The public support is about 722 Million € for the Action Plan compared to the 1.966 Million € for the E4 Strategy up to 2012.

In the following table, it is shown the total necessary investments (€) in Spain.

Sectors	2005	2006	2007	Total 2005-2007	TOTAL 2004-2012
Industry	26.948.583	194.452.200	267.778.630	489.179.413	2.160.500.000
Transport	352.762.000	338.992.000	321.392.000	1.013.146.000	2.552.500.000
Construction	137.920.429	1.578.964.571	1.579.645.602	3.296.530.602	14.414.000.000
Offices and domestic equipment	68.852.748	384.371.748	880.062.933	1.333.287.429	1.866.000.000
Public Services	117.700.000	127.788.571	128.705.714	374.194.286	932.000.000
Agriculture & Fishing	99.093.000	170.171.000	240.177.000	509.441.000	3.094.000.000
Total Final Use	803.276.759	2.794.740.091	3.417.761.880	7.015.778.730	25.019.000.000
Energy Transformation	105.907.000	432.771.000	365.748.000	904.426.000	1.044.000.000
Total Sectors	909.183.759	3.227.511.091	3.783.509.880	7.920.204.730	26.063.000.000

Source: Energy saving and Energy Efficiency Strategy 2004-2012 and Action Plan 2005-2007.

The following table shows the total volume of investments on energy efficiency from the public sector in order to mobilize required private resources in the horizon of the Plan.

In the following table, it is shown the financial public support by sectors (€) in Spain.

Sectors	2005	2006	2007	Total 2005-2007	TOTAL 2004-2012
Industry	5.962.293	43.912.020	61.337.833	111.212.146	481.584.460
Transport	7.762.000	53.992.000	66.392.000	128.146.000	418.500.000
Construction	9.349.000	103.536.000	103.536.000	216.421.000	577.079.000
Office and domestic equipment	161.000	106.625.000	106.625.000	213.411.000	220.000.000
Public services	7.700.000	8.360.000	8.420.000	24.480.000	61.271.000
Agriculture and Fishing	6.158.000	7.752.027	9.486.898	23.396.925	93.540.000
Total Use Final	37.092.293	324.177.047	355.797.731	717.06 7.071	1.851.974.460
Energy Transformation	1.603.000	2.161.000	2.161.000	5.925.000	115.000.000
Total Sectors	**38.695.293**	**326.338.047**	**357.958.731**	**722.992.071**	**1.966.974.460**

Source: Energy saving and Energy Efficiency Strategy 2004-2012 and Action Plan 2005-2007.

The public funds necessary to finance the Plan will come from the Central government, specifically the IDAE and other Ministry Departments and, in a higher percentage, from the electric tariff. The public funds coming from the government will represent, approximately, two thirds of the total while Autonomous Communities and local entities will contribute to the remaining third.

The electric tariff, at least for 2006 and 2007, will include (to cover the Action Plan costs), a total volume of 173,46 Million € and 176,76 Million € for 2006 and 2007 which is about 53% and 50% of the total necessary budget.

3 EXAMPLES OF GOOD PRACTICE, CASE STUDIES

=> Objective: select and document case studies / examples of good practices relating to RUE and RE. They should allow showing how concrete actions have been implemented and what the results were.

This section presents RUE and RE case studies providing concrete demonstration of specific projects implemented in Spain.

The first 6 examples show success stories related to implementing renewables (RE), while the 4 last ones present case studies entailing reductions in energy consumption (RUE), which are highlighted in yellow.

3.1 RE case studies

Case Study 1

FROM FOSSIL ISLANDS TO RENEWABLE ISLANDS.
A PRACTICAL CASE: EL HIERRO 100% RES

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Instituto Tecnológico de Canarias, SA (ITC)

ABSTRACT

The island of El Hierro, Canary Islands, Spain (declared a Biosphere Reserve by UNESCO in January 2000), has an area of 278 km², a population of approximately 10,500 inhabitants and is not connected to a continental electricity grid. Currently, the electricity demand is covered by a conventional power station (diesel system: 12.78 MW). The island has decided to implement a 100% RES (Renewable Energy Sources) project for its energy supply. In a first phase the project focus on a "100% RES for electricity supply" programme, which aims at covering 80% of the electricity demand of the island by the integration of several RES. The most innovative action will consist of the implementation of a Wind-pumped Hydro Power Station, with the target of covering 75% of the island's electricity.

A large number of European islands could benefit from the results of this project, since approximately 300 European islands are not grid connected.

I. CURRENT ENERGY SITUATION ON EL HIERRO

Nowadays the electricity demand is covered by a conventional diesel power station of 12.78 MW (peak demand: 6.3 MW, demand: 42 GWh/y). The island's electricity demand has increased rapidly in recent years (1984: 5.71 GWh; 1989: 10.13 GWh; 1999: 23.18 GWh; 2005: 35 GWh). Electricity represents approximately 65% of the internal energy consumption, the rest corresponds to transport. Although the renewable energy potential is very high, as on the other Canary Islands, the current contribution of renewables is still very low: there is only one grid-connected wind farm on the island (100 kW installed power), stand-alone PV systems with a total capacity of approximately 7 kWp (no grid-connected installation), around 25 kWp PV systems connected to the grid and about 500 m2 of installed solar thermal panels.

II. "EL HIERRO 100% RES" PROJECT

The island has a great RES potential, mainly wind, and is willing to implement a 100% RES project for its energy supply. In order to reach this objective, 3 different programmes will have to be developed and implemented:

- The Energy Saving Programme
- The 100% RES for the Electricity Supply Programme
- The Transport Programme (conversion from Fossil Fuels to Clean Transport)

The island government (Cabildo de El Hierro), with the political support of the Government of the Canary Islands, has decided to implement the first phase of this programme, the "100% RES for Electricity Supply" programme.

With the financial support of the DG TREN of the European Commission, a consortium of 7 partners, coordinated by ITC (Instituto Tecnológico de Canarias), is carring out a 5-year project that will take the first steps of the "100% RES for electricity supply" programme. The project aims, in an initial phase, to cover 80% of the electricity demand of the island. This objective can only be reached by integrating several RES. The most relevant action consists of:

- Implementation of a Wind-Pumped Hydro Power Station (with the target of covering 75% of the island's electricity demand)
- Implementation of a Solar Thermal Energy Programme (with the target of installing 500 m2 of solar collector area in 5 years)
- Implementation of a PV Roof Programme (with the target of installing 50 kWp gridconnected in 5 years)
- Implementation of a Biomass Programme (in order to evaluate the exploitation possibilities of biomass residues on the island)

Furthermore, feasibility studies for similar systems are under development on Crete (Greece) and Madeira (Portugal). Moreover, further feasibility studies will be developed for other Greek islands.

More than 20 islands in Greece alone could benefit from these kinds of systems. In fact, 9 islands have already been selected to carry out pre-feasibility studies.

Besides ITC, the other partners in the European project are: the National Technical University of Athens (NTUA, Greece), the Regional Agency for Energy and Environment of Madeira (AREAM, Portugal), the Regional Energy Agency of Crete (REAC, Greece), the Cabildo Insular de El Hierro (Canary Islands, Spain), INSULA and the company E4Tech (Switzerland).

