

English translation of the article

*El Sector Eléctrico Español y las Energías Renovables*

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## The Electrical Energy Sector and the Development of Renewable Energies in Spain

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The Spanish Energy Policy has been mainly focused during the last 10 years on the promotion and introduction of renewable energies for the generation of electricity. To achieve this, the Electricity Act of 1997 established a priority access to the national grid of electricity produced by renewable energy sources, in addition to more favourable economic conditions with respect to the electricity generated by traditional energy sources. The result has been a rapid increase of the share of the energy production with renewable energy sources, but, creating an important economic imbalance due to the high cost for the market introduction of the new energy sources. This led the central government to review the policy of subsidies and to limit the deployment of renewable energies with several new Royal Decrees after 2008.

The renewable energies should have an even higher share of the total primary energy, due to economic reasons and to reduce the international dependence on oil and gas supply. To fulfil this target it is important to strengthen the legal issues and to provide the necessary coordination to this fundamental sector of the Spanish economy to enable the fulfilment of its objectives.

### 1. Introduction

The present debate in Spain about solving the current economic problems is centred, preferably in the deficit of the public administration (central and local government) and the reformation and reorganization of financial institutions. The reasons for this approach are due to both internal political circumstances after the November elections of 2011, as well as the international pressure due to the increased exposure of Spain to international financing and the consequent risk that Spain cannot maintain that high foreign debt.

There is no doubt that the deficit is a major cause of Spain's precarious financial situation, but not least important is the deficit of its balance of payments and, within this, the negative balance of trade of energy products with foreign countries. It is therefore important to quantify the decisive role that the energy sector has in the deficit in foreign trade of Spain, since, without substantial reduction in a relatively short time, it will be difficult that Spain's foreign debt can be sustained. Here are some data which are included in the following **Table 1** and that confirm the previous statement.

It has been chosen to compare the years 2003 and 2010, since in that period it was tried to redirect the energy sector towards a greater self-sufficiency by the Royal Decree 436 of 12 March 2004, which established the legal and economic framework of the electrical energy production activity in the so called *Special Regime*.

As shown in that table, the balance of Spain's national import of energy products was about 15,000 million Euros in 2003, while net import of our total foreign trade was more than 46,000 million Euros, thus the contribution of energy products to the trade deficit rose in Spain in 2003 to 32.25%. In 2010, seven years later, the foreign trade deficit in energy products amounted to almost 34,500 million Euros, which accounted

for 66% of the total trade deficit, which was more than 52,000 million Euros. This meant that, in seven years, the share of the energy in the external trade deficit of Spain has doubled, which means that of each three Euros of the deficit, two were due to energy imports. This deficit equals 3.3% of the Gross Domestic Product of Spain. And it means that 66% of external financing needs of the Spanish Balance of Payments are due to the net imports of energy products. It is not viable for the Spanish economy to support any longer an energy deficit of that size.

Spain's foreign trade (in million Euro)

	<u>2003</u>			<u>2010</u>		
	Exports	Imports	Balance	Exports	Imports	Balance
<b>Total of Energy Products</b>	<b>4,210.2</b>	<b>19,135.9</b>	<b>-14,925.7</b>	<b>9,436.3</b>	<b>43,935.9</b>	<b>-34,499.7</b>
Petroleum and derivatives	3,485.3	14,623.4	-11,138.1	8,664.2	34,176.4	-25,512.3
Gas	364.1	3,433.1	-3,069.0	188.0	8,422.7	-8,234.7
Coal and Electricity	360.8	1,079.4	-718.6	584.1	1,336.8	-752.7
<b>Total Foreign Trade</b>	<b>137,815.3</b>	<b>184,094.5</b>	<b>-46,279.2</b>	<b>185,799.0</b>	<b>238,081.6</b>	<b>-52,283.0</b>
<b>% of Energy Products from Total</b>	<b>3.05%</b>	<b>10.39%</b>	<b>32.25%</b>	<b>5.08%</b>	<b>18.45%</b>	<b>65.99%</b>

Table 1. Spain's foreign trade in the years 2003 and 2010 (in million Euro). [1]

Spanish policy makers decided in the last years of the decade of the nineties to reduce Spain's foreign dependence on imported energy products and issued in November 1997 an Electric Power Act under whose main aim was to promote the implementation and use of renewable energy. It has passed the first decade of this century and, while renewable energy have been introduced to a significant extent, -around 20% in electricity production without including hydro power generation under the Ordinary Regime-, the Spanish dependence on foreign fossil energy products, oil and natural gas, has increased even more, which together have increased from 64.1% to 70.7% of the total primary energy between the years 2000 and 2010 (**Table 4**), and the given price trends of these products in origin explain the exceptional growth of the Spanish energy bill in the last ten years.

