ALICE Electricity Sector Country Study: **Spain**

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Contents

1 Introduction

Compared to other EU countries, the electricity sector in Spain is fairly diversified with a large expansion of natural gas and wind especially in the last 10-15 years. In 2003 the electricity market was fully liberalized, even at a faster pace than required by the EU (Eurostat 2007).
This study tries to describe the current situation.

The outline follows the structure of the "Country Comparison Catalog" (CCC) suggested by Michael. This study starts with a short and brief historical background of the nearest past of the Spanish electricity market, as the current situation might be a result of the historical evolution.

2 Historical Background

Spain comprises 17 autonomous regions. Every region has its own parliament. Although Spain is the second largest country in Europe with about 505,000 km^2 it is not very densely populated. Most inhabitants live in the capital Madrid and in large cities in the costal areas (IEA 2001).
In 2007 about 40.4 million people lived in Spain with a density of 81 persons per km^2 and a population growth rate of 0.12% (Encarta). The electricity consumption per capita was 6,000 kWh in 2006 (Domínguez et al. 2007).
In 2007 Spain had an estimated GDP of 1,434.3 bn US$. Since 2003 Spain has a static economic growth rate, in 2006 with a real GDP growth of 3.9% and an estimated growth rate of GDP of 3.3% in 2007 (Economist 2007).
With an unemployment rate of 8.5% Spain reached in 2006 an all-time low at least since 1995 (Eurostat).
Referring to Economist, energy products contributed with 9.5 billion US$ to the principal exports and with 49.8 billion US$ to the principal imports of Spain.

Figure 0: Map of Spain
(Source: IEA 2001)

Spain has experienced a high rate of economic growth during the last 25 years. Especially industrialization and the joining of the EU in 1986 contributed to this growth. During this time energy consumption increased as well with a high rate and there has been considerable investments in energy systems infrastructure and capacity. The energy and electricity market had to restructure to fulfill the growing energy and electricity demand after 1986. As a result of the increasing demand Spain had an increased reliance on imports. This has led to greater energy security concerns. Still in 2004, Spain is highly dependend on imports (energy dependency rate in 2004: 77%) and although the Spanish energy market is highly diversified in comparison to other EU countries, Spain is mostly dependend on petrolium products. Renewable energy resources developed substantially during the past 10-15 years, espacially wind power. In 2004, Spain was the second largest county of the EU in terms of installed wind capacity (Eurostat 2007).

The main challenges for the energy policy are energy security and climate change mitigation. Spanish policy tries to adress this chalanges mainly by energy efficiency and renewable energy resources (Eurostat 2007).

Electricity consumtion increased about 5% per year since 1980. This is nearly double the growth rate experienced in the EU. The major source of Spanish electricity generation comes from solid fuels, which is also Spain´s major domestic energy resource.
Hydro, as another important resource for electricity production, fluctuates in its contribution and thereby influates not only the other resources but also the share of imports and exports. Therefore hydro energy does not contribute much to the goal of energy security. In general the share of hydro decreased. When the share of electricity production was about 40% at the beginning of the last century, its share decreased over the time due to thermal power plants and later nuclear power plants starting in the mid-sixties of the last century (IEAHydro). Nevertheless electricity generation by hydro power plants is still a substantial resource with a share of 12% in 2004 (Eurostat 2007).
Much of the diversification of the electricity market occurred during the past 15 years as a result of the increasing demand. In particular the shares of natural gas and wind increased. Today natural gas fired power plants are the main resource for electricity production in Spain, in comparison to its share of rather 1% in 1990. Wind grew from 0% in 1990 to nearly 6% in 2004 (Eurostat 2007).

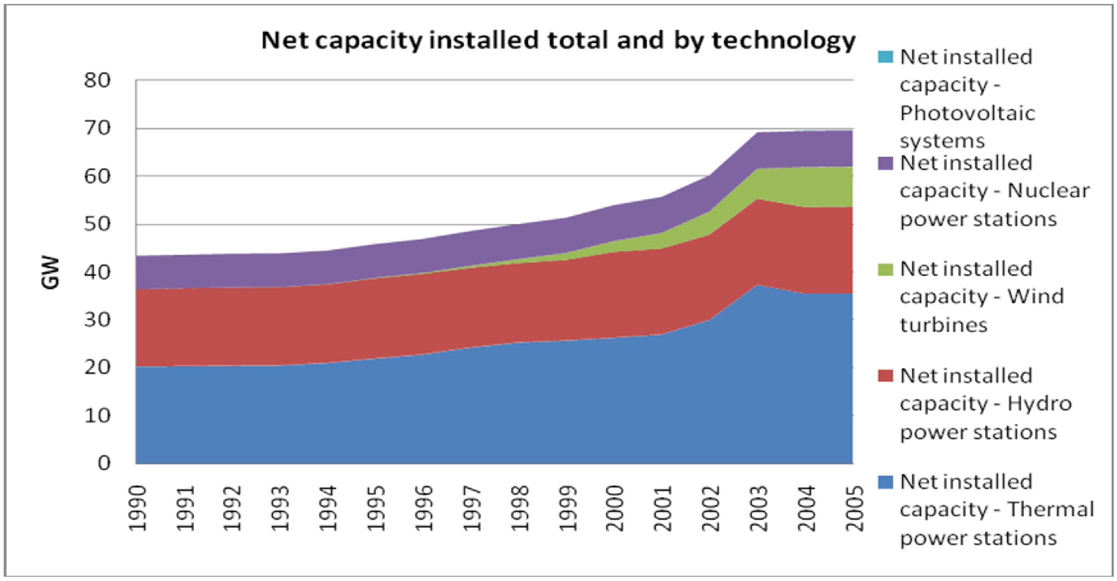
The electricity markets are fully liberalized since 2003, at a faster pace than required by the EU. Another challenge will also be the true competition on the electricity market beyond liberalization (IEA 2001).

Together with Portugal, Spain forms the Iberian electricity market (MIBEL). Since the Memorandum of Agreement, signed on 29 July 1998, the administrations of the countries aim to increase cooperation in case of energy. Although Spain and Portugal have much in common in case of electricity production and its current situation, there are differences in geography, economic and energy terms (Domínguez et al. 2007).

3 Basic Data

3.1 Total Capacity installed by technology since 1990

Figure 1: Net capacity installed total and by technology, cumulative (source: Eurostat NRG_113a)



Referring to the Eurostat database Spain had a total installed capacity of 69.590 GW in 2005 (see figure 1). Nearly 51% is allocated in thermal power stations (35.477 GW), some 26% in hydro power stations (18.219 GW), about 12% in wind turbines (8.317 GW) and about 10% in nuclear fission reactors (7.577 GW). The contribution of renewable energies without wind and hydro is less than 0.1%.

Regarding to the period from 1990 to 2005 nuclear power stations and hydro power stations remained quite constant while there was an increase in total capacity installed of about 60.3%, an increase in thermal power stations from about 1993 till 2003 followed by a decrease and an increase of wind turbines from 7 MW in 1990 to 8,317 MW in 2005).

Photovoltaic systems just contributed 0.037 GW in 2005 (Eurostat NRG_113A)[1].

[1] Eurostat only provides provisional values for net installed capacity – total / thermal power stations / nuclear power stations in 2005. The last exact value is 69.489 GW in 2004 for total net installed capacity.

3.2 Annual electricity production by technology since 1990

Figure 2: Evolution of Electricity Generation, cumulative, 1971-2004 (Source: iea.org 2006: http://www.iea.org/textbase/stats/pdf_graphs/ESELEC.pdf)

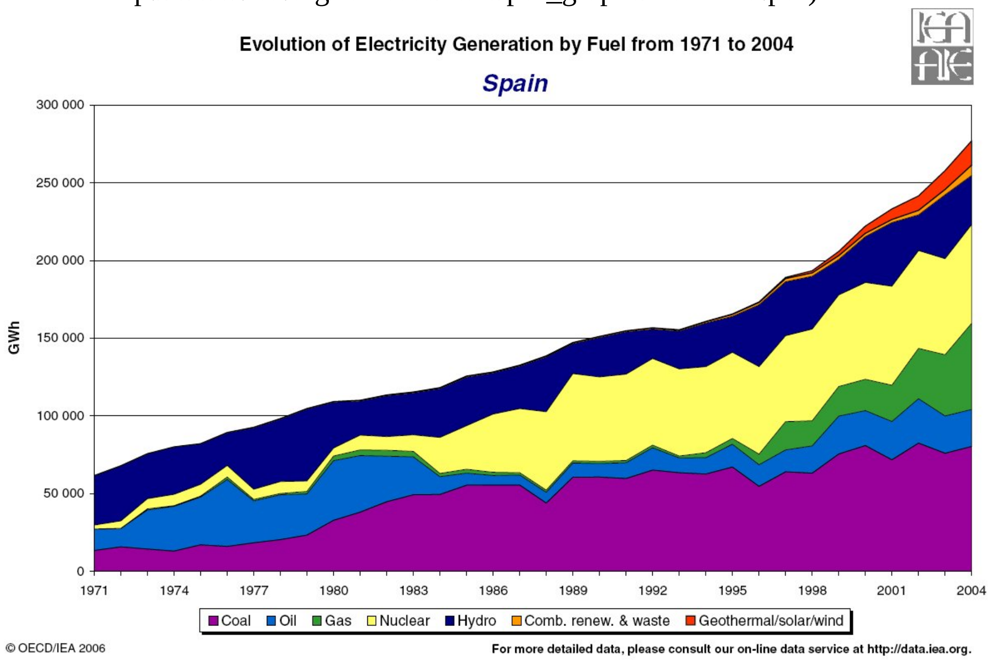


Figure 3: Gross electricity generation by fuel 1990-2005, cumulative (Source: Eurostat NRG_105A)