Figure 1: El Hierro island and the project location

III. THE WIND-HYDRO POWER STATION

III.1 Basic description of the System

The most innovative part of the project, from the technical point of view, is the Wind-(Pumped) Hydro power station (WHPS). This is an innovative concept of combination of 2 RES: wind and hydro power, using water as energy storage. The system overcomes the usual problems of intermittency (discontinuity) and power fluctuations caused by the random character of the wind resource and, thanks to the potential energy storage (pumped water) and the controllable power output of hydro turbines, it can establish a stable grid in terms of frequency and voltage. This is the first experience world wide of a WHPS that will provide, on a yearly basis, approximately 75% of the electricity demand of an isolated area and, in some months (such as June, July and August), 100% of the electricity demand. The rest of the demand will be covered by the existing diesel power station and/or the combination of other RES.

III.2 Components of the Wind-Hydro System

The WHPS will consist of the following subsystems:

Wind farm	20 MW
Pumping station	16 MW
Hydro power station (Pelton turbines)	13 MW
Diesel power station (existing)	2 MW
Upper reservoir (existing crater)	500,000 m^3
Lower reservoir	225,000 m^3
Penstock	
Distribution system	

Table 1: Main components of the Wind-Hydro System

The wind park (20 MW) will be installed at almost the same location of the existing one (100 kW). It will supply energy:

a) to inject directly into the grid or
b) to pump water from the lower to the upper reservoir (waterproofed volcanic crater), located at 682 m.a.s.l.

When the wind resource is scarce and does not cover the demand, the water from the upper reservoir will be turbined to the lower one. If a large period without wind has exhausted the water in the upper reservoir, the system will commute to the existing diesel power station. The dimension of the upper reservoir for the project purpose will be approximately 300,000 m3 (in fact this reservoir is larger, as an existing volcanic crater will be used for this purpose), which is enough to cover the energy demand of the island for 5 consecutive days without wind. The system enables the electricity production to match the electricity demand perfectly. This adjustment can be achieved because the turbines to be used (Pelton-type) are able to operate between 10 and 100% of their rated power (by changing the flow rate) with the same efficiency.

The estimated yearly electricity production from the system is:

- From the wind park: 41 GWh
- From the hydro station: 10 GWh

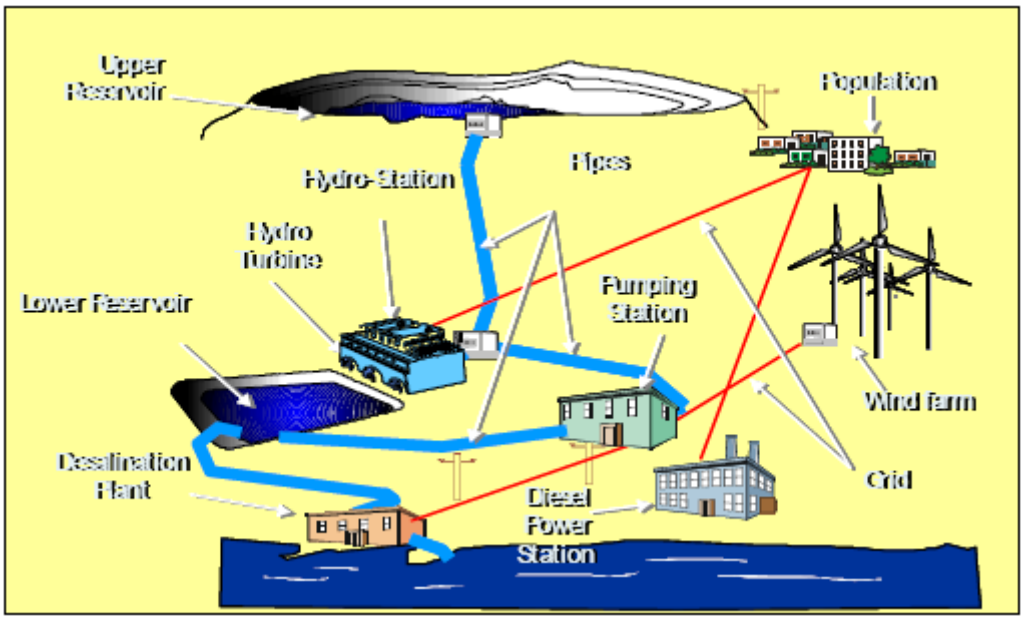

Figure 2: Basic scheme of the Wind Hydro Power Station (WHPS)

III.3 Innovations

The project has both technological as well as non-technological innovations.

Technological Innovations:

a) Hydraulic Subsystem – Distribution System. A hydraulic turbine and a pump station will be installed instead of a reversible hydraulic turbine. The installation of separated turbine and pump station allows the optimal operation between the wind farm, which produces a non-controlled load, and the pump station. The proposed system has the peculiarity of using only one penstock for both operations - the pumping mode and the turbine mode.

b) Intelligent dispatcher control system. An intelligent dispatcher control system that provides the control and co-ordinates the operation of all generators is foreseen. The control system has to control the upper and lower reservoir, the generators (hydropower, wind farm or diesel), the pumping station, etc.

c) Grid stability. The island will be a laboratory for grid stability issues and the experience will contribute to defining the real wind penetration limit.

e) Waterproofing of upper reservoir. The waterproofing of the upper reservoir (natural volcanic crater) represents a challenge in the project. The use of synthetic materials (including new geo-membranes) will be studied.

Non-technological innovations:

A company, “Gorona del Viento El Hierro”, has been created in order to promote, manage and exploit the proposed wind-hydro power station. The social purpose of this company will be to sell electrical energy to the distribution company (the utility established on the island is ENDESA), under what in Spain is called a “special regime” (generation from renewable energy sources and cogeneration, which establishes the legal framework for autonomous energy producers and the feed-in tariffs for each type of renewable energy installation). The shareholders of “Gorona del Viento El Hierro” are:

- the Island Government, Cabildo de El Hierro: 60%
- the Canary Islands Government through ITC: 10%
- the electrical utility, ENDESA: 30%

Given that this is an isolated small-scale electrical system, an electrical market with competing generation companies cannot be created, so that the system constitutes a natural monopoly.

The electricity generation on El Hierro island will be carried out by the "Gorona del Viento El Hierro" company, which will have preferential access to the electricity grid ("special regime" producer) and complemented under an ordinary regime by ENDESA when "Gorona del Viento El Hierro" cannot cover the island's electrical demand.

This configuration of the island's electrical system is compatible with the existence of small generators under the "special regime", which would complement the electrical supply, contributing to energy self-sufficiency. These contributions are foreseen in the project, particularly through grid connected photovoltaic and biogas plants. Given the dimension of the island (and the system), demand-side management aspects can be evaluated, taking into account the medium- and long-term contributions of these sources, as well as indirect contributions caused by foreseen increasing solar thermal energy systems (replacement of electric water-heating systems).

Another important issue will be that the population will be directly involved in the project. The Island Government (Cabildo de El Hierro) will probably implement a share scheme: a portion of the shares belonging to the Island Government will be divided into smaller shares, so that some SMEs can buy some of them, thus becoming co-owners of the WHPS. This is a highly innovative system from a social point of view, and an effective way of involving the island's population in the project.