## 2. The legal framework

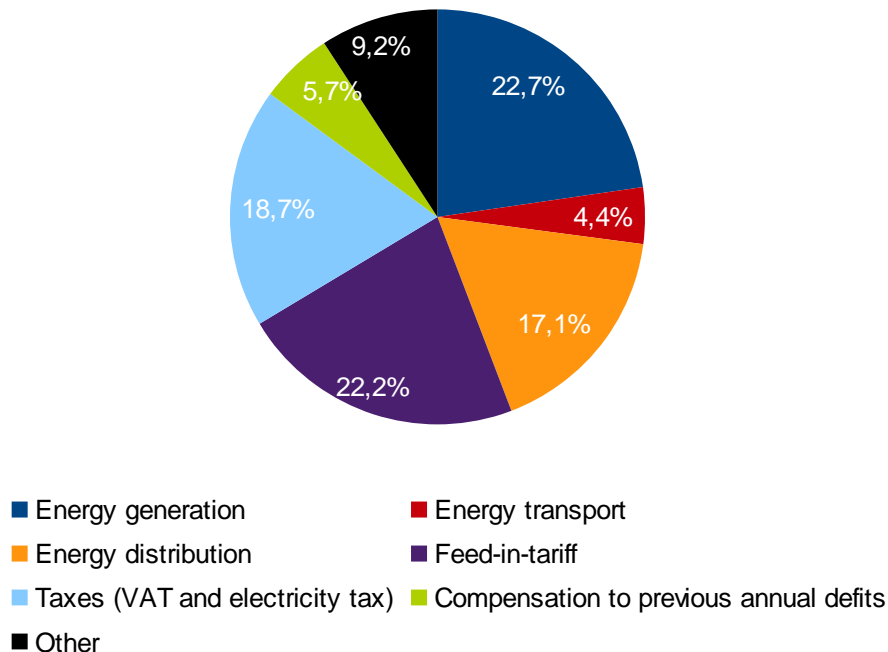
The current Spanish legal framework is based on the aforementioned Law 54/1997 of November 27 of the Electricity Sector which incorporates the rules laid down in Directive 96/92 of the European Parliament to ensure the establishment of the future European electricity market. This law establishes six basic aspects of the new organization of the electricity sector.

1. The legal separation of activities that are regulated by the Administration and activities that are not regulated. Among the first ones are the transport and distribution, which are activities operating in conditions of natural monopoly and therefore should be subject to regulation, while the generation and marketing activities would not be regulated so that they could develop under the principles of free competition.
2. The free access to public transport network for any producer of electricity, an access that until then was reserved to existing electric utilities.
3. The distinction between an *Ordinary Regime* and a *Special Regime* for the supply of electricity. The regular supply (Ordinary Regime) was provided by the utilities then in service, while the so-called *Special Regime* (Article 27 of the Act) was the supply of electricity from new producers from renewable and non-renewable sources. Among the renewable energy supply are hydro, wind, biomass, industrial and urban waste, and solar, and the non-renewable supplies included co-generation as well as electricity producers who were using agricultural residues,

livestock and other services. Producers under the Special Regime had preferential access to the electricity transmission system and a subsidy that largely improved the economic conditions of the prices paid to companies that supplied under the Special Regime. The impact that the Special Regime subsidies had on the distribution of the electric bill can be seen in data of 2010 given by UNESA [2] and shown in **Figure 1**, which stipulates that, for every 100 Euros of the annual bill, 22.7% went to ordinary generation, while 22.2% of the invoice was for the Special Regime subsidies. This means that the percentage of the cost of the electricity under the Special Regime is roughly equal to the one of the producers of electricity under the Ordinary Regime. These in turn supplied 70% of the electricity produced in Spain. The fact that the entire costs of the renewable energy electricity production was not transferred to the final price led to the so-called *tariff deficit* which has accumulated in the decade 2000 - 2010 25,000 million Euros as estimated by UNESA in the aforementioned publication.