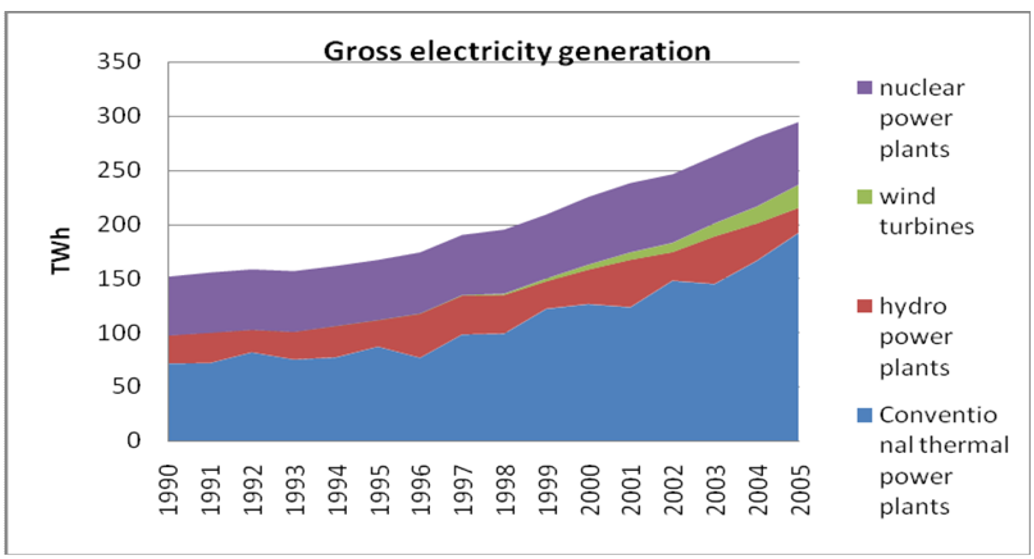
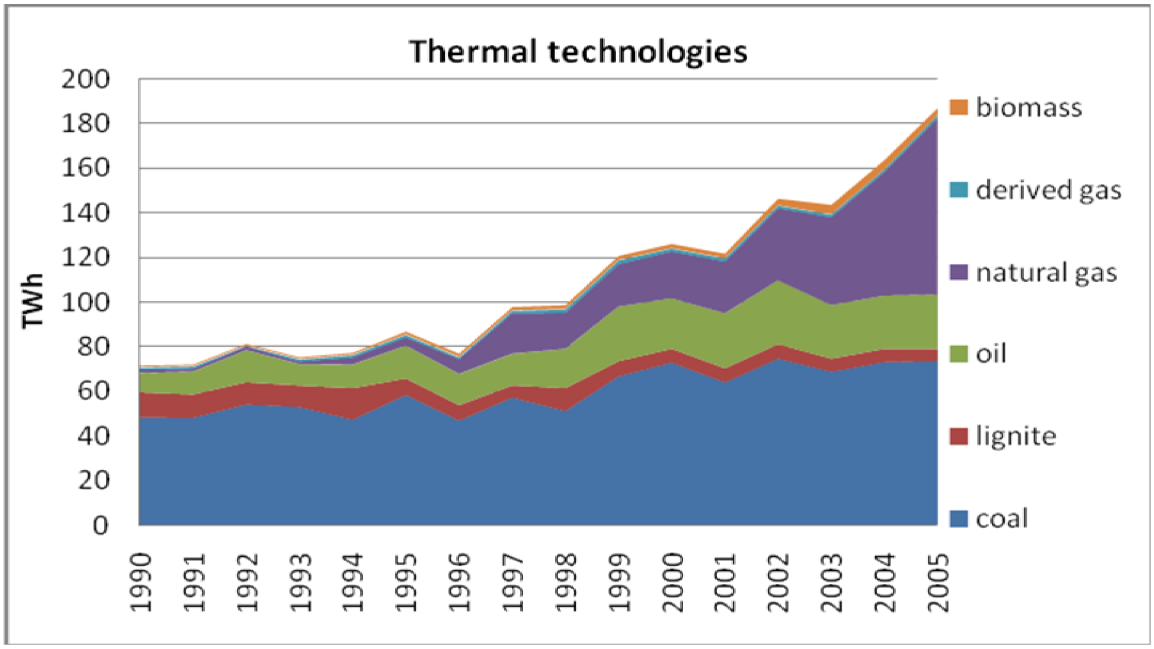


Figure 4: Gross electricity generation from thermal generation technologies, cumulative (Source: Eurostat NRG_105a)



The electricity power system in Spain, compared to other EU countries, is fairly diversified. The total electricity production in Spain increased from 151.838 TWh in 1990 up to 294.077 TWh in 2005. This is an increase of 142.239 TWh, i.e. a growth from 1990-2005 of about 93.7% (NRG_105a) (see Figures 2 and 3).

In 2005, conventional thermal power plants were the main fuel used for energy production, with a generation of 192.218 TWh and a share of 65.4%, followed by nuclear power plants (57.539 TWh / 19.6%), hydro power plants (23.023 TWh / 7.8%) and wind turbines (21.219 TWh / 7.2%).

In case of conventional thermal power plants with a total generation of 294.077 TWh natural gas played the mayor role and contributed 79.011 TWh, followed by coal with 73.636 TWh, oil, lignite, biomass and derived gas (see Figure 4).

That means, natural gas fired thermal power plants developed to the main fuel used for electricity production in 2005 in Spain with a total share of 26.9%, followed by coal fired thermal power plants (25%), nuclear power plants (19,6%), oil fired power plants (8.3%), hydro power plants (7.8%) and wind turbines (7.2%).

Non-hydro renewable energy sources (wind turbines (7.2%), biomass fired thermal power plants (1%)) have a total share of 8.2% in the Spanish energy mix. Therefore 16% of the Spanish electricity generation is produced out of renewable sources.

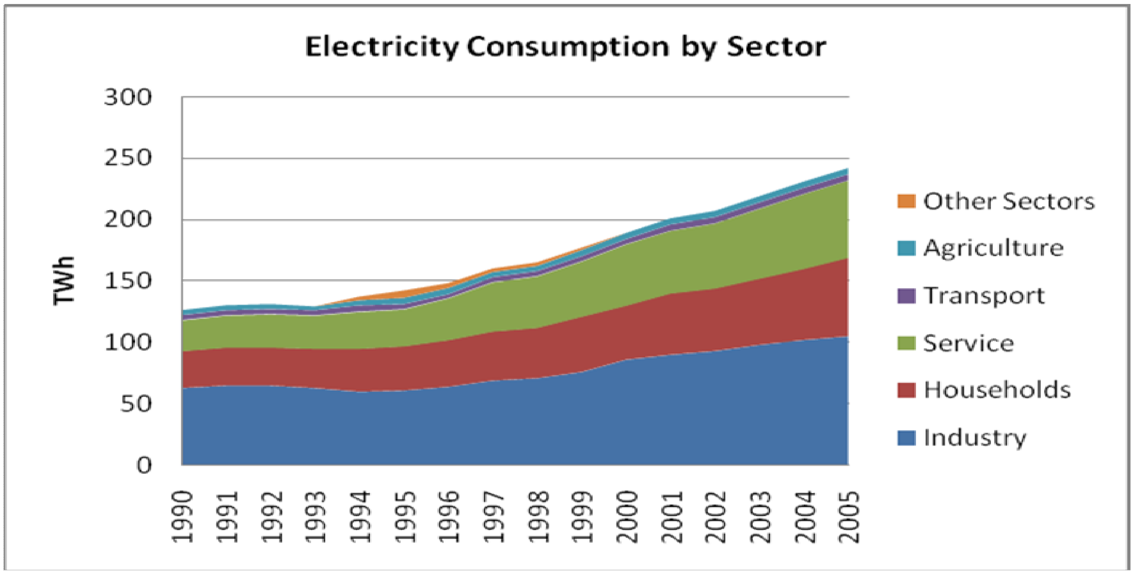
Especially the role of natural gas increased dramatically in the last years (from 1.509 TWh in 1990 up to 79.011 TWh in 2005) with a growth rate of 42.5% in 2005, while the role of lignite decreases a bit. Nuclear power plants and hydro power plants remained quite constant during the years while wind turbines also increased dramatically (from just 0.014 TWh in 1990 up to 21.219 TWh in 2005), especially since 1996.

In total, natural gas has established to play the major role in the Spanish energy mix while renewable resources also play an increasingly important role. The increasing gross electricity generation can be traced back to the increasing role of natural gas and, in a smaller amount,

wind turbines and renewable energies, because no other energy resource decreased dramatically.
This corresponds also with the country case study of IEA of 2001. Regarding to the study the generation mix in 2010 is expected to change a lot. The share of nuclear is expected to be 24.4%, natural gas 24.1%, hydropower 14.7%, renewable and waste 14.9%, coal 14.2%, and oil 7.6%. Thereafter renewable and natural gas would increase their shares, while coal, nuclear, and oil would decrease (IEA 2001).

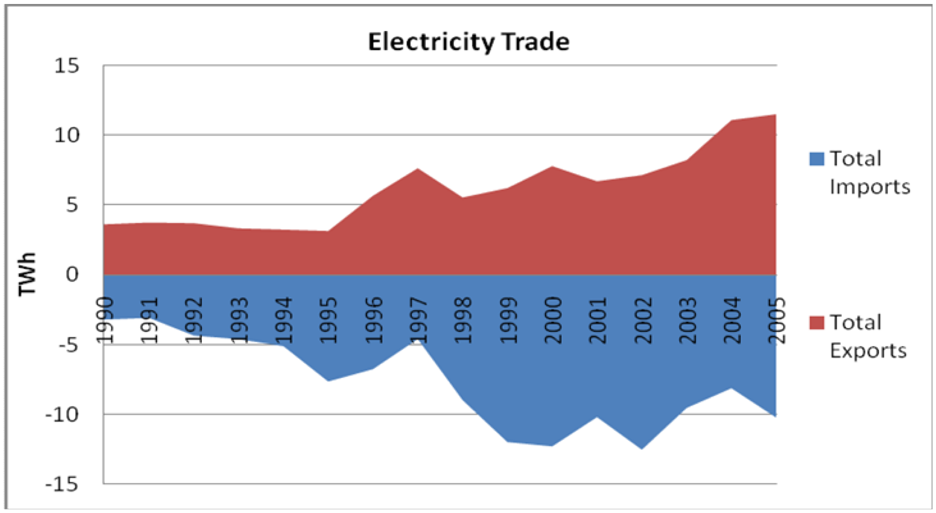
3.3 Electricity Demand and Trade

Figure 5: Electricity Consumption by Sector
(Source: Eurostat NRG_105A)



The development of electricity energy consumption is shown in figure 5. 242 TWh of electricity was consumed in 2005 by all sectors. In this year, electricity energy consumption is driven by the industry sector (105 TWh / 43% of total consumption), the household sector (64 TWh / 26%), the service sector (63 TWh / 26%), the transport sector (5 TWh / 2%) and the agriculture sector (5 TWh / 2%). The electricity demand increased in all sectors. The industry sector had a consumption growth from 1990-2005 of 67%, the household sector of 113%, the service sector of even 152% and the transport and agricultural sector of each 25%. The total growth of electricity consumption during this time is 92%.
Since 1980 electricity consumption has grown about 5% per year. This is nearly double the rate experienced in the EU as a whole (Eurostat 2007).

Figure 6: Electricity Trade 1990-2005 (Source: Eurostat NRG_105A)

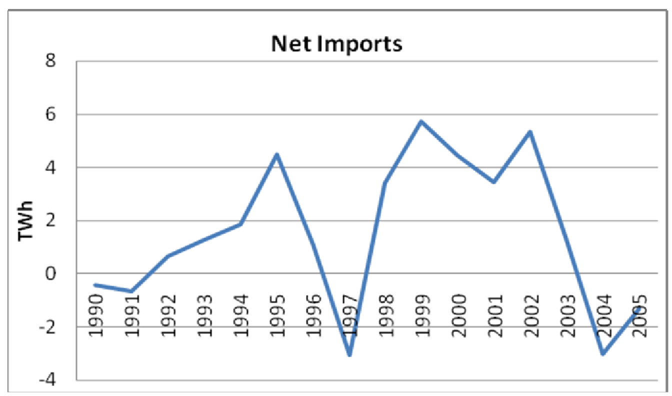


The imports, as well as the exports of electricity, have grown over the last years. In the time between 1999 and 2002 imports exceed over exports. Table 1 and figure 7 give an overview of the development of im- and exports and declare Spain as a net importer, although exports exceed over imports in the last years.