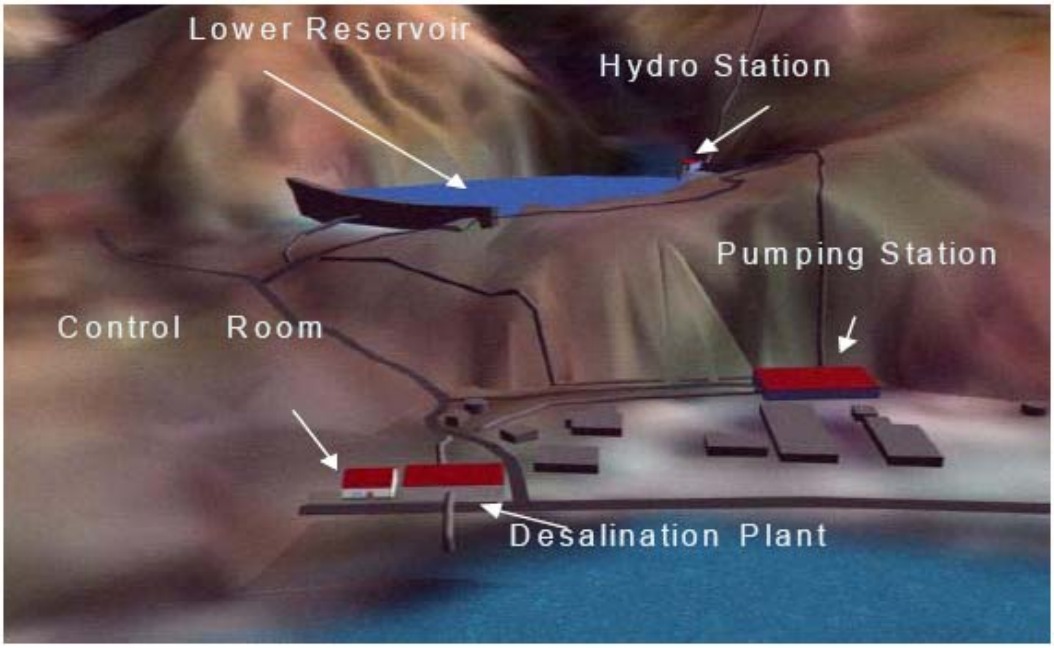

Figure 3: Details of the siting of the main system components

III.4 Environmental Impact of the Wind-Hydro Power Station

The WHPS will contribute to reducing CO2 emissions into the atmosphere by 25,500 tonnes per year, considering that 80% of the electricity demand will be covered by renewables. But there are economic benefits

as well as environmental ones, as the cost of the diesel purchase for the next 20 years alone will be greater than that of the WHPS investment

IV. INTEGRATION OF DIFFERENT RES: PV, SOLAR THERMAL AND BIOMASS

IV.1 PV Programme

At the beginning of the project, in 2003, no PV system had been connected to the grid on the island. The quantitative objective of the programme is to install 50 kWp by 2008. Up to now 25 kWp have been installed on the island. The PV integration is particularly interesting since solar PV electricity is produced during the day, when the electricity demand is higher.

IV.2 Solar Thermal Programme

A high penetration of solar thermal systems for domestic hot water production should be reached. The aim is to substitute electrical heating by solar thermal systems, which is important for reducing the total electricity demand and helping to reduce peaks in the demand curve. In 2003 the total collector area installed on the island was approximately 370 m2, corresponding mainly to old installations, all low-temperature systems for domestic hot water production. The quantitative objective of the programme is to install 500 m2 by 2008. During the last 3 years 130 m2 have been installed.

IV.3 Biomass Programme

A detailed study has been carried out in order to evaluate all kind of possibilities of biomass exploitation on the island. The available biomass potential of forestry residues is 3,000 tons. A power supply system based on gasification coupled to a modified existing engine seems to be a particularly interesting option in El Hierro.

Around 250 hectares of tagasaste (1% of the total surface of El Hierro), in addition to the available forestry residues, would be needed to achieve 100% RES and fully displace the diesel share in the electricity supply. If available land for energy crops were limited to 20 hectares (~300 t of tagasaste per year), it would be enough to run a 2 MW biomass power plant, which would process in the region of 3,540 dry tonnes of biomass. The resulting overall power generation system would be associated with a 91% share of renewable energy sources in the electricity generated annually.

V. OVERALL BENEFITS OF THE PROJECT

Hundreds of islands worldwide could benefit from the results of this project. The foreseen actions are expected to yield the following results:

- Reduction of GHG emissions
- Increase of quality of life on islands
- Increase of energy independence on islands
- Demonstration of the fact that RES integration is a way of providing 100% energy supply on islands
- Demonstration of the fact that synergies between RES (e.g. combination of wind, hydro, solar, etc.) can contribute considerably to increasing the penetration of RE into weak grids in isolated areas
- Demonstration of the fact that pumped water storage is an economical way of accumulating energy
- Optimisation of the available potential of RES using them together in integrated systems for local power supply

Case Study 2

ECOBUS Project: Collecting used cooking oils to their recycling as biofuel for diesel engines

Project Promoter: Municipal Transport Company of Valencia City (EMTV)
Project promoter description: The beneficiary is the EMT, a public company which leads the Project and is in charge of its development
Total Budget: 1,000,000 €
Duration: November 2002 to November 2004

Introduction

The City Council of Valencia and the EMTV lead the Project ECOBUS, which is a pilot project, approved by the European Commission within their Environment - LIFE program in the call 2002 that consists of a selective used vegetal oil collection used in cooking and its later valuation, turning it into biodiesel, which will be used in the urban buses of Valencia. The project has as a main objective the removal of a waste, the used vegetal oil, by turning it into a resource, biodiesel.

ECOBUS is a pilot project approved by the European Commission within the framework of the LIFE-Environment 2002- program, promoted by the Valencia City Council, with the beneficiary being the Municipal Transport Company EMT, which is the body responsible for managing the city's urban buses in the Spanish regional capital of Valencia.

The main aim of the ECOBUS project is to recycle a waste product, in this case used vegetable oil, and convert it into a resource, by manufacturing an eco-friendly fuel for use in a total of 120 vehicles of the 480 making up the municipal bus fleet.

The city council's commitment to protecting and maintaining its natural, urban and cultural heritage encouraged it to undertake a variety of environmental activities such as the strengthening of projects for optimising energy management and improving the quality of life of its citizens. This is the case of the ECOBUS project, concluded in October 2004.

Project Background

Cooking oil is a waste material that can be found everywhere in the European Union and for which collection schemes and recovery options are not sufficiently developed. Cooking oil is generally recycled and used for animal feed. However, because of recent legislative developments, this practice may not be possible in the near future. Therefore it is necessary to find another recovery option and an outlet for waste cooking oil.

The common method of deposing the oils in the sewage system is an illegal practice that causes many problems. The oils clog the sewage systems causing malfunctions in the filters and oil/water separators. Cooking oils can be recycled into an environmentally friendly fuel and could then be used by public transport in the city centre of Valencia, in Spain.

Project Objectives

The main objective of the project is to put Valencia's large volume of used cooking oils to good use. The project will develop a pilot scheme, the results of which will serve as a starting point for setting up an adequate collection system for waste vegetable oils. This system will collect not only domestic oils, but also those coming from the catering sector – the collection procedure involves oils used in the frying process in bars, restaurants and hotels.

All collaborating establishments are identified with a sticker, and they are given containers for the collection of used oil. Subsequently the oil collected in this way is processed in a plant that transforms it into biodiesel fuel, which is then used in Valencia's urban bus fleet. In this way, the project will also help reduce the amount of hazardous and polluting emissions, thus improving air quality in Valencia.

Project results

The project achieved the objectives outlined:

1. Implementation of a used vegetable oil collection procedure has stopped it from being dumped into the public drainage system. The collection system operated as follows:

- Three points were established in Valencia to collect domestic waste oils (on average around 100 litres/month were collected)

- In relation to the commercial establishments different kind of containers were used (from 20 to 60 litres). By the end of the Project 800 establishments were involved and around 800,000 litres of used cooking oil had been collected.

2. The oil collected was stored and sent to a transformation plant to produce bio-diesel, fuel to be used by urban buses. During the Project 322,654 litres of eco-diesel were used. The amount of eco-diesel/diesel mix used in the fleet was 1,778,140 litres and the buses covered 3,228,783 km.