The Electricity Act abandoned the planning as a territorial and functional coordination of the electric sector, except for the transport network and the electricity generation would affect more than regional area. The administrative authorizations for renewable energies were transferred to the local governments (autonomous regions). This decision meant in practice the decentralization of the electrical power policy, whose ultimate consequence was that the administrative authorizations of new renewable electricity generation were a regional competence, while the payment of subsidies had to be supported by a national electric bill tariff, that could not assume those growths in power and production decided locally.

Cost distribution of Spain's electricity bill



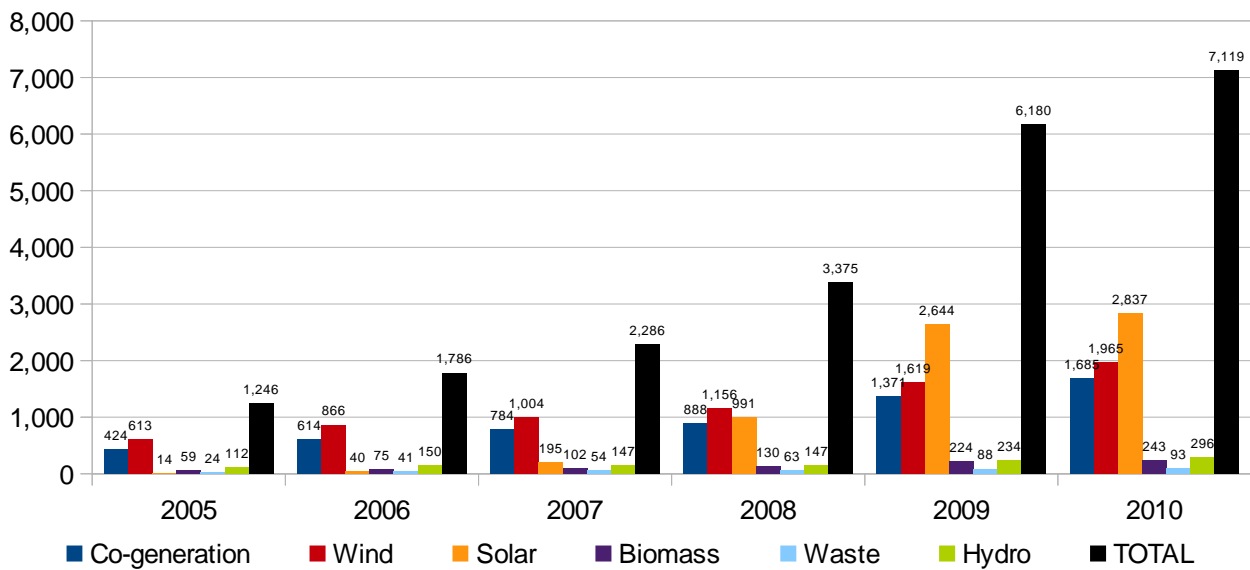
**Figure 1.** Distribution of cost of Spain's electricity bill in 2010. [2]

4. It should also be mentioned the two aspects that might have negatively affected the development of the sector: The power limitation in facilities to 50 MW and the express exclusion of companies that operated in the Ordinary Regime, thus excluding the development of renewable energy to traditional utilities.

5. Finally, with the growth of the tariff deficit, totally overwhelmed and unaffordable as seen in **Figure 2**, in 2010 enacted two decrees which aimed to both reduce the overall cost of supply and to limit the subsidies to the renewable energies. The first of these decrees, the 134 of

February 2010, states that the national coal could be used up to 15% of the electricity produced in conventional power plants, and the second decree, the 14/2010 of December 23<sup>rd</sup>, strongly reduced the so-called *equivalent reference hours* of photovoltaic installations, a decision that meant a reduction of the use of installed capacity or a significant reduction in average earnings if still keeping the same hours of operation.

### Evolution of the cost of subsidies in the Special Regime in Spain (in million Euro)



**Figure 2** Evolution of the cost of the subsidies of the *Special Regime* between 2005 and 2010 (Mill. €) [3]

### 3. Consequences of the legal framework

A quick reflection on the evolution of energy supply reflects the unfavourable situation compared to how it was ten years ago is going to be discussed in more detail in the following section. The contribution of coal to the primary energy demand in 2010 was just over 6%, compared to almost 17% in 2000, and domestic coal and imported coal were traditionally cheaper than oil. The nuclear energy, which had together with hydraulic power the lowest production costs, has dropped its contribution by four percentage points because of the moratorium on building new nuclear power plants that was adopted in the mid-80s, although it had achieved highly positive economic and technical results. Finally, all renewable energies reached 8.2% of the primary energy production, compared to the 3.9% from 10 years ago, but are being questioned by its high introduction costs. The whole Spanish energy system depends on the supply of oil and gas, which are the most expensive energy sources. The final consequence is a sharp increase in the external cost of our energy supply.