Table 1: Total Im- and Exports (Source: Eurostat NRG_105A)

Jahr	Total Imports [TWh]	Total Exports [TWh]	Net Imports (Imports - Exports) [TWh]
1990	3,208	3,628	-0,42
1991	3,083	3,762	-0,679
1992	4,351	3,71	0,641
1993	4,606	3,339	1,267
1994	5,106	3,251	1,855
1995	7,633	3,147	4,486
1996	6,75	5,69	1,06
1997	4,597	7,67	-3,073
1998	8,964	5,562	3,402
1999	11,959	6,24	5,719
2000	12,268	7,827	4,441
2001	10,177	6,727	3,45
2002	12,504	7,175	5,329
2003	9,52	8,257	1,263
2004	8,111	11,139	-3,028
2005	10,212	11,555	-1,343

Figure 7: Net Imports (Source: Eurostat NRG_105A)

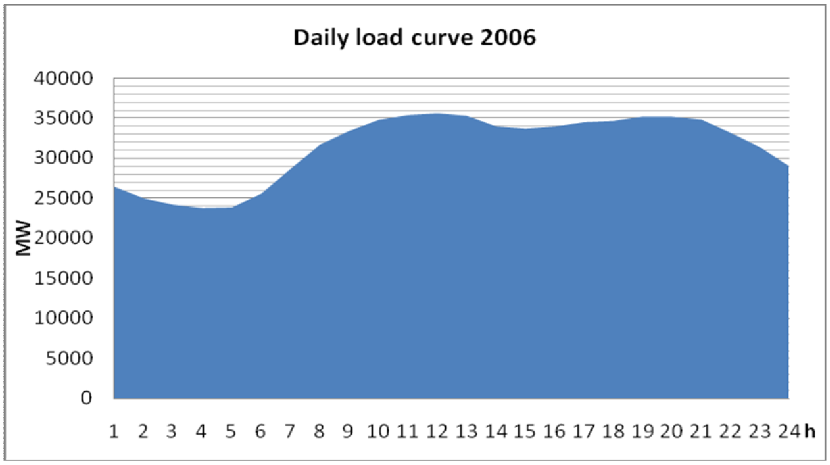


In 1998 Spain had a high reserve margin of 50% indicating over-capacity. However, consumption increased rapidly and there were only modest investments in new capacity in the following years. Additionally, hydro power is very sensitive to weather conditions and the generation varies from year to year and season to season. Therefore, excess capacity has diminished.

In 1999 18.1 TWh electricity was traded. The volume of imported electricity increased up to 5.6% of total electricity consumed in 1999. Spain is importing electricity from France and Portugal und exports electricity mainly to Andorra, France, Morocco and Portugal. Spain tries to increase interconnections with France (see section 8), but this has not yet happened mainly because of environmental and other constraints (compare IEA 2001, 2007).

3.4 Load Factors

Figure 8: Daily Load Curve 2006
(Source: own calculation based on UCTE 2006)



A description of how energy is used is given by the daily load curve (see figure 8). It shows the hourly capacity of every third Wednesday of a month, in this case averaged for all month, in 2006. The all-day minimum load value is between 4-5 am and about 33% less than the all-day maximum around 12 am and 7-8 pm.

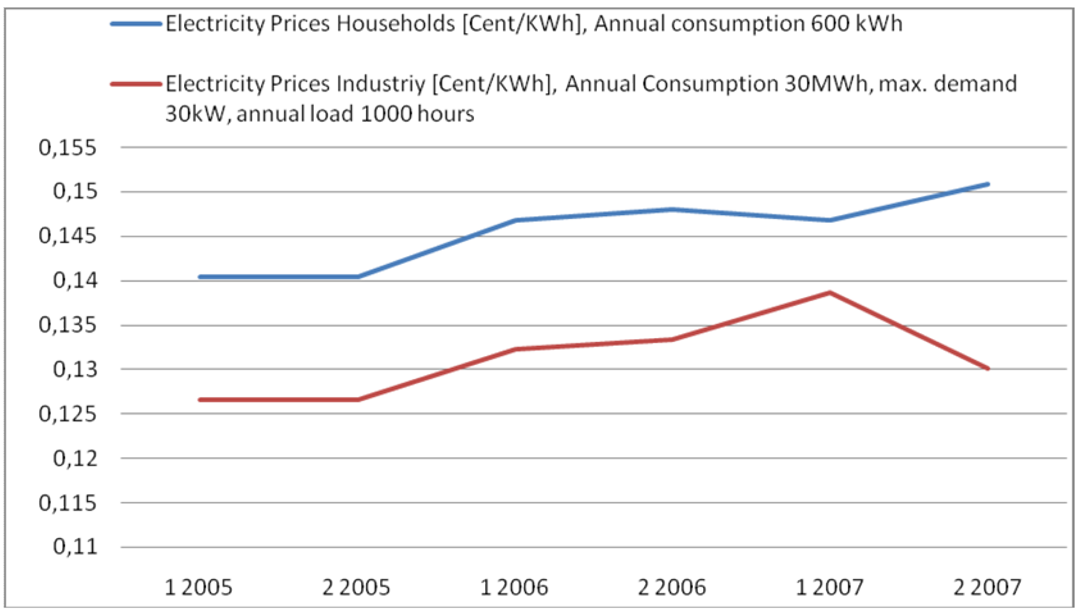
Table 2: Spanish record loads on a 3rd Wednesday
(Sources: own calculation an the basis of UCTE and NRG_113A)

Date	Peak Load on a 3rd Wednesday [GW] (UCTE)	Capacity Installed [GW] In stated year (NRG_113A)	Load/Capacity [%]
20.12.2000	34,500	53,980	63,913
19.12.2001	37,431	55,695	67,207
16.01.2002	35,924	60,195	59,679
15.01.2003	39,535	69,168	57,158
15.12.2004	39,570	69,489	56,944
21.12.2005	40,972	69,590	58,876
20.12.2006	42,744		
17.01.2007	40,477		

In the years between 2000 and 2005 peak loads reached up to 67% in 2001 (see Table 2).
A more detailed overview can be seen on the web page of UCTE, peak loads are usually reached in the winter month between November and January and usually in the evening around 7-8 pm or during mid-day around 12 am.
Regarding to information on the web page of UCTE, the load in the summer months is low due to the time of the year. This is also the reason why fixed periodical programs for overhauls in thermal power stations, in most countries belonging to the UCTE, are usually carried out in the summer months (UCTE Information).
Regarding to nuclear power plants Spain is currently operation with a load factor of 78% and has thereby, in comparison to other countries, a relatively high load factor. The load factor could be due to the age of the reactors (compare table 9), among other factors. The Spanish reactors are quite old and regarding to the study of Maloney, time works against the load factors of reactors. The older the reactors get, the lower are the load factors (Maloney 2003).

3.5 Electricity Prices

Figure 9: Electricity prices for Households and Industrial Consumers, All taxes included (Source: NRG_PC_204, NRG_PC_205)



Compared to other European countries the electricity prices in Spain are above the average. This is because Spain is not generously endowed with domestic energy resources (Kahn 1995).
Until 1997 the spanish electricity market and thereby the electricity prices were regulated and uniform across the country. Taxes for electricity were set by the central government, additionally municipalities could set local taxes. All consumers paid a 1.5% municipal tax for electricity. The general VAT is 16%.
But since the law of 27 November 1997, the Spanish Electricity Act, the Spanish electricity sector entered liberalization. The prices are set by the market, there are no more regulated price ceilings set by the government.
But regarding to the information from the IEA study from 2001, even beyond 1997 eligible consumers can choose to stay under the regulated tariffs. However, to enhance competition

this option was removed from the government for large consumers in 2007. But for small costumers the government planed to give the option as long as there is not enough competition that market prices settle at a reasonable level.
Most consumers chose to stay under the regulated tariffs when the regulated tariff was lower than the market price at the beginning of market opening in 1998. But when the prices began to fall in 2000 only 35% of the consumers chose to stay under the regulated tariffs and their number is further decreasing. In addition, since 2007 high-voltage electricity consumers have to buy their electricity on the liberalized market (IEA 2001 and Arocena et al. 1998).

Electricity prices for small consumers like households are higher than those for industrial consumers (see figure 9).
Regarding to 2007, households with an annual consumption had to pay 14.67 eurocent per kWh in the first half and even 15.08 eurocents in the second half including all taxes. Prices without taxes were in both semesters 12.37 eurocent. Thereby the tax burden for households in the first half of 2007 is 2.3 eurocent and in the second half 2.71 eurocent. VAT is in both cases 16%, here 2 eurocent.
Industrial consumers with an annual consumption of 30 MWh, a maximal demand of 30 kW and an annual load of 1000 hours paid 13.87 eurocent including all taxes and 11.38 eurocent without taxes in the first half of 2007 and the price decreased in the second half to 13.01 eurocent including all taxes and 10.67 eurocent without taxes. For industrial consumers the tax burden in 2007 was 2.49 eurocent in the first half with a decrease to 2.34 eurocent in the second half and is thereby lower than the tax burden of households (NRG_PC_204, NRG_PC_205).
Comparing to other IEA Countries the electricity price in Spain for households was about 39% above the average for OECD Europe and for industry 9.5% below the average in 1999 (IEA 2001).

3.6 Greenhouse Gas Emissions

Figure 10: Greenhouse Gas Emissions of Spain (GHG and CO_2) from 1990-2005 (Source: ENV_AIR_EMIS)

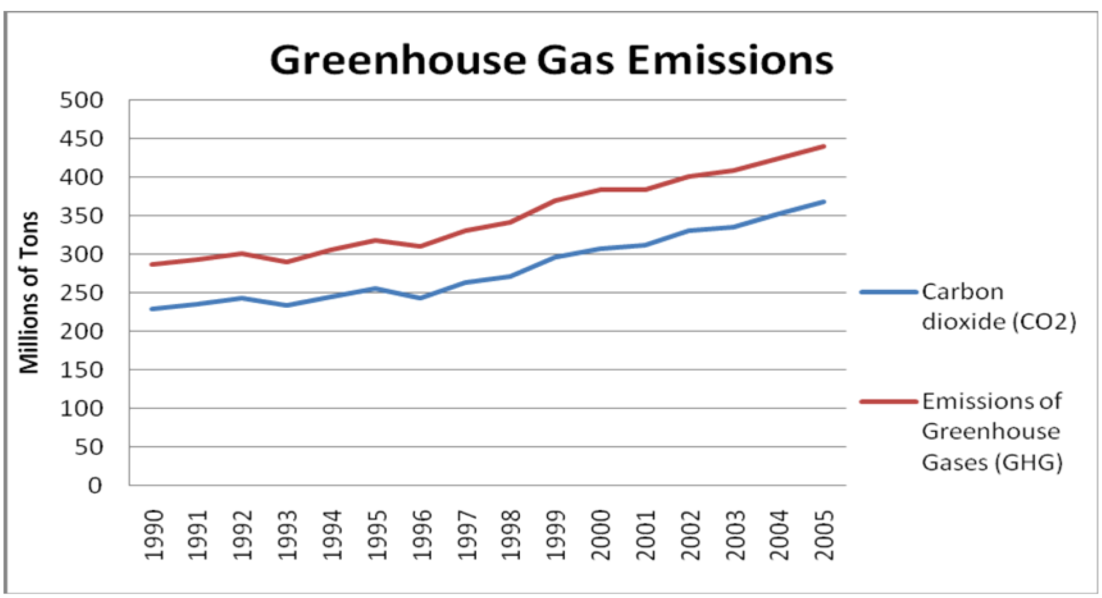


Figure 10 gives an overview of the greenhouse gas emissions of Spain during the time from 1990 till 2005, on the one hand of CO_2 and of emissions of greenhouse gases (global warming potential, CO_2 equivalent) (GHG) on the other hand, regarding to the Eurostat dataset ENV_AIR_EMIS. In comparison to other countries the emissions are increasing although the emissions are still less than in for example Germany and France. The increase in the emissions might be due to the incresae in total electricity generation.

4 Resource Endowment

4.1 Available fossil resources/reserves

Table 3: Spanish non-renewable resources and reserves
(Source: BGR 2007)

Fuel type	Reserves	Resources	Production	Consumption	% of worldwide consumption in 2006
conventional oil (Mt)	20	20	0,2	78.1	2.0
conv. Natural gas (10^9 m^3)	3	500	0.1	33.4	1.2
hard coal (Mt)	500	4,600	11.5	38.5	0.7
lignite (Mt)	30	n.a.	7.1	7.2	0.7
Uranium (t)	n.a.	11	n.a.	13.6	2.1

Fossil and nuclear resources are few in Spain except solid fuels (i.e. hard coal) (see Table 3). Spain has significant reserves of solid fuels (Eurostat 2007). But in all cases domestic demand exceeds inland production by far.