3. As an additional result of the project, the beneficiary sent to Valencia City Council a proposal to establish, at local level, legal regulations to manage the used cooking oil.

Partners & Collaborators

IDAE (Institute for Energy Diversification and Saving).
UPV (Polytechnic University of Valencia).
FENEBUS (National Passenger Road Transport Federation).
FEVET (Valencian Federation of Tourist and Environmental Businesses).
AVEN (Valencian Energy Association).
FVMP (Valencian Federation of Municipalities and Provinces).
Department of Administrative and Procedural Law of the University of Valencia.
FEHV (Catering Business Federation of Valencia)

Case Study 3

MONTAÑA PELADA WIND FARM

Sector:	Wind Energy
Location:	Gáldar-Gran Canaria (Canary Islands)
Year:	March 2001

The company Agragua, S.A., which is registered in the town of Gáldar, on the island of Grand Canary, was set up on 10th February 1990 with the purpose of constructing and operating a sea water desalination plant to produce water for both agricultural use and for the general public supply. Initially Gáldar Council (Ayuntamiento de Gáldar) held a 60% stake in the company. In July 1997 the company took on its current shareholder structure, whereby it has over 500 shareholders from the agricultural sector.

Following the construction of a desalination plant with a capacity of 10,000 m3/day in 1991 and its subsequent expansion in 1998 to its current capacity of 15,000 m3/day, AGRAGUA S.A contacted the IDAE with a view to setting up an installation to reduce its energy bills and at the same time bring significant social benefits to the local area. Of the possible solutions put forward, that selected as being most favourable from the technical and economic point of view was the construction of a wind farm.

The Montaña Pelada wind farm is a wind power facility producing energy primarily for the operator's own use, as on average it does not feed more than 50% of the power generated into the grid and its main activity is not electricity generation. The desalination plant has an estimated annual electricity consumption of 25,000 MWh and it is envisaged that a large part of its energy requirements will be supplied by the new wind farm.

Description

The wind farm has an installed capacity of 4.62 MW and comprises 7 wind generators with a unit rated power output of 660 kW. It is located on a hill of the same name as the wind farm, south east of Gáldar. The wind generators are at a height of between 95 and 165 m above sea level and face the prevailing wind direction. This area is marked by steep slopes and was not used for any particular purpose. It has a number of access tracks which have been used by the wind farm.

The average annual wind speed is estimated to be 8 m/s at the hub height, and the main orientation is northnortheast.

The seven wind generators stand perpendicular to the dominant wind direction (trade winds) with a NWW-ESE orientation. They are arranged in two groups of 3 to 4 wind generators.

The net equivalent number of hours over the long term is estimated at 2,835 (capacity factor: 32 %). The wind generator are AE-46/I models, with a 46 m rotor diameter and 45 m hub height. The turbines control input power by aerodynamic loss. The generators used are of the asynchronous, double-winding type with reactive compensation and have proven themselves to be robust and reliable. The rotor turns at two speeds, a fact which, as well as increasing the power output, also reduces the noise emissions significantly. This model of wind turbine has been certified as class I.

The wind generators produce alternating-current electricity at a voltage of 690 V. This is stepped up to the wind farm's internal grid voltage (20kV) by drytype 700 kVA transformers located inside the towers. The power is conducted along a 3.5 km underground three-phase line (so as to avoid the visual impact of overhead electricity cables) to the substation at the desalination plant. Here it is used to power the reverse osmosis equipment and the excess is fed into the grid operated by UNELCO (ENDESA Group), which buys the electricity for distribution on the island of Grand Canary.

Promoters and parties involved

The promoter is AGRAGUA, S.A. The IDAE was responsible for procurement of the installation as a whole (call for tender, analysis of offers, contracting and supervision of the assembly, installation, commissioning and testing) and project management. MADE was selected as the supplier for the wind farm, which was delivered on a turnkey basis.

Financial resources

This wind farm received finance under the SMEs programme run by the IDAE with funds from the Institute itself and from the European Regional Development Fund (ERDF). Small and mediumsized companies interested in implementing rational use of energy and renewable energy projects, and which were located in regions of Spain considered to be "Objective 1" in 1998, were eligible for the programme.

The installation required an investment of €3,691 m, which was entirely financed through the IDAE-ERDF programme for SMEs at an interest rate equal to the MIBOR (Madrid Inter-Bank Offered Rate) minus three points, with a lower limit of the forecast CPI (reviewed annually) for the duration of the period financed (set at 8 years).

The project received a subsidy of €0.601m from the Energy Saving and Efficiency Plan (Plan de Ahorro y Eficiencia Energética, PAEE), 30% co-financed by the Directorate-General for Industry and Energy (€0.180m) and 70% co-financed by the ERDF (€0.421 m).

Results

a) In energy terms
It is envisaged that the plant will produce 13,100 MWh/year, equivalent to 2,835 hours a year of operation at its rated output. This is equivalent to the domestic consumption of approximately 4,000 Spanish households, and is equal to approximately 1,125 toe/year in terms of primary energy. During the first six months of effective operation of the wind farm (April to September 2001) the electricity generated was 7,768 MWh.

b) In environmental terms
The wind farm avoids the atmospheric emission of approximately 12,300 tonnes a year of CO2 (the main greenhouse gas).

c) In social terms
In addition to the energy it provides and its overall environmental friendliness, the wind farm has also created direct and indirect employment totalling 60 man/years during the design and construction period. This has had considerable impact on the local area, and in particular, civil engineering, electrical infrastructure and building the installation have all been contracted locally on the Canary Islands.

Potential for replication

The replicability of this wind power installation producing electricity for use by a desalination plant is of particular significance in the Canary Islands given the scale of demand for electricity and fresh water. The Canary Islands had 115 MW of installed wind power at the end of 2000, which represents 5% of the national total (2,270 MW). The Spanish renewable energy promotion plan (Plan de Fomento de las Energías Renovables en España), approved in late 1999, sets as its target for wind power the installation of a total of 250 MW electricity generation on the Canary Islands by 2010.

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Case study 4

BIOMASS CENTRALIZED DISTRICT HEATING NETWORK IN CUELLAR

Sector:	Biomass
Location:	Cuellar, Segovia (Spain)
Year:	January 2000.

The district heating and domestic hot water project at Cuéllar (Segovia) enables use of wastes from woodland underbrush clearance and other types of biomass to be used as fuel for a heating plant where water is heated for subsequent distribution to users via a pre-insulated dual pipe system.

Centralized district heating systems supply energy directly to users, avoiding the need for them to oversee their own installations or handle and store fuels. Such systems have a long tradition in countries such as the United States and in the centre and north of Europe (in Denmark and Sweden they provide half of all heating). By contrast, in Spain the installation of such heating grids is still a very new idea.

An additional important innovative feature of the project, which took place in Cuéllar is precisely the fact that the heating plant is fed on biomass. The use of this indigenous renewable energy source brings a variety of advantages. These are primarily environmental, given that it reduces the use of more polluting fossil fuels, but also social, as supplying the plant with biomass creates new economic activities in the vicinity.

An additional benefit for users of district heating systems is their lower cost compared with conventional systems. In the case of Cuéllar this can be quantified as a 10% reduction on previous heating bills. At present twelve single-family homes, five housing cooperatives, a social centre, a school and a sports centre are supplied with heating and hot water from the plant. In the future it may be possible for new users to connect to the grid, as the plant has sufficient capacity to allow for this.

Description

Obtaining the biomass

Cuéllar Council (Ayuntamiento de Cuéllar) manages the supply of biomass used as fuel by the plant. The boiler allows for the use of a broad variety of fuels, including initially the use of wastes from woodland underbrush and brash clearance, bark, wooden packaging materials, pine cones, etc.