Given the delicate situation, not only economic, that faces the energy sector in general and the electricity in particular, the question that arises is whether the existing legal framework could be the main cause of the difficult situation of the sector.

The fact of excluding traditional electric utilities from the Special Regime for renewable energies caused the relocation of large utilities, which have brought their business to other countries. In 1998,

companies that are part of UNESA (the Spanish association of utilities) had 93% of its turnover in Spain, while in 2010 this volume was 35%. Therefore, there has been a significant internal reduction of capitalization. In addition, the widespread access to the transmission grid to new renewable energy producers caused that the number of electricity suppliers went from 4 companies in 1998 to 900 suppliers in 2010, which made the energy management more difficult.

**Production, installed capacity and load factor of different types of energy of the Spanish electrical system**

	<u>2003</u>			<u>2010</u>		
	GWh	MW	GWh/MW	GWh	MW	GWh/MW
<b>Special Regime</b>						
Hydro (1)	4,942	1,559	3.17	6,811	1,991	3.42
Wind (1)	11,720	6,240	1.88	43,355	20,057	2.16
Biomass (1)	1,622	416	3.90	3,119	711	4.39
Waste (1)	1,315	284	4.63	1,862	339	5.49
Solar (1)	9	9	1.00	6,719	4,140	1.62
<b>Total Renewable and Waste</b>	<b>19,608</b>	<b>8,508</b>	<b>2.30</b>	<b>61,866</b>	<b>27,238</b>	<b>2.27</b>
Cogeneration (CHP) (1)	21,804	6,371	3.42	29,036	6,992	4.15
<b>Total Special Regime (Renew., Waste and CHP)</b>	<b>41,412</b>	<b>14,879</b>	<b>2.78</b>	<b>90,902</b>	<b>34,230</b>	<b>2.66</b>
<b>Hydro (1)</b>	<b>38,872</b>	<b>16,657</b>	<b>2.33</b>	<b>38,653</b>	<b>17,561</b>	<b>2.20</b>
<b>Thermal (1)</b>	<b>95,275</b>	<b>22,889</b>	<b>4.16</b>	<b>88,526</b>	<b>39,475</b>	<b>2.24</b>
<b>Nuclear (1)</b>	<b>61,875</b>	<b>7,876</b>	<b>7.86</b>	<b>61,990</b>	<b>7,777</b>	<b>7.97</b>
<b>Total Spanish System (2)</b>	<b>265,071</b>	<b>66,501</b>	<b>3.99</b>	<b>305,420</b>	<b>101,589</b>	<b>3.01</b>

**Table 2.** Production, installed capacity and load factor of different types of energy of the Spanish electrical energy system for the years 2003 and 2010 (1) REE [4] and (2) UNESA [2]

**Production, installed capacity and load factor of different types of energy of the German electrical system**

	<u>2003</u>			<u>2010</u>		
	TWh	GW	GWh/MW	TWh	GW	GWh/MW
Coal	304.7	52.7	5.78	262.9	52.9	4.97
Oil	9.9	5.1	1.94	8.4	5.9	1.42
Gas	61.4	19.5	3.15	86.8	23.8	3.65
Nuclear	165.1	22.1	7.47	140.6	21.5	6.54
Hydro	23.5	9	2.61	27.4	10.4	2.63
Wind	18.7	14.6	1.28	37.8	27.2	1.39
Solar	0.3	0.4	0.69	11.7	17.3	0.68
Biomass	6.5	0.9	7.22	27.6	4.8	5.75
Other	16.8	4.2	4.00	25.1	6.2	4.05
<b>Total German System</b>	<b>606.9</b>	<b>128.5</b>	<b>3.80</b>	<b>628.3</b>	<b>170</b>	<b>3.50</b>

**Table 3.** Production, installed capacity and load factor of different types of energy of the German electrical energy system for the years 2003 and 2010 [5]

The exceptional increase in the number of suppliers of electric generation after the 1997 law, according to the report of UNESA, substantially changed the operational organization of the sector, and that in response to the growing and important new renewable energy supply, electricity companies in the Ordinary Regime had to reduce the use of their installed power, to give access to the net production of new renewable power. And, due to the oscillations of the generated power with renewable energy sources, the traditional power plants had to cover those deficits, deficits that were supplied by coal, fuel gas and combined cycle with gas.