Referring to a study of BGR (German federal Institute for geosciences and resources) in 2007 Spain is in the cases of imports always among top importers of all countries in the world. In the case of oil on position 9 with 61.2 Mt, that is 2.7% of worldwide imports. Oil is mainly imported from Russia, Mexico, Saudi Arabia, Libya and Nigeria.

In the case of natural gas Spain is on 7th position with 35.2 10^9 m^3 (4.1%). This high position results of the Spanish natural gas market as one of the fastest growing in the world. Natural gas is mainly imported from Algeria (through a pipeline and by LNG delivery. Nigeria is also a major supplier for natural gas (LNG). In total 88% of imported energy consists of the imports of oil and gas (EC 2007). Gas interconnections with neighboring countries are complicated due to the geography of Spain. The Iberian Peninsula lies at the end of the long natural gas supply chain. This extends southward and westward within the EU. Thus, imports from northern Africa and gas imported as LNG are elements of the import strategy. To secure the supply gas imports from a single country and a single agent a by law limited to 60% of the total gas imports (Eurostat 2007).

Liquefied natural gas (LNG) is natural gas consisting of methane and ethane and liquefied for transport reasons under high pressure and cooling to -162°C. LNG is not an alternative to natural gas but an option for transport next to the conventional transport per pipeline. It is transported by special vessels. A lot of energy is needed to liquefy the gas and therefore the costs of LNG are only competitive to the costs of pipeline transport by a distance over 3000km. Also because of the reasons mentioned above the import of LNG is of increasing importance for Spain and in 2006 Spain was on worldwide position 3 of LNG importers with 24.4 $G.m^3$ of $211G.m^3$ total world imports (BGR 2007).

In the case of solid fuels Spain is with hard coal on position 18 of the most important countries which produce hard coal with 11.5 Mt or 0.2% of the worldwide production. This supports the fact, that Spain has high reserves of solid fuels. But despite this fact the primary production of solid fuels has steadily declined in the last 20 years and the imports increased from 25% in 1985 to 67% in 2004. This is why Spain accomplishes position 9 in imports of hard coal with 27.0 Mt or 3.2%. Lignite plays a minor important role but Spain is in this case still on position 19 of the most important lignite producers with 7.1 Mt or 0.7%. There are still considerable reserves and resources of hard coal, but the costs of domestic production are no longer competitive to imports (Eurostat 2007 and BGR 2007).

4.2 Usage of fossil fuel (imported/not imported) for electricity generation

Spain strongly depends on imports in case of primary energy as well as electricity production (see Table 4).
Domestic production of primary energy is mainly focused on nuclear energy with a share of 50% (22% higher than the EU-27 average) and, since the last years, on renewable energy (see figure 11). The share of renewable sources (28% in 2004) has increased since 1990 and is far above the EU-27 average share of 12%. Spain has the second largest wind capacity installed after Germany (EC 2007).
Note that all data refers to 2004. Some facts can vary in comparison to the data in the previous sections. The last reference year there is 2005. During this year natural gas for example became the most important resource of electricity production before coal. Also the share of renewables increased.

Table 4: Key Figures Spain 2004
(Source: EC 2007)

Key Figures (2004)

Mtoe	Primary Energy Supply	Domestic Production	Net Imports	Final Energy Consumption	Electricity Generation (TWh)
Solid fuels	21.1	6.5	14.2	1.9	79.1
Oil	68.9	0.3	75.5	52.1	23.8
Gas	25.2	0.3	24.6	16.8	56.7
Nuclear	16.4	16.4			63.6
Electricity				19.8	
Renewables	9.0	9.0		3.8	50.2
Other	-0.3				6.5
Total	**140.2**	**32.4**	**114.3**	**94.3**	**280.0**

The source for all data is the European Commission, unless otherwise stated

Spain is with an amount of 77.4% dependent on energy imports. The average energy import dependency of 50.1% of the EU-27 is thereby clearly exceeded.
As mentioned above the domestic production is mainly focused on nuclear energy. The domestic production of coal and lignite, because Spain has relevant reserves and resources of solid fuels (see section 4.1), used to be quite important in the past but decreased and is now slightly below the EU average of 22% (EC 2007).
Figure 11 and 12 give an overview of which sources are mainly used for electricity production, and the domestic production of primary energy by source of Spain. Note that

figure 12 only shows percentile values of the sources which are domestically produced of the total domestic production. Thereby the figures are not directly comparable. Nevertheless it can be seen for example that although solid fuels play a major role in electricity production and Spain has relevant reserves, its domestic production of primary energy only amounts 20% of Spain´s total domestic production. In this case Spain would have the possibility to higher domestic production but the domestic production is not competitive to imports.

Figure 11: Electricity generation by source 2004 (Source: Eurostat 2007)

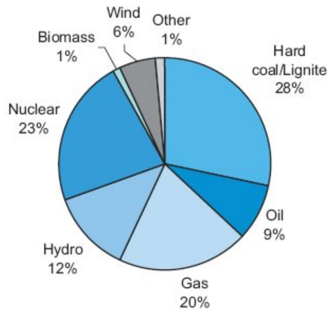
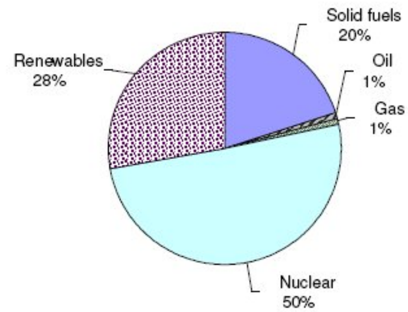


Figure 12: Domestic production of primary energy by source 2004[2] (Source: EC 2007)



With regard to table 3 Spain is energetically independent in terms of nuclear and renewable resources because has no imports of electricity out of this sources.

4.3 Available potential for Renewable Energy Resources

Table 5: Potential and Use of renewable energy resources for electricity generation

RES	Tech. Potential [TWh/year]	Actual usage [TWh/year]	used Pot. [%]	Sources
Wind onshore	86	21.2	24.7	EWEA 2004; NRG_105A
Wind offshore	7-140	0	0	EWEA 2004
Hydro small[3]	7[4]	4.0	57.1	IEAHydro; NRG_105A
Hydro large	57	16.1	28.2	IEAHydro; NRG_105A
Solar el.	11.8-362	0.078	0.04	Espey 2001; Šúri et al. 2007; Bruyas 2002; landusewatch.info; NRG_105A
Biomass	54.7[5] (25.1 MtOE in 2030)	3.1	5.7	Espey 2001; EEA 2006; NRG_105A

Table 4 gives an overview of the potential and use of the most important renewable energy resources in Spain. The data varies between the sources and the publication date. The author

[2] Nuclear power, as well as renewable energies, is counted as domestic primary energy, although the required uranium for nuclear power production has to be imported.

[3] < 10 MW

[4] Hydro plants of less than 5 MW

[5] Own estimate, assuming that the unspecified 165.8 TWh/year of Biomass (waste wood, waste agricultural, energy crops, industrial waste, household waste, landfill gas) from (Espey 2001) can be used for electricity generation with an efficiency of 33%.

tried to put the most actual data available, as this should give greater estimates coming along with the technological progress. Particularly in the cases of wind and solar there is some probability that the data will increase in the future.

Referring to the potential of onshore and offshore wind resources there is no complete report which can draw the potential, but the report of EWEA 2004 collects the facts about the potential by comparing different reports.
In case of onshore wind resources the data refers to a study from 1993 for onshore wind potential of OECD countries (van Wijk and Coelingh 1993). The data for the actual usage refers to table NRG_105A of the Eurostat database for 2005. Spain is the second largest country in the EU after Germany in terms of installed wind capacity. Regarding to EWEA, 2004 Spain contributes to the top group of European counties in terms of onshore wind potential with a potential of 86 TWh of electricity production.
The offshore wind potential refers to studies of the European commission from 1995 (Garrad Hassan, Germanischer Lloyd, Windtest, 1995) and, the lower value, to a study of a commission-funded CA-OWEE project from 2001 (Concerted Action on Offshore Wind Energy in Europe, Delft University et al., 2001). By now no offshore project is realized or planed in details but plans are in progress.

The potential of hydro energy refers to the international small-hydro atlas. Electricity generation via hydro energy is very depended on weather conditions. Therefore the potential varies a lot also within the county. The hydrology of Spain is characterized by great differences in rainfall between the northern parts and extremely dry zones in the south of Spain. Even within the zones great variations from year to year exist (IEAHydro).
Recent news from Reuters state that the Spanish reserves of hydroelectricity (i.e. the water levels in Spain´s hydroelectric reservoirs) slip to under 50% and thereby affirms the dependency on weather conditions. The hydroelectric reservoirs fell to under 50% because of dryness and therefore shrieked since June last year. The remaining water levels translate to around 7.5 TWh of electricity available, which is only 74% of the potential available one year ago (Reuters News 2007).
Nuclear power therefore is used to reduce the dependency on water availability, because of its low variable costs (Domínguez et al. 2007).

The potential of electricity generation with solar energy refers to a recent study of Šúri et al.. Energy production is highly dependent on solar irradiation. The Photovoltaic Geographical Information System (PVGIS) provides data about irradiation. The study estimates and analyses the solar potential for all EU-25 counties, using the European solar radiation database on the basis of the PVGIS.
Results are that Spain belongs to the top groups of high solar potential with an electricity generation of a typical crystalline silicon PV system of 1100 – 1330 kWh per installed kW_p. The northern part of the county belongs more to a group with a potential of 1000 – 1100 kWh/kW_p per year.
This fact again shows the differences of potentials within the country. While the higher potential of solar energy is in the southern parts of Spain, the higher potential for hydro energy lies in the northern part. In terms of PV electricity generation Spain even has the largest differences of potential within the country (with up to 450 kWh/kW_p per year) comparing to the other member states.
Nevertheless, also the northern parts of Spain belong to the groups with the highest potential in photovoltaic electricity production of all EU-25 states.

The study also analyses the theoretical PV potential. While the EU-25+5 would need 0.6% of the territory covered with PV modules to satisfy its total electricity consumption, Spain as an individual country would only need 0.32% of its territory covered and is thereby clearly under the EU average (Šúri et al. 2007).
In comparison to the high potential the actual usage of solar energy for electricity production is negligible. But with the recent technical progress in this field and the potential as a background an increase of the usage is expected. New support mechanisms (feed-in tariffs) were set by the government to put economic pressure on PV generators (see section 5 and 6) (IEA PVPSa).