Main principles of the installation

The installation consists of the following main components:

Heating plant

The heating plant consists of the following components:

- Storage silo with a capacity of 100 m3 and a fuel feed system.
- Main water tube boiler for the production of hot water, with a capacity of 4,500,000 kcal/h, with a moving grate combustion chamber and a multi-cyclone exhaust fume precleaner with a heat recuperator.
- Auxiliary water tube boiler for the production of hot water, with a capacity of 600,000 kcal/h, with a moving grate combustion chamber and a multi-cyclone exhaust fume precleaner with a heat recuperator.
- Electric pump units for hot water circulation through the boilers and circuit.
- Transformer, expansion tank, control system and other auxiliary components.

Distribution grid

The distribution grid connects the heating plant with the consumer centres. The grid uses pre-insulated carbon-steel piping with polyurethane insulation and high-density polythene for external mechanical protection. The pipe runs underground along a trench about 1 m deep and incorporates all the necessary stop valves, expansion joints, etc.

Connections with users

Each consumption centre has one or two heat exchangers in parallel with the current generation systems, and where necessary a domestic hot water storage tank. In addition there are stop valves, control valves, control devices, interconnection, and the other necessary items.

Energy process

The biomass arrives at the plant by lorry, where it is deposited in the 100 m3 silo. The fuel is pushed from the silo onto a series of belts by a series of hydraulic pushers at the base. These belts transport the fuel to the hoppers which feed the boiler.

In the boiler the water circulating in the coils is heated. This water exits the plant at a temperature of 95ºC, and is pumped around the 2 km distribution grid, which connects the various consumption points.

During the winter months when the system is providing heating and hot water, the main boiler is operated, whereas in summer, when only hot water is required, the auxiliary boiler is used and the grid operates at a lower flow rate.

Via the heat exchangers at the consumption points the water delivers the heat necessary to heat the secondary circuit, which provides the user with heat, and when necessary, hot water. Once it has delivered its heat, and thus at a lower temperature, the water returns to the plant via the return pipe, which runs parallel to the outbound pipe.

Promoters and parties involved

The project promoter was the Cuéllar Council (Segovia). EREN, the Castilla-Leon regional energy body (Ente Regional de la Energía de Castilla y León) and the IDAE (Instituto para la Diversificación y Ahorro de la Energía) participated in the financing of the project.

Financial resources

Implementing the turnkey system required an investment of €1,158,000. The financial resources needed to undertake this project were provided in equal parts by EREN, the Castilla-Leon regional energy body (Ente Regional de la Energía de Castilla y León) and the IDAE (Instituto para la Diversificación y Ahorro de la Energía), which signed a Participation Accounts contract for this purpose. A Third-Party Finance contract was also signed by Cuéllar Council.

The project benefited from a subsidy from the PAEE, the Energy Saving and Efficiency Plan (Plan de Ahorro y Eficiencia Energética) under the 1997 Order, for the sum of €220,252.

The project also receives a subsidy from the Regional Government of Castilla-Leon (Junta de Castilla y León).

Results

a) In energy terms
The use of waste biomass as fuel for the plant entails the substitution of conventional fuel. In this case the fuel previously used was C grade diesel. Under normal conditions of operation of the plant, this has been estimated to result in an energy diversification of 644 toe/year.

b) In technology terms
First of all the innovative nature of this project in Spain should be highlighted. The installation is functioning satisfactorily. The use of waste biomass to fuel a district heating network like that described is a replicable application. Applications of this kind do not need such a large supply of biomass as other projects, such as electricity generation.

c) Environmental
In addition to eliminating the risk of accidents existing with other types of fuel, the use of biomass entails a reduction in pollutant emissions.

d) Economic
The cost of the fossil fuel that would have needed to have been purchased if this project had not been carried out would have come to approximately €210,000 a year.

Potential for replication

The use of waste biomass in biomass thermal applications is particularly feasible in areas where there is forestry management and agriculture. Using this waste biomass in this way makes a contribution in terms of waste disposal and offers a service using a less polluting fuel.

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Case Study 5

SOLAR-THERMAL SYSTEM AT THE EL RAPOSO SPA

Sector:	Solar-Thermal Energy
Location:	Badajoz (Extremadura)
Year:	November 2000

Introduction

The El Raposo health resort was built in 1922 to exploit the medicinal mineral waters from springs on the site and it was declared to be of “public utility” in 1926. With a view to offering improved and more competitive services, the operating company Herederos de Antonio Cortes SCR decided to install a solar heating system to produce hot water for use at the spa and thereby reduce diesel usage.

Description

The system comprises a solar collector array of 150 flat solar panels, with a south-facing useable surface area of 315 m2 sloping at 30º to the horizontal. The storage system comprises five 5,000 litre tanks, a forced circulation system with an independent heat exchanger, auxiliary energy system and a remotely controlled electrical system for control and monitoring the performance of the system.

Energy data:

Design values:
Solar panel area: 315 m2
Usable annual solar power: 188.122 kWh
Energy demand: 253.431 kWh
Fuel substituted: 18.54 toe
CO2 emissions avoided: 166 tonnes

Technical details:
Unit: Solar collector
Manufacturer: Made

Model: 4,000 E
Unit: Storage tank
Manufacturer: Lapesa
Model: LPR-5,000
Unit: Heat exchangers
Manufacturer: Alfa-Laval
Unit: Water circuit
Technology: Disol

Promoters and parties involved

Owner: Herederos de Antonio Cortés SRC, a company whose main business is the establishment providing hospitality services and thermal waters.

Financial resources

Investment in system: €127,286
Own resources: €61,025
Investment subsidies:
Outright grant from PGE/Junta Extremadura: €19,878
ERDF/IDAE: €46,383

Results

As the installation is fitted with a remote monitoring system it has been possible to evaluate its energy performance. This has been found to be better than the design values, with an increase of 12.1% in the energy demand and 19.48% in the energy supply. Work is therefore underway to expand the system so as to make use of the excess thermal energy to offer new services at the spa (swimming pools, cafeteria, etc.)

Potential for replication

The positive experience acquired in the implementation of this project makes implementation of other similar installations among the large number of spa resorts in Spain a real possibility.

For more information

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Case Study 6

THE BIGGEST PHOTOVOLTAIC PLANT IN THE WORLD

The small Spanish town of Beneixama (Alicante) is at the moment scenario of the biggest photovoltaic solar park in the world. The company City Solar has installed 200 individual facilities of 100 KWp each inside the Costa Blanca, County of Alicante (Spain), a mega-project that began in August, 2006 and it was inaugurated on February, 2007. See air of the construction works in Beneixama in January 2007. At the end the solar park will supply with solar energy to more than 12.000 homes.

The park has a surface of 500.000 m², as big as 71 soccer fields. This data shows the dimension of this project. The project has 100.000 photovoltaic modules that will provide clean energy to more than 12.000 Spanish homes.

During the short phase of construction (1 year), more than 80 technicians will work on the project at the same time. Almost all tasks have been carried out by Spanish companies. The electric equipment is responsibility of the German multinational company Siemens. After its opening, the plant has produced up to 10 permanent work posts for plant maintenance. The same area was supposed to host a power plant, but the project had failed in 2005 due to citizen and city councils opposition. The local community on the search for environmental alternatives of power generation proposed this Solar project, which had been demanded for a long time by environmental groups.

Air view of the construction works in Beneixama in January 2007. The solar park will supply with solar energy to more than 12.000 homes.