The profound change that involved the substitution of electricity generation from conventional power plants - mainly coal and combined cycle gas - for electricity from renewable energy can be evaluated, as discussed below, by the use of power hours per year (load factor) of all electricity generation in Spain: in 2003 all plants were used 4,000 hours per year of a theoretical potential use of 8,760 hours (365 days x 24 hours per day) while in 2010 the use of all electric power plants amounted to 3,000 hours annually, which means, if considering the same cost in both years, an average increase in price of 25% per each kilowatt in 2010, as compared to 2003 (**Table 2**).

Of particular relevance is the decrease in the average use of the total power - or load factor - in this seven years as a result of the substitution of electricity production from Ordinary Regime to Special Regime: in 2003 this factor was 3.99 kWh/W compared to 3.01 kWh/W in 2010, resulting in a decrease of 25% of the whole Spanish electric power system.

The intensity of the replacement of electricity generated in the Ordinary Regime by electricity generated in the Special Regime is evaluated in **Table 4**, which quantifies the percentage of the share of renewable electricity of the total generated energy.

**Tables 2 and 3** compare the development of load factors in Spain and Germany for the years 2003 and 2010, since Germany is considered of the most effective country in the implementation of renewable energies. It must be stressed for a proper interpretation that even when the values for production and power are expressed in GWh and MW (for Spain) and TWh and GW (for Germany), the load factors - the third column in each tables, have the same unit, and multiplied by 1000 express annual hours of power use for each type of energy.

While in Spain the use of the installed power fell by 25% between 2003 and 2010, in Germany, it only decreased by 8%. What is the reason that the reduction in the use of the installed capacity in Spain is three times bigger than that in Germany? The explanation can be deduced when comparing Tables 2 and 3, and considering that the share of renewable energies in the total for each country is equal. Between 2003 and 2010 the available wind power in Germany was multiplied by 1.9 and the solar by 43, while in Spain it was a factor of 3.2 for wind and of 460 for solar, a fact that confirms a lack of planning in the introduction of renewable energies in Spain and a more sustained growth in Germany.

It should also be noted that in the case of Germany, the contribution of coal in 2003 was of 50.6% of total electricity, and 41.9% in 2010, which helped to keep a high contribution of coal in the electrical system, while gas increased its share from 8.5% in 2000 to 13.8% in 2010 due to the agreements between Germany and Russia [5].

Finally, we should also refer to the so-call *tariff deficit*. In a regime of regulated prices, as it is for the electricity sector in Spain, revenues have to cover the incurred costs. But the tariff in Spain never covered the actual costs of energy production.

The first decade of this century has been very negative in terms of energy, not only because of the high cost of external and internal supply, but also because of the raised controversy among the different participants in the Spanish energy sector. Spain should get back to a greater diversification of primary energy. This means that coal should increase its contribution with technological adaptation of the power



stations to minimize environmental impact, and nuclear power should be maintained to keep the experience, knowledge and results achieved over the past 30 years. Moreover, the above considerations do not mean that renewable energy should not have a significant role, but they should be considered within a framework of central planning, something that has lacked in the past 10 years. This development plan of electricity supply should consider not only the technical aspects of the generation and distribution when adding new capacity, but also financial aspects. In this sense, if the rates cannot afford the full cost of the development of the sector, the Spanish Government should provide funds to temporarily balance costs and revenues. The current price difference between the two types of electricity, the one supplied in the Ordinary Regime and the one supplied in the Special Regime, cannot be maintained.

In any case it is true that the experience in Spain shows that the changes in energy policy have been constant over recent years, and it is worth to make use of that experience, an experience that will be described in the next section.

#### 4. A historical review (1960 - 2000)

In the past 50 years the supply of energy in Spain has undergone exceptional changes. It is true, it also has happened in other countries, but not to the extent that has been recorded in Spain, as we shall see later.

In 1960, the total energy consumption in Spain was 20 million tons of oil equivalent (Mtoe), where coal was the most used energy source, with almost 52% of the total (51.8%), while oil and hydropower had almost equal contribution to the remaining 48.2% (24.3% and 23.9% respectively).