The total theoretical technical potential of solar energy for electricity generation can be estimated[6], but the results vary a lot depending on the source. The potential can be estimated by multiplying the available area for electricity production out of solar energy with the annual energy yield per installed power unit divided through the size of a power unit which produces 1 kWp. The size of a power unit is 9.5 m^2/kW_p (Šúri et al. 2007) and the averaged annual energy yield per installed power unit is 1165 kWh/kW_p (Šúri et al. 2007).
In a first approach the author estimates the technical potential with an available area of 29,549 km^2, which is the settlement area of Spain in 2000 (landusewatch.info) and the assumption, that 10% of this area can be used for PV modules. The estimated potential in this first approach is 362 TWh.
In a second approach the author estimates the potential with an available area of 808 km^2. This is 10% of 1.6% of the total area of Spain (504,782 km^2 (weltatlas.info)). Regarding to a study of Eurostat (Bruyas 2002) the average residential area (area covered with buildings) of the EU-15 without UK and Ireland is 1.6%, again with the assumption, that 10% of this area can be used for PV modules. The estimated potential in this approach is 99 TWh.
Another approach refers to an article in the magazine "Sonne Wind & Wärme" in 2003 (Quaschning 2003). The planed total installed area for solar energy production in 2010 is 4.8 km^2, with estimated electricity production by solar energy is 0.6 TWh, assuming that all solar energy modules are used for electricity production. Compared to the estimated potentials (see above) this would only be 0.17% of the upper value of the theoretical technical potential and 0.6% of the lower value.
A last estimation checks up on the calculated conclusion of Šúri et al., that Spain would only need 0.32% of its territory covered with PV modules (see above (Šúri et al. 2007)). With this assumption and the calculation the author used above the electricity generation by PV would be 198 TWh, 18% lower than the real total electricity consumption in 2005 of 242 TWh (Eurostat NRG_105A).

In comparison to the estimated potentials Espey estimated in 2001 a potential of electricity generation by solar power of 11.8 TWh/year referring to data of 1995. Although this is the smallest value of theoretical photovoltaic estimated potential, regarding to data from 1990, half of Spain's generated fossil and nuclear electricity could be generated by photovoltaic installed on roof tops (Espey 2001). But the other estimated potentials exceed the potential estimated by Espey by far.

The potential of biomass for electricity generation is difficult to assess. Biomass could not only be grown for electricity generation but also for biofuel or food. Another fact is that the production of biomass should also be environmentally compatible. A rise in the use of

[6] Note that this is only a rough estimation.

biomass also increases the pressure on farmland and forest biodiversity as well as soil and water resources. A study of EEA compares and estimates different potentials of biomass under these conditions for 2010, 2020 and 2030. With a calculated bioenergy potential of 25.1 MtOE in 2030 Spain is on 4th position of all EU-25 countries (EEA 2006).
Espey estimated an overall potential of biomass of 165.8 TWh. Assuming that 33% of this potential can be used efficiently for electricity production, the estimated potential, with regard to Espey, is 54.7 TWh/year (Espey 2001).

In conclusion the theoretical technical potential of electricity generation by renewable energy resources exceeds the overall electricity consumption of Spain by far. Particularly the potentials of wind and solar are estimated high and the future development of this energy resources might be interesting.

5 Investments and Decommissions of Plants and Installations

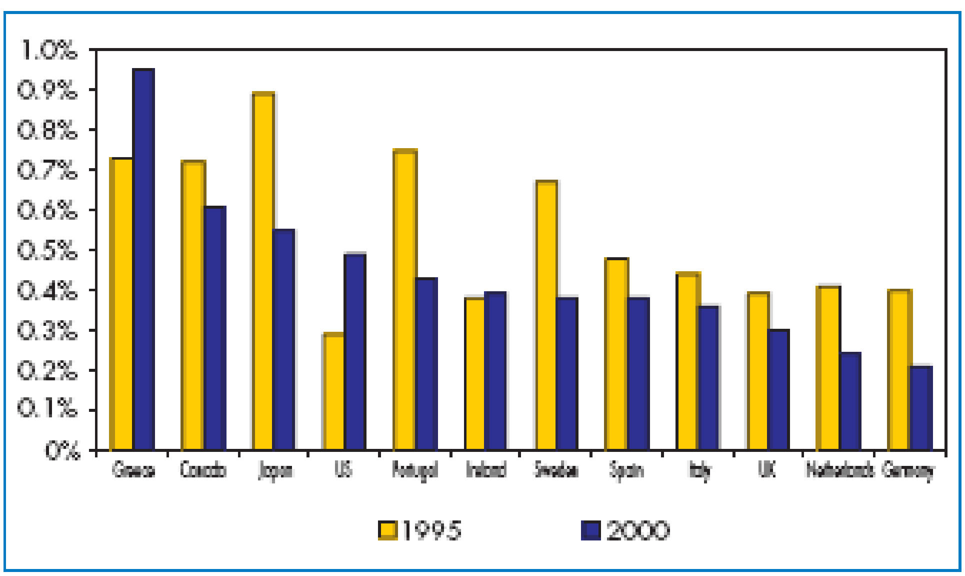
Nuclear energy is used to decrease the dependency on hydro energy and its high fluctuation. This program demanded investments. In total, the re-structuring of energy supply, the increasing role of natural gas and particularly renewable energy demand investments, in building power stations as well as developing the infrastructure needed to ensure the energy supply and to keep combined cycles provided with natural gas (compare section 3 and 4 and Domínguez et al. 2007).
The role of combined cycles energy production increases. The trend to produce energy with combined cycles is motivated by high thermal efficiency (close to 57%) and relatively low investment costs (500€/kW), a short construction time (24-28 month for a 400MW power plant), lower personnel needs and low CO_2 emissions. The large investment effort is due to various reasons such as economic growth and peak demand, environmental limitations, programs to extend the lifespan and high presence of intermittent energy sources like wind and hydro (Domínguez et al. 2007).
The main instrument (but not the only one) to support renewable energies and thereby the main instrument to influence investments by the government by giving investment security and leading to profitability of investments is the feed-in tariff system (FIT) (compare section 6.2.2). Quite successful and combined with high investments, was the FIT in terms of wind, based on good wind conditions and generous FITs. This combination counterweighted several negative factors like bureaucracy. In no other renewable energy technology (RET) the FITs have been comparable successful mainly because of these negative factors like permitting productions and grid connection (del Rio et al. 2007).
In terms of hydro, investments only increased slowly, due to relatively low FITs but high investment costs. And although the potential of photovoltaic (PV) is high, the contribution is low because of the negative factors even though FITs are quite high. Major barriers are high costs, poor credits and again bureaucratic delays – also concerning to the granting of investment subsidies (del Rio et al. 2007).

To sum up, the re-structuring of the electricity market and the policies towards to meet the targets of the Kyoto-protocol demanded investments. Investment security for investments in renewable energy was ensured, at least since 1994. In this year electricity from renewable energy sources (RES-E) promotion became major policy priority by the Royal Decree (RD) 2818 and the feed-in tariffs. (Compare table 6 for more policy instruments and governmental influence of investments in case of RES-E). Negative aspects were a specified duration, which

is two short than necessary to recover investments. The duration was specified to "a minimum of 5 years" in art. 17 of RD 2818.
The paper of del Rio et al. 2007 is assessing the situation of every RET in Spain in terms of risk factors for investment and its influence on diffusion pattern by using Dinica´s general classification of investment contexts (Dinica 2005). A general conclusion of this assessment might be "The further in the Northwest region, the least attractive the technology for potential investors and the greater the public effort needed to encourage investment in such a technology" (del Rio et al. 2007). That means, in case of all renewable technology, an investment in the south is in general more attractive and more profitable than in the north. Nevertheless, Spain is, according to Greenpeace, the most attractive country to invest in renewable energy (del Rio et al. 2007).
Some examples of money invested in renewable energies are also provided in section 6.2.3.

The World Energy Investment Outlook 2003 (IEA 2003) provides an investment analysis at each sector of the electricity supply (generation, transmission, distribution). Regarding to all OECD counties there are in general two reasons, why the electricity sector will continue to need large investments: First, the electricity sector is capital-intensive and second, there is a continuous shift from primary fuels to electricity as well as electricity demand increases as income increases. Concerning all OECD countries, the electricity demand will double over the next 30 years. Additionally, market liberalization has created new challenges in OECD countries and created investment uncertainty. This is also relevant for Spain, as its market is fully liberalized.
Figure 13 gives an overview over investments relative to GDP. Spain is under the top positions due to the mentioned reasons.

Figure 13: OECD Electricity Sector Investment Relative to GDP
(Source: IEA 2003)

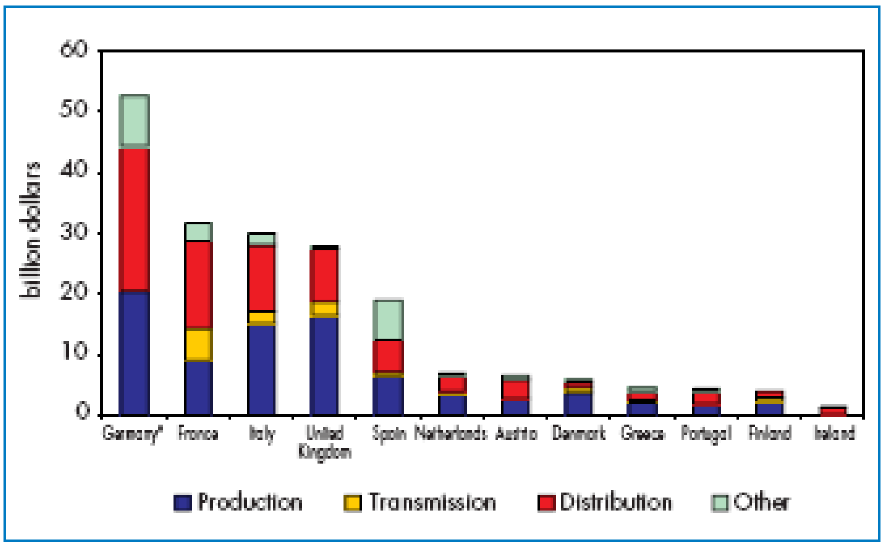


Sources: Various electricity associations and IEA.

One Spanish company, Endesa, is part of the “Seven Brothers”, large electricity firms which are expected to finance a significant portion of new investments. Beside Endesa, the “Seven Brothers” are: EDF, E.On, RWE, Vattenfall, Electrabel, ENEL.

A more detailed analysis of the European Union states an electricity demand increase of 50% over the next 30 years. Another important factor is the interdependency of the European market. Regarding to the Investment Outlook investments over a trillion dollar will be needed in power infrastructure, divided equally between generation and networks. That means, not only the type of energy generation is important, but investments in networks and infrastructure, especially in the European Union play a major role.
Figure 14 provides an overview over the different investment sectors in the electricity sector.

Figure 14: Electricity Sector Investment in EU Countries, 1993-1997
(Source: IEA 2003)



* Transmission in Germany is included in distribution.
Source: Eurelectric (1999).

Additional to the development of networks and infrastructure, the European electricity sector is undergoing reconstruction, from state-owned companies to private generators, due to the liberalization of the markets. Therefore, most future investments will be private investments.

To sum up, investments will be needed in generating new capacities, especially gas-fired capacities, to create a transmission network, to increase the efficiency of infrastructure and to create and improve networks in the European Union (IEA 2003).

Additionally, special investment efforts for the UN to address climate change are provided by the paper “Investment and financial flows to address climate change” by UNFCCC (UNFCCC 2007).

6 RES Electricity - Manufacturing, Generation and Regulatory Environment

6.1 Manufacturing and Generation of RES

Renewable resources are widely dispersed in Spain but with a high potential in electricity generation out of renewable, including hydro, wind and solar energy. There are no single RES companies with very high market shares, in comparison to the four big generators in Spain (see section 7.1), but with regard to a recent German newspaper article a large number of renewable energy distributers and manufactures. Spain is seen as a very attractive area for investors in renewable energies because of the high potential of these renewable resources. Many companies trade or plan to trade their shares on the stock exchange (Grüttner 2007).
With regard to the newspaper article some of these successful companies are introduced in the following.
In case of solar technology the growth in the photovoltaic market of Spain has been strong due to the new regulations (see sector 6.2), including cost reductions, an increasing number of applications, special R&D efforts and essentially high guaranteed prices for new photovoltaic installation (Eurostat 2007). The installation of solar panels on roof tops increased substantially from 20 MW up to 200 MW in just two years (2005-2007) and is thereby currently on worldwide position four behind Germany, Japan and USA in term of new installations (Grüttner 2007).
In terms of wind power, Spain was the second-largest producer in 2004 in absolute terms. 6% of the total gross electricity generation is generated by wind power. In 2004 8,220 MW wind capacity was installed, with high potentials of additional 57,000 MW planned in various stages (Eurostat 2007).