3.2 RUE case studies

SPAIN

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Centre per a l'Empresa i el Medi Ambient

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n.26 *Pollution prevention case studies*

Replacement of cyanide salts in the cementation process of steel parts

Company background	Construcciones Mecánicas Domènech (Olot, Spain).
Industrial sector	Machining and assembly of power transmission components.
Environmental considerations	Parts of the geared-wheel, cogwheel, general gearing and axle, etc. -type, are subject to a two-stage heat treatment at an intermediate stage of the process. One of these is cementation (surface treatment to protect from friction and corrosion) and the other is tempering. The cementation process consists in adding carbon to the surface of the part at a specific penetration. These parts are deposited in ovens where, by using molten cyanide salts (that act as a fuel medium), the reductive atmosphere that works in forming the enriched cementation layer on parts is produced. The temperature, the time parts are in the ovens and the fuel media that are used are the factors that determine the depth of the cementation. The heat treatment ends with a tempering stage by oil or water bath, depending on the characteristics of the steel, the purpose of which is to obtain the required hardness. The use of these salts as a fuel medium involves the production of molten salts as well as the production of corrosive vapours that damage the facility's metal structure.
Background	The factors that led the company to make this change were the possible effect on the environment associated with the handling and storage of these salts, the complexity of the inertisation treatment of this special waste element and the incidence of the use of these cyanide salts in the working conditions of the company.
Summary of actions	The company replaced the cyanide salts with a hydrocarbon (methyl alcohol). The reductive gas is produced by a hydrocarbon controlled drip system that, when ignited within a furnace chamber (oven), produces the cementation or reductive atmosphere. This replacement involved the redesign and replacement of the cementation ovens, of their heating system and of the tubing and control units. Once the required cementation depth has been attained, the part goes on to the production line.

Diagrams

OLD UNIT

NEW UNIT

Balances

	Old process	New process
Balances of material and energy		
Consumption of cyanide salts	3,349 kg/year	0 kg/year
Consumption of methyl alcohol	0 l/year	820 l/year
Generation of special wastes associated with this stage	2,850 kg/year	0 kg/year
Electrical consumption of cementation	465,150 kwh/year	118,200 kwh/year
Consumption of gas natural	0 m^3/year	18,725 m^3/year
Economic balances		
Cost of cyanide salt consumption	11,072.3 €/year	0 €/year
Cost of methyl alcohol consumption	0 €/year	1,652.8 €/year
Cost of cyanide waste management	8,173.8 €/year	0 €/year
Cost of electrical consumption	50,736.8 €/year	8,882.2 €/year
Cost of natural gas consumption	0 €/year	10,127.1 €/year
Cost of facility maintenance	8,392.3 €/year	2,424.9 €/year
Savings		
Consumption of cyanide salts		11,072.3 €/year
Waste management		8,173.8 €/year
Consumption of energy		31,727.1 €/year
Facility maintenance		5,967.4 €/year
Investments		
Investment in facilities		186,185.0 €
Payback period		3.3 years

Conclusions

The replacement of raw materials with other materials that pollute less have meant the 100% reduction at source of the waste generated in the process under study as well as the reduction in risk to the environment and to people with no change in the quality of the product sold. It should also be mentioned that, with this initiative, the company is preventing the production of a waste that involves difficulties both in transport and subsequent treatment.

NOTE: This case study only seeks to illustrate a pollution prevention example and should not be taken as a general recommendation.

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nº 51 Pollution prevention case studies

Substitution of a system of chemical pickling by a process of pickling by vibration

Company background

Munne Alsina, SL (Cornellà de Llobregat, Spain)

Industrial sector

Steel and metal industry. Non-iron metal forge and hot hobbing.

Environmental considerations

The company is dedicated to forging and hot hobbing of non-ferrous metals using as raw materials brass, bronze and other metals to obtain a wide range of articles, basically hobbed pieces for several industrial sectors. The company also manufactures special pieces upon request by its customers.

The production process consists of the following steps: first, the moulds are produced according to the pieces to make; second, the pieces are obtained by means of forging presses that perform, in the same machine, cutting, hobbing and typing. Finally, the finishing process of the brass pieces is made. Finishing is carried out by means of chemical pickling with nitric acid and chromic passivation. Between operations, the necessary rinsings are carried out.

During the finishing process, water and acid raw materials are consumed, generating sludge with heavy metals during the treatment of the waste flows in the wastewater treatment plant.

Background

In the production process described in the preceding section, Munne Alsina, SL generated acid and chromic aqueous waste flows that, along with the drags with heavy metals, generated sludge in the wastewater treatment plant and water with nitrates.

The amount of sludge generated was 69 tons per year.

Therefore, the company considered as objectives:

- To reduce at source the waste generation
- To save in the purchase of raw materials

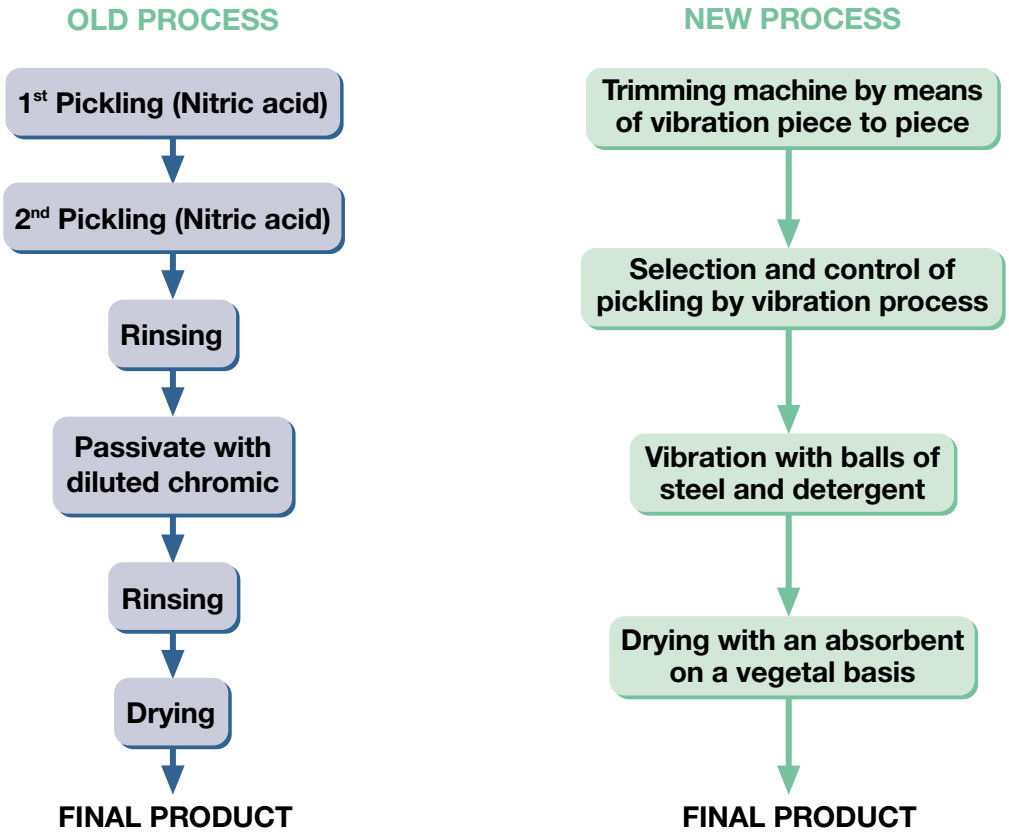
Summary of actions

In order to carry out the objectives proposed, a new installation was installed to replace the process of chemical pickling. This new installation consists of a trimming machine by means of vibration piece to piece and pickling by vibration with balls of steel and detergent that, through physical contact, allows obtaining the desired quality in the pieces.