Evolution of the share of primary energy sources in Spain during the period 1960 - 2010							
	1960	1973	1985	1990	2000	2008	2010
Coal	51.80%	17.70%	26.10%	22.60%	16.70%	9.70%	6.30%
Oil	24.30%	66.50%	53.00%	53.20%	51.90%	46.90%	47.30%
Gas		1.70%	2.90%	5.70%	12.20%	25.10%	23.40%
Nuclear		2.60%	8.30%	16.10%	13.00%	11.10%	12.20%
Hydro	23.90%	11.50%	9.70%	2.40%	2.30%	0.80%	2.60%
Geothermal, Solar, Wind, other					3.90%	6.40%	8.20%
<b>Total</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>	<b>100.00%</b>

**Table 4.** Evolution of the share of primary energy sources in Spain for selected years during the period 1960 to 2010 [6]

In 1972, twelve years later, was the so-called *first oil crisis*, and at that time the change of primary energy sources has been radical. In 1973 the coal barely covered 18% of the primary energy, hydropower contributed with 12% while oil was the biggest energy source with a contribution of 67% (see **Table 4**). The impact that the oil crisis on the Spanish economy was very costly because, due to the lack of national energy resources, Spain had to continue with a strong dependence on oil imports at a price per barrel that had increased fourfold, from 3 \$ per barrel until 1972 to 12 \$ per barrel from that year on.

The impact that rising oil prices had on the balance of Spain's foreign trade is apparent when one considers that in 1973, the net cost of importing oil and oil products amounted to 19% of the total value of Spain's export, while in 1980 this percentage was 60%.

Given the increasing deterioration of the economy as a consequence of the deficit of the Balance of Payments, the Spanish Government tried to act on three different fronts, which resulted in the primary energy mix are shown in Table 4 and Figure 3. The main consequences are the following:

- a) First, with a drastic reduction of the growth of energy consumption through the increase in price in raw oil in its origin market that was transferred to the final oil prices. Even though this action was delayed in the first years after 1973, in the period from 1960 to 1973, the increase of primary energy consumption was 184%, while from 1973 to 1985 it was only 33%.
  - b) Second, by substituting oil by other primary energy sources, decreasing its share in total consumption from 66.5% in 1973 to 53% in 1985. This relative decline in oil consumption was compensated by the increase of the coal consumption by 8.5% of total energy and by the start of production of the first new nuclear power stations with a share in 1985 of just over 8%.
  - c) Third, by pushing decisively the development of the electricity sector, giving priority to production through new nuclear power plants, to that point that in 1990 just over 14% of primary energy were from nuclear power plants. To this development contributed effectively the Department of Energy through the newly developed First Energy Plan 1975-1985, that was based on own development plans of the utilities and in which the Central Administration had been coordinating.
- ci)

**Primary energy supply in Spain (period 1960-2010) in Mtoe**

	1960	1973	1985	1990	2000	2008	2010
Coal	10.31	10.04	19.68	19.90	20.91	13.48	8.50
Oil	4.84	37.62	39.87	46.85	64.85	65.05	62.60
Gas		0.96	2.18	4.97	15.21	34.90	31.00
Nuclear		1.48	6.26	14.14	16.21	15.37	16.20
Hydro	4.76	6.51	7.29	2.14	2.82	1.07	3.40
Geothermal, Solar, Wind, other					4.87	8.93	10.60
<b>Total</b>	<b>19.91</b>	<b>56.61</b>	<b>75.28</b>	<b>88.00</b>	<b>124.87</b>	<b>138.80</b>	<b>132.30</b>

**Table 5.** Evolution of the primary energy supply in Spain for selected years of the period 1960 to 2010 (in million tons of oil equivalent) [6]

Finally, in 1990 the process of implementation of nuclear power stations can be considered completed with a contribution of 16.1% of the primary energy. In the same year the contribution of oil increased by seven percent compared to 1985, and reached 46.85% of total consumption, an increase that can partially be explained by the low rainfall in that year. Coal maintained its contribution of 20% while natural gas began to increase in importance with a share of 5% that would rise sharply in the following years.