- Solaria Energy and Environmental S.A. is a manufacturer of solar panels, thermal and photovoltaic, is one of the leading companies and currently the fastest growing company in the renewable energy sector in Spain. The company has the ambitious plan of becoming one of the largest producers of solar energy in the world. Currently the company has a production capacity of 90 MW per year (solariaenergia.com).
  Solaria started to trade their shares on the stock exchange in 2006 with a stock price gain of over 70% since then. Stock exchange analysts provide further increase of the stock (Grüttner 2007).

- Iberdrola Renewables is a subsidiary of Iberdrola (see section 7.1). The company is the world´s largest wind power company by installed capacity (7,000 MW) and a world leader in the renewable energy industry with an installed capacity of more than 7,300 MW in September 2007 in 19 countries (iberdrolarenovables.es).
  Since 2007 the company trades 20% of their capital on the stock exchange and is thereby the world´s largest manufacturer of wind energy listed on the stock exchange (Grüttner 2007).

- Eolia Renovables SRC incorporates 22 different holding companies, 43 projects and 122 investors. Eolia is a manufacturer of wind and solar energy systems with an installed capacity of 1,400 MW (mainly wind). According to its CEO the company plans to be one of the 20 largest renewable energy producers worldwide (Grüttner 2007).

Referring to another article from October 2007 Eolia planed an initial public offering for November 2007 to get ahead to the December listing of Iberdrola Renewables (Thomson Financial 2007).

6.2 Regulation of RES Electricity

Government support for renewable energy resources for electricity generation increased considerably after the liberalization of the electricity sector in 1997. Electricity generation from renewable grew from 37.3 TWh in 1998 to 51.3 TWh in 2001.This is an annual growth of 11.2% (IEA 2004).

6.2.1 Most important subsidies and policies

In the following (table 6) the Spain Policy Chronology is described with regard to IEA 2004. Most important subsidies and policies for technologies and fuels are illuminated. The feed-in tariff system of Spain is described in section 6.2.2. Note that beside the governmental policies local authorities play an important role in the development of RES. Legislation varies among regions, and regions often have their own renewable energy plans and different incentives to promote renewable energy through investment subsidies (IEA 2004).

Table 6: Spain Policy Chronology for renewable energy resources (Source: IEA 2004)

Policy Instrument	Year	Type	Technology	Description
Energy Conservation Law	1980-1994	Guaranteed Prices/feed-in tariffs	all RES	first legal framework for support of RES; special regime from which hydro (<5MW) and other could profit
Renewable Energy Programme	1991-2000	Regulatory and administrative rules	all RES	promotes energy security and diversification
Electricity Law	1994-1997	Guaranteed Prices/feed-in tariffs	all RES	reorganization of Spain´s electricity industry; guarantee on purchase contracts 5 years
Royal Decree	1994-1997	Guaranteed Prices/feed-in tariffs	all RES	specification of Electricity Law
General Electricity Law	1997-present	Guaranteed Prices/feed-in tariffs/Obligations	all RES	liberalization of electricity sector; guarantee electricity supply at lowest possible costs; elaborated plan for achieving 12% primary energy consumption from RES by 2010; special regime for producers which are not allowed to surpass a max. of 50MW power

Royal Decree: "Special Regime"	1998-present	Guaranteed prices/feed-in tariffs	all RES	increase of feed-in tariffs
Renewable Energy Promotion Plan	1999-2010	Obligations	all RES	supply 12% of total energy demand with energy generated from RES by 2010
R&D Priorities	1999-2003	RD&D	all RES	National Plan on Scientific Research and Technology Development and Innovation: more efficient, less polluting energy systems, energy transmission, sorting, distribution, use, reduction of CO_2 emissions
Feed-in tariffs for Small Scale Co-generation/Renewable Electricity Production	1999-present	Guaranteed prices/feed-in tariffs	all RES	generators with capacity <50MW have right to sell electricity to the grid at a pre-set price - market price + premium, premiums are established and decreased on yearly base
Plan on Renewables	2000-present	Obligations	Biomass; Onshore wind, Offshore wind, Hydro, Solar PV, Solar thermal, Concentrating solar, waste	doubling the renewable energy share from 6-12%
R&D Energy Programme	2000-2003	RD&D	all RES	integration of specific programs
Royal Decree	2000-present	Feed-in tariff	Solar Photovoltaic	standard contract and invoice for solar PV installations connected to low voltage grids
National Energy Programme of the Promotion of Technical Research	2000-2001	Capital Grants; RD&D	all RES	facilitate the integration of renewable energy and the environmental and socio-economic aspects of energy; grants for industrial research and technology demonstration programs
Law on Fiscal, Administrative and Social Measures	2001	Investment tax credits	all RES	corporate tax deductions for investments in RES; 10% tax deduction

Inter-ministerial Commission for Biomass	2001-2010	Regulatory and administrative rules	Biomass	promote package of measures and remove barriers to the development of biomass
Aid Programme for Solar PV and Solar Thermal	2001-2003	Capital Grants	Solar Photovoltaic, Solar Thermal	as part of renewable action plan; subsidies for solar thermal and solar photovoltaic projects started in 2002 and were finished before October 2003
Low Interest Loans	2001-present	Third-party finance	all RES	provides investment assistance to renewables through low interest loans
Planning and Development of the Electric and Gas Transport Networks	2002-2011	Regulatory and administrative rules	all RES	gives priority to installations of power lines coming from renewable energy facilities and for combined cycle power plants; increase installed capacity of wind to 13,000 MW in 2011 and of combined cycle power plants to 14,800 MW by 2011
Modification to the Biomass, Waste and Wind Energy Premiums	2001-2010	Guaranteed prices/feed-in tariffs	Biomass, Offshore wind, Onshore wind, Waste	increasing of premium for biomass, livestock manure management, decreasing of premium for wind energy
Royal Decree	2002-present	Guaranteed prices/feed-in tariffs	all RES	specification of changes to the special regime, regulating installations producing electricity from renewables and the incentives for them

6.2.2 Feed-In Tariffs

Spain offers a feed-in tariff system, comparable to the German feed-in tariff system[7]. The success of the high supply of renewable energy technologies might also be linked to the successful feed-in tariff system. A closer look to the Spanish system, with regard to Ragwitz et al. 2007, is provided in the following.

The system is regulated by a regime by which each kWh produced with renewable energy is paid to the producer at a special price. This price is usually higher than the market price. In addition the producers can sell their renewable energy electricity directly to the grid at the price agreed.

[7] A comparison between the German system, the Spanish system and the system in Slovenia is provided by Ragwitz et al. 2007

The system was first applied in 1980 with the Electricity Conservation Law (see table 6), quite early in comparison to other countries. The law was the first law to support renewable energies. Since then, lots of instruments have been used to provide further support, mainly legislative measures and financial support. In addition the Energy Conservation Law has been modified since then by a series of Royal Decrees in 1998, 2004 and recently in 2007. The current situation of feed-in tariffs in Spain in accurately described in table 7, last modified by the Royal Decree 661/2007.
In general the system aims to contribute to the national target, that 12% of total energy consumption and 29% of electricity generation should be generated by renewable resources by 2010.

Table 7: Current Feed-In Tariffs in Spain (Royal Decree 661/2007) (Source: Ragwitz 2007)

Technology category		Installed Power	Period [years]	Fixed price Fixed Tariff [€ Cent/kWh]	Market option Reference premium [€ Cent/kWh]	Cap [€ Cent/kWh]	Floor [€ Cent/kWh]
b.1 Solar	b.1.1 Photovoltaic	≤ 0.1MW	1 - 25	44.0381			
			> 25	35.2305			
		0.1MW – 10MW	1 - 25	41.7500			
			> 25	33.4000			
		10MW – 50MW	1 - 25	22.9375			
			> 25	18.3811			
	b.1.2 Solar Thermal		1 - 25	26.9375	25.4000	34.3976	25.4038
			> 25	21.5498	20.3200		
b.2 Wind	b.2.1 Onshore		1 - 20	7.3228	2.9291	8.4944	7.1275
			> 20	6.1200			
b.3 Geothermal and Ocean			1 - 20	6.8900	3.8444		
			> 20	6.5100	3.0600		
b.4 Small-scale Hydro		< 10MW	1 - 25	7.8000	2.5044	8.5200	6.5200
			> 25	7.0200	1.3444		
b.5 Large-scale Hydro		10MW – 50 MW	1 - 25	$6.60 + 1.20 \times \frac{50-P}{40}$	2.1044	8.0000	6.1200
			> 25	$5.94 + 1.08 \times \frac{50-P}{40}$	1.3444		
b.6 Biomass	b.6.1 Energy crops	≤ 2MW	1 - 15	15.8890	11.5294	16.6300	15.4100
			> 15	11.7931	0		
		> 2MW	1 - 15	14.6590	10.0964	15.0900	14.2700
			> 15	12.3470	0		
	b.6.2 Agricultural wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	10.7540	6.1914	11.1900	10.3790
			> 15	8.0660	0		
	b.6.3 Forestry wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	11.8294	7.2674	12.2600	11.4400
			> 15	8.0660	0		
b.7 Biomass	b.7.1 Landfill gas		1 - 15	7.9920	3.7784	8.9600	7.4400
			> 15	6.5100	0		
	b.7.2 Gas from anaerobic digestion	≤ 0.5MW	1 - 15	13.0690	9.7696	15.3300	12.3500
			> 15	6.5100	0		
		> 0.5MW	1 - 15	9.6800	5.7774	11.0300	9.5500
			> 15	6.5100	0		
	b.7.3 Liquid bio-fuels, Manure		1 - 15	5.3600	3.0844	8.3300	5.1000
			> 15	5.3600	0		

b.8 Biomass from industrial processes	b.8.1 Agricultural wastes	≤ 2MW	1 - 15	12.5710	8.2114	13.3100	12.0900
			> 15	8.4752	0		
		> 2MW	1 - 15	10.7540	6.1914	11.1900	10.3790
			> 15	8.0660	0		
	b.8.2 Forestry wastes	≤ 2MW	1 - 15	9.2800	4.9214	10.0200	8.7900
			> 15	6.5100	0		
		> 2MW	1 - 15	6.5080	1.9454	6.9400	6.1200
			> 15	6.5080	0		
	b.8.3 Black liquor	≤ 2MW	1 - 15	9.2800	5.1696	10.0200	8.7900
			> 15	6.5100	0		
		> 2MW	1 - 15	8.0000	3.2199	9.0000	7.5000
			> 15	6.5080	0		

Source: Own depiction based on Ministerio de Industria, Turismo y Comercio (2007)

The producers of renewable energy electricity receive a premium for their energy. They can choose between a fixed price, and a market price. In this case a "premium" is added to the negotiated electricity market price. The choice is valid for one year.

Major reasons for the recent modification of the Electricity Conservation Law were the increase in the consumer costs and windfall profits under the market option and insufficient development of biomass.
The market option was introduced in the Royal Decree 2004. The producers sell their energy through a bidding system managed by the market operator (see section 7) in the open market. The price is set by the market, plus a premium for the power guarantee.
Major recent modifications were, beside others, the introduction of cap and floor prices. Minimum and maximum prices for overall remuneration were introduced to reduce the flexibility of the market option. The overall remuneration regarding to the new system can now be estimated in four different calculation areas:

1. As long as the sum of the market price and the reference premium is less than the minimum limit, the remuneration is equal to the floor price. The premium in this case is calculated as the difference between the market price and the minimum level.