With this new installation, the following is achieved:

- Reduction in water consumption
- Reduction in electricity consumption
- Reduction in raw materials consumption
- Reduction in the generation of sludge in the wastewater treatment plant
- Less use of hazardous raw materials

Diagrams



Balances

	OLD PROCESS	NEW PROCESS
Material balance		
Sodium hydroxide (kg/y)	42,911	5,871
Sodium bisulphite (kg/y)	11,880	0
Nitric acid (kg/y)	48,031	0
Chlorhydric acid (kg/y)	2,200	0
Dilute chromic (kg/y)	15,510	0
Vegetal-based absorbent (kg/y)	0	500
Detergent (kg/y)	0	5,000
Water (m^3/y)	6,497	5,493
Energy (kW/y)	92,000	42,000
Sludge (t/y)	69	5
Economic balance - Savings		
Raw material (€/y)		21,223
Water (€/y)		911
Energy (€/y)		3,900
Treatment of sludge (€/y)		5,050
Total savings (€/y)		31,084
Investment (€)		106,284
Payback period		3.42 years

Conclusions

By carrying out this project, the company has been able to reduce 95.44% the consumption of raw materials, sludge equivalent to 92.75% of the generated waste volume and finally, reduce 15.45% the water consumption. In addition, the quality of the wastewater has been improved, which favours its recycling by means of a previous process of regeneration.

This action of pollution prevention at source is part of the environmental policy of the company since it is included within the framework of continual improvement initiated by the company in 2000.

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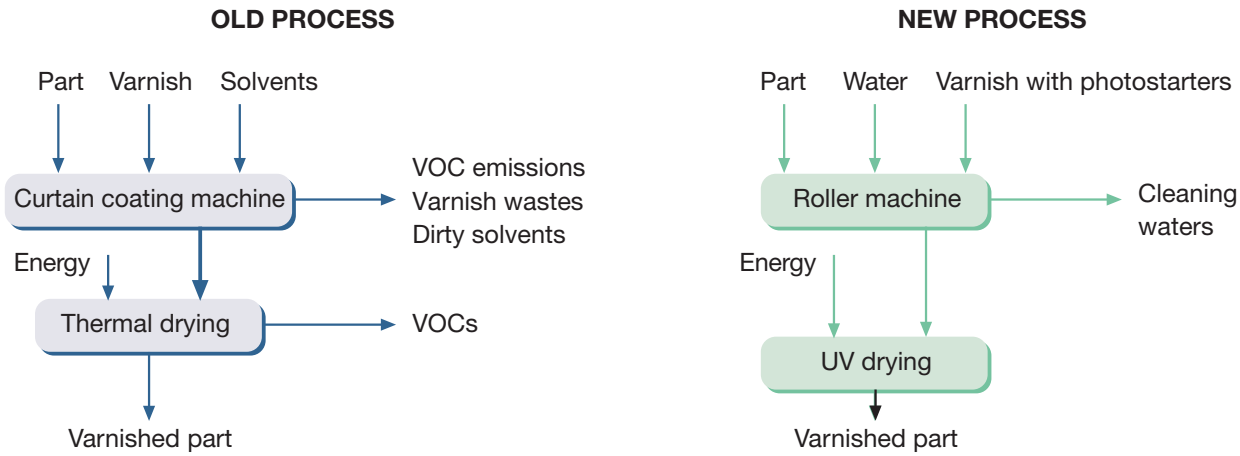
n. 64 Pollution prevention case studies

Changing of the installation of varnish application and drying of wood parts

Company	Sillería Vergés, SA, Tortellà (Spain).
Industrial sector	Wood and furniture sector.
Environmental considerations	The company Sillería Vergés, SA manufactures wooden tables and chairs, amongst other pieces of furniture. During the manufacture process, the parts first go through the dyeing phase, followed by the finishing phase in which varnish is applied. This last coat is applied by a curtain coating machine and the varnished parts are then introduced in a hot air tunnel to dry. This varnishing operation can be repeated according to the type of part and finishing required. The products used in the varnishing process are solvent-based and the machine used is batch-operated and therefore always requires a minimum quantity of varnish for a smooth application. Once the product is applied to the parts, the machine is cleaned using a solvent and, in order to prevent varnish residue incrustations, the machine is left full of solvent. This technology led to the emission of volatile organic compounds (VOCs) and the generation of wastes from excess varnish and dirty solvents.
Background	As explained previously, the company produced waste from used varnish and dirty cleaning solvent wastes. In 2003, a plan was outlined to minimize the generation of these residues, while introducing some modifications to optimize the production process. Actions were based on the following measures: • To reduce varnish consumption. • To reduce solvent consumption. • To reduce the quantity of varnish and solvent residues. • To reduce VOC emissions to air.
Summary of actions	The project consists in: • Installing a continuous varnish application line and roller conveyor. • Changing solvent-based products for aqueous-based products. • Drying or fixing the varnish using UV lamps. The use of this type of products based on acrylic acid esters and photostarters (aqueous-based) presents many advantages when compared to traditional systems, as it allows to eliminate the use of solvents, reuse excess machine product, use water for cleaning operations, minimize the amount of product consumed and dry the parts without heat and in less time, in seconds; this also guarantees that there is no loss of quality in the handling of the parts painted.

Diagram of the process



Balances	OLD PROCESS	NEW PROCESS
Balance of materials		
Varnish consumption (t/y)	14.4	2.0
Solvent consumption (t/y)	5.7	0.3
Cleaning water consumption (m^3/y)	0.0	95
Varnish wastes (kg/y)	3,300	150
Solvent wastes (kg/y)	5,100	50
Economic balance		
Cost of varnish with photostarter purchase (€/y)	18,079	11,900
Cost of solvents purchase (€/y)	6,625	1,450
Cost of water purchase (€/y)	0	28
Cost of varnish waste management (€/y)	1,782	92
Cost of solvent waste management (€/y)	4,581	100
Cost of cleaning water management (€/y)	0	570
Energy cost (€/y)	1,815	1,002
Savings and expenses		
Savings in varnish purchase (€/y)		6,179
Savings in solvent purchase		5,175
Savings in varnish waste management (€/y)		1,690
Savings in solvent waste management (€/y)		4,581
Energy savings (€/y)		813
Total savings (€/y)		17,740
Investment in installations (€)		32,044
Investment payback		1.8 years

Conclusions

Through the implementation of this project the company achieved a reduction of 12.4 t/y in varnish waste, 5.4 t/y in finished solvent waste, 17.8 t/y in raw material consumption, 813 €/a in energy consumption and associated emissions to air; 100% of VOC emissions to air have been eliminated.

These at source pollution prevention actions are the result of the company's environmental policy included in the continual improvement programme that was started in 2000. During that year, the company carried out a Minimization Opportunities Environmental Diagnostic (MOED) jointly with the Centre for the Enterprise and the Environment (CEMA) aimed at identifying at source pollution minimization opportunities.

NOTE: This case study only seeks to illustrate a pollution prevention example and should not be taken as a general recommendation.

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n. 66 Pollution prevention case studies

Ultrasonic welding system of plastic parts

Company	Peguform Ibérica, SL, Polinyà (Spain).
Industrial sector	Automotive. Manufacture of plastic parts for motor vehicles.
Environmental considerations	Peguform Ibérica, SL, manufactures plastic parts for the automobile industry such as, bumpers, shock absorbers, mudguards, door panels, trims, etc. The production process is based on the manufacture of the different plastic parts using injection machines and high temperature and pressure moulds. Subsequently, the paint, varnish and finish are applied. One of the manufactured pieces are the airbags. The passenger seat airbags must comply with the requirements of damage prevention to persons in case of use, which is achieved by using composite materials for the cover. These materials are obtained by joining a polypropylene part with an elastomer part (EPDM rubber). These two parts are joined together with a double injection machine that uses a one-shot system to join both parts through fusion heat. This technique causes many rejects due to lack of quality of the finished parts.
Background	The high costs that company had to assume as a result of the large amount of waste generation and high consumption of raw materials and resources, led the company to implement an action plan in 2002 to minimize them. Actions focused on the following aims: • Achieving a process that would allow reducing the rejects from the manufacture of airbag covers. • Reducing the consumption of raw materials and resources by increasing process efficiency.
Summary of actions	The project consisted in installing a system to join both parts using ultrasound or vibration welding. This technique allows welding the two parts using heat generated by the Joule effect. This change in the way of joining the parts has enabled to reduce the generation of non-conformities of parts that are joined and also of finished parts, allowing to minimize the generation of waste and to reduce the raw materials and natural resources used.

Photograph of the installation

Balances	OLD PROCESS	NEW PROCESS
Balance of materials		
Polypropylene consumption (t/y)	210	159.9
Elastomer consumption (EPDM rubber) (t/y)	22	Outsourcing manufacture
Injection rejects (t/y)	58	2.6
Economic Balance		
Polypropylene cost (€/y)	273,000	207,900
Elastomer (EPDM) cost (€/y)	77,000	107,400*
Management cost of internal injection rejects (€/y)	1,000	48
Energy cost (€/y)	64,000	28,900
* Cost increase due to outsourcing manufacture		
Savings and expenses		
Savings in raw material consumption (€/y)		34,700
Savings in rejects management (€/y)		952
Energy savings (€/y)		35,100
Total Savings (€/y)		70,752
Investment in installations (€)		51,700
Payback period (years)		0.73

Conclusions

The implementation of the project has led Peguform Ibérica, SL to minimize the amount of internal rejects from injected and welded parts, whether finished and painted or not, allowing to reduce its internal rejects by 95.52% and its polypropylene consumption by 23.85%, while avoiding the processing of defective parts and the consumption of paint and resources such as energy and water, which lead to additional benefits aside from those shown on the balance and that are difficult to quantify.

NOTE: This case study only seeks to illustrate a pollution prevention example and should not be taken as a general recommendation.

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4. PROPOSALS FOR A MORE SUSTAINABLE ENERGY DEVELOPMENT

Objective: Pointing out the feasibility of relevant changes within the country, to propose new, more ambitious RUE and RE objectives, their appropriate policies and strategies, and the most adequate tools and financing. These propositions will provide a first set of possible actions for a more sustainable energy development scenario. Its relevant costs and economic, social and environmental advantages will be mentioned.

4.1 Proposals

In this section, some **proposals**, which will help strengthen the country's sustainable development policies within the field of energy, have been elaborated. They are listed below.

The Spanish government should revise, update and upgrade the **National Sustainable Development Strategy** and at the same time, using if necessary this updated strategy as a reference document, promote the elaboration or update by each Autonomous Region of its own **Sustainability Autonomous Region Strategies** according to global and EU objectives.

This National Strategy should incorporate, update and/or upgrade all already developed strategies and plans related to Spain's future Sustainability and act and interact at horizontal level with all national sectoral strategies, plans, Ministries, departments and public policies. As an example, the National Strategy should incorporate **more ambitious** policies, specific sectoral strategies and action plans in fields that so far are not fully addressed (all of which directly related to *energy efficiency, renewable energy and GHG emission reductions*) such as:

- Sustainable **land use / urban development "smart growth"**;
- Sustainable **transport** strategy (land, sea, air transport and its infrastructure);
- Sustainable **technology "low carbon"**;
- Sustainable **population**;
- Sustainable **public services.** The Spanish government should give example to all stakeholders and the society as a whole with *more aggressive energy efficiency, renewable energy and green purchasing* policies and projects in its own facilities, buildings and infrastructure at all levels and in all governmental institutions.

Other energy related measures:

Energy / carbon policies

- Set a "real" price of carbon implemented through taxes, trading or regulation.
- Review energy tax and subsidies policies to prevent market distortions and send the right signals to consumers.
- Enhance co-ordination of energy-related policies among different ministries and regional authorities in order to improve the coherence of energy policies (e.g. energy vs. land use / infrastructure planning / "urban smart growth", etc.).

Research, development and innovation

- Support innovation and deployment of low-carbon technologies.
- Support energy R&D and deployment of new low-carbon technologies in coordination with the new EU Energy policy.

Outreach and education

- Increase initiatives to inform, educate and persuade individuals and companies about what they can do to respond to climate change.

Energy competition

- Consider how to increase the number of energy market players (including foreign companies) to stimulate competition further on all types of energy.

Coordination with Autonomous Regions

- Consistency should be sought in the measures taken by Autonomous Regions.
- Encourage Autonomous Regions to formulate their own strategies and policies for CO2 emission reductions in line with national policies.

Electricity, natural gas, co-generation and nuclear power

- Develop an effective energy infrastructure, electricity and gas networks in Spain and network interconnections with neighbouring countries to achieve the objectives of sustainability, competitiveness and security of supply.
- Ensure fully market liberalization in the gas and electricity sectors while not preventing new entries.
- Monitor gas sector growth, plan for possible effects of a major gas supply disruption and set up an emergency plan.
- Assess the impact that retiring nuclear reactors would have on energy security, diversity of energy supply, the economy and the environment.
- Assess the operating life extension of existing nuclear reactors until other low-carbon energy sources are introduced to cover that energy supply.
- Ensure progress and plan formulation on the final disposal of high-level radioactive waste.

Coal

- Start up as soon as possible the planned co-combustion program on combining combustion of biomass and coal in 19 existent power plants in Spain.
- Continue restructuring the coal industry, cut subsidies, eliminate other distortions and progressively decrease the industry's size, while limiting welfare and regional effects.

Renewables

- Conduct a National Study to radically increase renewable energy production in Spain (including cost-benefit analysis, objectives, measures, budget, potential financing, obstacles, etc.).
- Examine the need to increase funding to facilitate the integration of renewable energy into the energy grid.

5. ANNEXES

5.1 List of main references used

Energy Saving and Energy Efficiency Strategy 2004-2012 (E4 Strategy). Ministry of Economy, 2003.
Energy Saving and Energy Efficiency Strategy 2004-2012 (E4 Strategy). Action Plan 2005-2007. Ministry of Economy, 2003.
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5.2 Acronyms and symbols

Acronyms

IDAE: Instituto para la Diversificación y Ahorro de la Energía (Energy Saving and Diversification Institute)
INE: Instituto Nacional de Estadística (Statistical National Institute)
CORES: Oil Products Strategic Reserves Corporation
REE: Red Eléctrica de España, S.A. (Spanish Electric Network Company)
DGPEM: Dirección General de Política Energética y Minas (Department of Energy Policy and Mines)
EU: European Union
CNE: Comisión Nacional de Energía (National Energy Commission)
CCGFT: Combined-cycle, gas-fired turbines technology
GN: Gas Natural Company
CLH: Compañía Logística de Hidrocarburos (National Hydrocarbons Logistics Company)
PNA: National GHG Emissions Assignment Plan
RUE: rational use of energy
RE: renewable energy

Units

GWh: Gigawatt per hour
MWh: Megawatt per hour
Ktoe: Thousands of oil equivalent tons
Kt. Thousands of tons
Toe: oil equivalent tons
Mt: Million tons
Boe: barrels of oil equivalent

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