2. If the sum of the market price and the reference premium ranges between floor and cap prices, the reference premium is paid plus the electricity market price.

3. As long as the sum of the market price and the reference premium is more than the maximum limit, the remuneration is equal to the cap price. The premium in this case is calculated as the difference between the cap and the market price.

4. If the market electricity price exceeds the cap price, no premium is paid. The remuneration is equal to the electricity market price.

The system and the new calculation mechanism guarantees a minimum income to the producer and provides investment certainty, but also cuts off windfall profits that have occurred due to rising electricity prices, but without increasing costs in the technology (Ragwitz 2007).

In a recent paper, del Rio and Gual were assessing the feed-in tariff system in Spain in the time period between 1998 and 2003 by a multi-methodological and multi-criteria approach. The feed-in tariff system is the main instrument to promote renewables in Spain. Parts of the

assessment are effectiveness, the costs and benefits of RES-E support, cost distribution, transaction costs and transparency, dynamic efficiency, initiating the market for RES-E deployment, contribution to job creation and uncertainty for investors.
Results in general are that the feed-in system in Spain has its pros and cons. It has highly been successful in promoting wind energy, but not that much in promoting other technologies, e.g. solar, although the potential is high and the FITs are high as well. But several barriers make its contribution very low to the renewable energy market in Spain.
The environmental benefits outweigh the costs only in the cases of wind and small hydro. Regarding to other technologies the costs overweight the benefits. The greatest negative difference can be seen for solar PV, because of the high support per GWh in comparison to other technologies. To sum up, the FIT under RD 2818 has led to environmental benefits and, although the costs overweight the benefits in most cases the FIT does not represent an excessive consumer cost in relative terms.
In addition, because of the FIT, profitability of investments for private investors is ensured. FITs create incentives to invest in the RES-E market and the RD2818 led to significant increase in RES-E development (del Rio et al. 2007).
A closer look on the results for the specific assessed points is provided in the paper.

6.2.3 Money involved

Besides describing the instruments it is interesting to know, how much money is involved in the specific instruments. The study of Eurostat 2004 provides data for some instruments, which is pictured in the following (compare table 6):

Total investment costs for the Renewable Energy Programme (1991-2000) were estimated at PTA 334,000 million (2,007.4 million €) and total public aid was PTA 70,118 million (421.4 million €) over ten years.
As part of the Renewable Energy Action Plan 2000-2010, the Aid Programme for Solar PV and Solar Thermal subsidized solar thermal with 10.8 million € and solar PV with 10.8 million € in 2002, to projects that started in 2002 and were completed before October 2003.
Under the Renewable Energy Plan 2000-2010 the Official Credit Institute (ICO) and the Institute for Diversification and Energy Saving (IDAE) have provided a financing line for the installation of renewable energy systems, with a maximum of 70% of investment costs that can be financed. It is open to public and private organizations with a maximum loan size of € 6.3 million per project. In 2000 € 9.98 million was provided, in 2001 nearly € 13.5 million and in 2002 € 150.2 million (estimated).
The total budget for 2001 for the program “Low Interest Loans” was 9.62 million €.

In total Spain spent US$ 2.7 billion (in 2002 prices and exchange rates) on government energy RD&D between 1974 and 2002. With US$ 288 million funding peaked in 1984. The funding in 2001 was US$ 47.9 million. The share of renewable energy expenditures in total energy RD&D was about 20% in the last 20 years, with an average of US$ 13.4 million per year from 1985 to 2002. Over half of this was spent on researching concentrating solar power since the early 1980s, although in this time there was no commercial use of this technology. 27% of the budget went to RD&D in solar-thermal electric technology from 1974 to 2002. 22.4% of the budget has been directed to biomass technologies in this time, 18.3% to solar PV, 11.6% to wind and 9.5% to solar heating. The total funding for renewable energy in 2002 was US$ 15.5 million.
The National RD&D Plan had a budget of 51 million € over four years from 2000-2003.

Aid to biomass technologies under the Renewable Energy Action plan was € 6 million in 2000, supporting five projects.
Wind energy was supported with an accumulated investment of € 4,206 million over the past decade by the government (Eurostat 2004).

6.2.4 Nuclear Phase-Out

The Spanish government is committed to phasing out nuclear power. Prime Minister Jose Luis Zapatero was speaking to the Spanish parliament in May 2006. But the phase-out should only be done "if circumstances permit", there is no exact time table and there will not be one before the next General Election in March 2008 (Nuclear Spin).

With regard to the Nuclear Europe: Country Guide of BBC of February 2006 Spain will phase out nuclear power in favor of renewables. Since 1983 Spain has a moratorium on reactor-building (BBC 2006).

The opinions on the phase-out are highly dependent on its composer.
Referring to an article of Greenpeace from May 2006 Spain is the fifth county to abandon nuclear power and Zapatero has thereby "[…] shown true leadership in preparing the phase out of this dangerous and polluting problem and phasing in safe renewable energy sources", regarding to Jan Vande Putte of Greenpeace International (Greenpeace 2006).
In contrast to this and referring to an article of October 2005 of Nuclear Engineering International the IEA urges Spain to not phase out nuclear power due to concerns about "[…] a significant negative impact on economic growth and environmental protection […]" (NEI 2005).

7 Market Structure

7.1 Main Market Operators

Electricity generation in Spain is dominated by four large public utilities. The data of the four large public utilities refers to IEA 2001 and therefore to the year 1998:

- Endesa Group was founded in 1944 as a state-owned enterprise but privatized in 1998. Its share of total power production in 1998 was 48%. The Spanish government holds a so called "golden share" and has thereby the power of veto in energy policy of Endesa Group.

- Iberdrola was created in 1992 as a private company out of the merger of two large electric utilities, Hidroelectrica Español and Iberduero. Its share was 26% (in 1998).

- Unión Fenosa was with a share of 11% the 3rd largest electricity generator, Hidrocantábrico had a share of 4%, both are private companies and have a long tradition in generating and distributing electricity for more than 80 years (IEA 2001).

In addition Table 8 provides a recent overview of electricity consumption in the Spanish system during 2006. Consumption is shown in terms of distributers, number of consumers and electricity turnovers in the regulated and liberalized market. In this year 90.5% of consumers

were in the regulated market and consumed 75% of total electricity, the remaining 9.5% in the liberalized market consumed 25% of total electricity.
The table provides a good overview of the market actors and their shares as well as a good comparison of the regulated and liberalized sectors of the market. Note that the number of customers operating in the free market decreased in 2006, since the regulated market offered better prices. By December 2006 just 1,946,000 customers were being invoiced in the free market in comparison and contrast to the state increasing trend of the increasing number of customers operating in the free market since the complete liberalization on 1[st] January 2003 and 2.6 million customers being supplied in the free market at the end of 2005 (CNE 2007).

Table 8: Structure of Spanish Peninsular electricity market by distributors (2006) (Source: CNE 2007)

Distributor		Regulated market				Liberalised market				Total	
		No. cons.	%	GWh	%	No. cons.	%	GWh	%	No. cons.	GWh
Iberdrola	Domestic	8,733,751	91.74	27,342	91.55	785,929	8.26	2,523	8.45	9,519,680	29,865
	SMBs low	244,592	86.23	10,629	78.76	39,059	13.77	2,866	21.24	283,651	13,495
	Med ten<36KV	44,821	86.48	24,065	71.99	7,008	13.52	9,361	28.01	51,829	33,426
	High ten>36KV	782	73.36	13,469	81.38	284	26.64	3,081	18.62	1,066	16,550
Total Iberdrola		9,023,946	91.56	75,505	80.90	832,280	8.44	17,831	19.10	9,856,226	93,336
Endesa	Domestic	7,913,689	87.60	26,697	67.13	1,120,520	12.40	3,942	12.87	9,034,209	30,639
	SMBs low	239,476	86.46	11,360	72.80	37,513	13.54	4,244	27.20	276,989	15,604
	Med ten<36KV	15,139	65.49	9,819	35.20	7,979	34.51	18,073	64.80	23,118	27,892
	High ten>36KV	232	63.56	11,248	73.24	133	36.44	4,109	26.76	365	15,357
Total Endesa		8,168,536	87.51	59,124	66.07	1,166,145	12.49	30,368	33.93	9,334,681	89,492
Unión Fenosa	Domestic	3,178,270	95.12	10,316	95.36	163,131	4.88	502	4.64	3,341,401	10,818
	SMBs low	86,930	84.67	3,115	69.50	15,736	15.33	1,367	30.50	102,666	4,482
	Med ten<36KV	9,758	74.37	5,137	58.91	3,363	25.63	3,583	41.09	13,121	8,720
	High ten>36KV	180	68.70	8,465	87.54	82	31.30	1,205	12.46	262	9,670
Total Fenosa		3,275,138	94.73	27,033	80.24	182,312	5.27	6,657	19.76	3,457,450	33,690
H Cantábrico	Domestic	518,864	90.66	1,534	92.08	53,458	9.34	132	7.92	572,322	1,666
	SMBs low	13,263	82.72	541	68.83	2,770	17.28	245	31.17	16,033	786
	Med ten<36KV	344	40.71	415	34.55	501	59.29	786	65.45	845	1,201
	High ten>36KV	16	69.57	5,647	96.10	7	30.43	229	3.90	23	5,876
Total H. Cantábrico		532,487	90.37	8,137	85.39	56,736	9.63	1,392	14.61	589,223	9,529
E de Viesgo	Domestic	515,821	96.58	1,239	94.36	18,292	3.42	74	5.64	534,113	1,313
	SMBs low	19,051	85.21	500	68.68	3,307	14.79	228	31.32	22,358	728
	Med ten<36KV	546	61.83	447	39.95	337	38.17	672	60.05	883	1,119
	High ten>36KV	56	74.67	1,783	80.06	19	25.33	444	19.94	75	2,227
Total E. Viesgo		535,474	96.06	3,969	73.68	21,955	3.94	1,418	26.32	557,429	5,387
Fuerzas Eléctricas de Valencia	Domestic	3,927	99.87	7.00	100.00	5	0.13	0	0.00	3,932	7
	SMBs low	74	100.00	2.20	100.00	0	0.00	0	0.00	74	2
	Med ten<36KV	4	100.00	3.68	100.00	0	0.00	0	0.00	4	4
	High ten>36KV										
Total FEVASA		4,005	99.88	13	100.00	5	0.12	0	0.00	4,010	13
SOLANAR	Domestic	876	100.00	1.47	100.00	0		0.00	0.00	876	1.47
	SMBs low	68	100.00	1.76	100.00	0		0	0.00	68	1.76
	Med ten<36KV										
	High ten>36KV										
Total Solanar		944	100.00	3.23	100.00	0	0.00	0	0.00	944	3
All Distributors	Domestic	20,865,196	90.69	67,136	90.35	2,141,335	9.31	7,173	9.65	23,006,533	74,309
	SMBs low	603,453	85.98	26,149	74.50	98,385	14.02	8,950	25.50	701,838	35,099
	Med ten<36KV	70,612	79	39,887	55	19,188	21.37	32,475	45	89,800	72,362
	High ten>36KV	1,266	70.69	40,612	81.75	525	29.31	9,068	18.25	1,791	49,680
TOTAL DISTRIBUTION		21,540,529	90.51	173,784	75.08	2,259,433	9.49	57,666	24.92	23,799,962	231,450

Red Electrica (REE) is the Transmission System Operator (TSO) and owns most of the high-voltage networks. It is responsible for the technical management of the electricity system, including guaranteeing the security of electricity supply and the coordination of electricity transport and production. It was established in 1985 by the electric utilities as a state-owned company. During the time the State reduced its ownership share to today 25%, the four power utilities own 10% each and another 35% are free floating (IEA 2001).

The National Energy Commission (Comisión Nacional de Energía / CNE) is the regulatory body of Spain´s electricity and energy systems. It was set up in 1998 and developed by the Royal Decree in 1999. The CNE is a public body and attached to the Ministry of Industry, Tourism and Commerce. Its major goal is to ensure effective competition in the Spanish energy systems which are, among others, the electricity markets (cne.se).

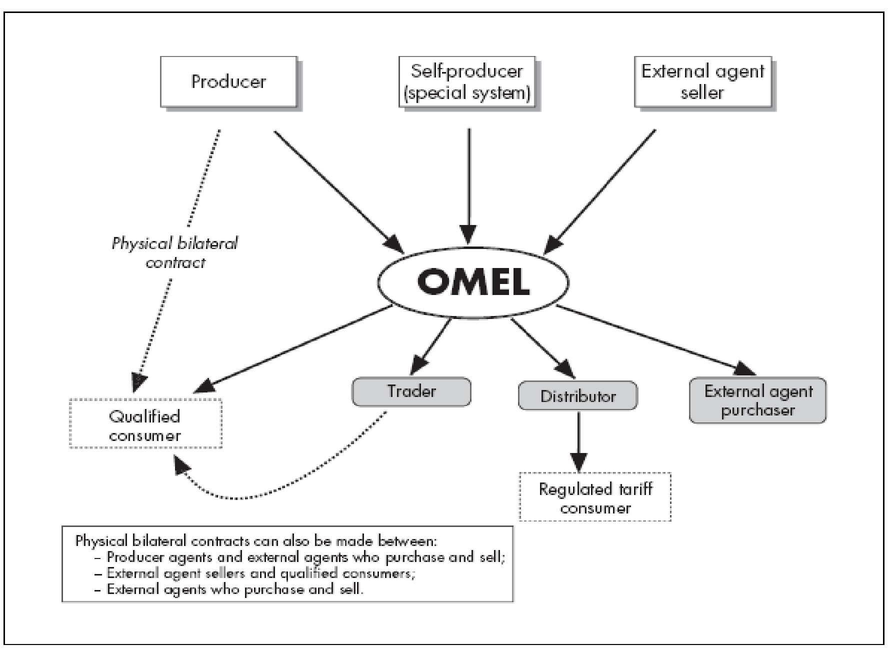
The CIEMAT (Centro de Investigaciones Energéticas, Medoambientales y Technológicas) is a public research agency in the energy sector. It is part of the Ministry of Education and Science (ciemat.es). The department for renewable energy (Departamento de Energías Renovables) has a focus on research of renewable energies (energiasrenovables.ciemat.es).

The IDEA (Instituto de Diversificación y Ahorro de Energía) is an institute which promotes renewable energies and carries out the aid to renewable energies (idea.es).

Also in terms of distribution, the four big electricity generators dominate the market with distribution shares in 2000 of 41% (Iberdrola), 39% (Endesa), 14% (Unión Fenosa) and 5% (Hidrocantábrico). Additional distributers on the Spanish Islands account for 1% (IEA 2001).

Spain developed a trading system for electricity. According to the 1997 Spanish Electric Power Act the government established the OMEL (Compañia Operadora del Mercado Español de Electricidad, S.A.) as a new company to act as the Market Operator. The Market Operator runs the electricity pool (see figure 15) by matching sale and purchase bids, determine prices and information of the regulation authority. The electricity generators offer their electricity daily to the electricity pool, a market mechanism that governs the sale of power in the market (IEA 2001).

Figure 15: Electricity Pool
(Source: IEA 2001)



Source: OMEL.

Electricity generation is dominated mainly by two large actors and two smaller ones. Other independent generators only contribute 11% in total to the overall share of electricity generation. Competition can be enhanced by new entrants in the market and structural reforms of the two main operators (IEA 2001).

The recent development of the Spanish electricity market is stated in a recent newspaper article of the German “Handelsblatt” from February 2008. Referring to this, the second largest operator in Spain and the fifth largest in Europe, Iberdrola, is standing on the threshold of an acquisition by its competitors. The biggest share holder, ACS, is planning to inherit Iberdrola with some partners and to unite Iberdrola with the third largest operator in Spain, Union Ferosa. The French company EDF seems to be interested as a partner for the acquisition.
Endesa, the – until then – largest operator is in a similar situation and is actually being slit up between Enel, Acciona and Eon.
The reason for this situation might be the liberalized market structure in Spain to ensure the presents of many different players. Although this has many advantages, like higher efficiency, the risk of acquisitions by foreign companies is high. The European court of justice recently called for the abolishment of a special law, the “Lex Ratio”, which allows foreign companies to only hold a share of maximal 3%, because of borders to competition. Thereby the Spanish electricity market is free for acquisitions (Handelsblatt 2008).

A more recent and more actual description of the main market operators and the actual market situation is given in the paper of Domínguez and Bernat dealing with the Iberian electricity market. Regarding to this paper the electricity production is dominated by Endesa (29%), Iberdrola (22%), Unión Ferosa (11%), HC Ebergía (5%), Viesgo (2%), Gas Natural (7%) and Elcogas (1%). This data from 2006 is different from the data of the IEA in 1998 (see above).
In general the electricity markets of Portugal and Spain are highly connected. The Portuguese-Spanish market is generally known as the Iberian Electricity Market (MIBEL). It was originated in the Memorandum of Agreement on 29 July 1998 by Spain and Portugal to increase cooperation in terms of energy. This market provides 12% of the electricity in the EU-15. This figure is only exceeded by Germany, France, the UK and Italy. A closer look on the MIBEL is provided in the paper of Domínguez and Bernat (Domínguez et al. 2007).

In terms of nuclear power, as the main source of domestic production, Spain has nine operational reactors. Table 9 gives an overview over the plants, their types and their shareholders:

Table 9: Operation nuclear power reactors in Spain
(Source: IEA 2001)

Plant	*Year of commissioning*	*Capacity (MW gross)*	*Type*	*Shareholder*
José Cabrera (Zorita)	1968	160	PWR[1]	Unión Fenosa 100%
Sta Maria de Garoña	1971	466	BWR[1]	Iberdrola 50% and Endesa Group 50%
Almaraz-I	1981	974	PWR	Iberdrola 52.7%, Sevillana Electricidad 36%, Unión Fenosa 11.3%
Ascó-I	1983	1,028	PWR	Endesa Group 40%
Almaraz-II	1983	983	PWR	Iberdrola 52.7%, Endesa 36%, Unión Fenosa 11.3%
Cofrentes	1984	1,025	BWR	Iberdrola 100%
Ascó-II	1985	1,015	PWR	Endesa Group 85%, Iberdrola 15%
Vandellós-II	1987	1,082	PWR	Endesa Group 72%, Iberdrola 28%
Trillo	1988	1,066	PWR	Iberdrola 48%, Hidroelectrica del Cantábrico 15.5%, Nuclenor 2%

[1] PWR = Pressurised Water Reactor. BWR = Boiling Water Reactor.

Sources: Ministry of Science and Technology; Ministry of Economy, Spain.

The Nuclear Safety Council (Consejo de Seguridad Nuclear, CSN) is responsible for regulating and controlling nuclear safety.
The National Radioactive Waste Corporation (Empresa Nacional de Residuos Radioactvos, ENRESA) is responsible for back-end activities of the nuclear fuel cycle (IEA 2001).

7.2 Market Liberalization

Since 2003 the Spanish electricity market is fully liberalized, even at a faster pace than required by the EU directives. A law from 1997, the Spanish Electric Power Act, which transposed the EU directive from 1996, describes the schedule of the liberalization. Table 10 gives an overview of the schedule:

Table 10: Electricity market liberalization schedule
(Source: IEA 2001)

Date	*Eligibility*[1]	*Market opening*
1 January 1998	Consumption > 15 GWh/year	26.5%
1 January 1999	Consumption > 5 GWh/year	34%
		(Directive requires 26% in Feb. 1999)
1 April 1999	Consumption > 3 GWh/year	37%
1 July 1999	Consumption > 2 GWh/year	40%
1 October 1999	Consumption > 1 GWh/year	42%
1 July 2000	All supplies 1 kV voltage level	54%
		(Directive requires 30% in Feb. 2000)
1 January 2003	All consumers	100%
		(Directive requires 35% in Feb. 2003)

[1] Under current legislation, eligibility is defined for purchases from the domestic markets. Only consumers with at least 50 GWh annual consumption are allowed to buy from foreign suppliers.

Source: National Energy Commission.

Market liberalization has given consumers the right to choose their suppliers and enhanced market diversification as well as real competition (IEA 2001).

7.3 Market prices

The spot market of Spain, as well as of the MIBEL is based on the present market for Spanish supply managed by the OMEL (see above), the Electric Market Operator of Spain. It will be run from Madrid and includes the daily markets and that of intra-daily settlement.
Beside the spot market the MIBEL will be based on two other sorts of contracting: term market and bilateral contracts (Domínguez et al. 2007).

Table 11 gives an overview over the evolution of the market price in Spain (in the second line) in comparison to Portugal.

Table 11: Evolution of market price
(Source: Domínguez et al. 2007)

Table 4
Evolution of market price in Portugal and Spain (€/MWh), Brent ($/bbl), coal ($/t), hydraulic production and exchange rate ($/€), 1998–2006

	1998	1999	2000	2001	2002	2003	2004	2005	2006
Market price in Portugal (€/MWh)	31.2	31.4	39.4	37.8	45.1	36.0	33.8	60.9	60.2
Market price in Spain (€/MWh)	25.6	26.7	31.9	31.5	38.9	30.3	28.7	55.7	55.5
Brent ($/bbl)	12.7	17.9	28.5	24.5	25.0	28.9	38.3	45.6	66.5
Coal ($/t)	32.0	28.8	36.0	39.3	31.6	42.5	71.9	61.1	74.8
Hydro energy capability in Portugal (%)	1.0	0.7	1.1	1.2	0.8	1.3	0.8	0.4	0.9
Hydro energy capability in Spain (%)	0.9	0.7	0.9	1.1	0.7	1.2	0.8	0.5	0.7
Change ($/€)	1.12	1.07	0.92	0.90	0.95	1.13	1.24	1.24	1.25

Source: OMEL, UNESA and own elaboration.

The hydrological situation of Spain was difficult in 2005 (compare section 4.3) and demand rose about 10%, as a result, the spot prices increased. Deployment, the types of power plants, the electricity demand and the CO_2 prices will be the drivers of future price trends (EGL 2005).

7.4 Imports and Exports

Spain will probably stay a net importer, although exports exceeded over imports in 2004 and 2005. The import volume will probably stay at a low level (EGL 2005).
Compare section 3.3 and table 1 for details as well as sections 4.1 and 4.2.

8 Networks

The Spanish transmission operator is Red Eléctrica de Espãna, REE. REE is a member of the UCTE (Union for the Co-ordination of Transmission of Electricity, a TSO (Transmission System Operator for Western Europe and thereby member of the ETSO, the association for European TSOs. Although production and retailing of electricity were liberalized, transmission (by REE) and distribution remain regulated (Domínguez et al. 2007).
Total Net Transfer Capacities (NTC) from Spain are 2400GW (600GW to Morocco, 1300GW to Portugal, 500GW to France), and 4200GW to Spain (600GW from Morocco, 1200GW from Portugal, 1400GW from France) (ETSO 2007).

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