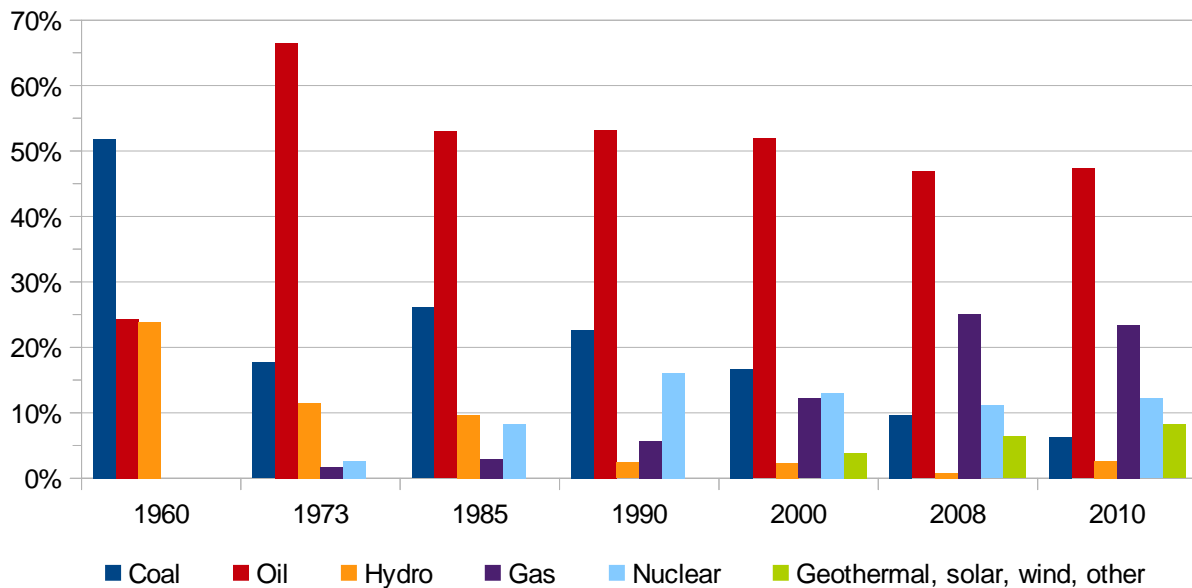
The most important fact of the decade 1990 - 2000 is undoubtedly the increase in primary energy demand that rises during these ten years from 88 Mtoe to 124.9 Mtoe respectively, i.e. 42% (**Table 5**).

Summarizing, and before analysing the evolution of the energy sector in the first decade of this century, it can be highlighted in Figure 3 that between 1960 and 2000 the coal rapidly reduced its share from 52% to 17 %, oil has remained with an important contribution, the same as natural gas, whereas hydraulic energy has lost weight from 24% to barely 2% while the nuclear moratorium in the mid 80's has avoided the



construction of new power plants and therefore has kept its electricity production while its contribution has fallen to just over 12% of total primary energy supply.

### Evolution of the share of primary energy sources in Spain



**Figure 3** Share of primary energies in Spain (period 1960 to 2010) [6]

## 5. The decade of the renewable energies (2000 - 2010)

The first 10 years of this century have again been testing the difficult conditions in which Spain is moving, in order to meet the energy supply in a safe and internationally competitive way. Many of these challenges lie in an erratic sector development in Spain, apart from the global problem of the security of energy supply.

Internationally, the strong tension in oil prices during this period and the impact of the Kyoto Protocol on reducing the greenhouse gas emissions in each country, affect both the cost of oil imports and the progressive reduction of the production of electricity from coal-fired power plants. These were replaced by combined cycle power plants with higher cost, since natural gas has an important role in its production of electricity, and in the case of Spain, its price is linked to the price of long-term crude oil import contracts.

In the balance of primary energy consumption between the years 2000 and 2010 (**Table 4**), it is worth to mention that the share of coal has been reduced to less than half, from 16.7% in 2000 to 6.3% in 2010. This reduction is mainly due to falling domestic coal consumption in power plants. According to UNESA in its latest annual report, between 2009 and 2010 the use of coal and domestic anthracite was reduced by 51%, lignite by 21.8% and by 30.1% the subbituminous coal.

The decrease of domestic coal was compensated with natural gas imports, 11.2% higher in 2010 than in 2000, with a slight decline in oil. Both together, oil and gas, had a contribution that rose in 2010 to

70.7% of total primary energy, compared to 64.1% in 2000, i.e. 6.6%, which is more than half of the reduction of the coal usage. Consequently, our dependence on oil increases as the use of coal decreases.

The contribution of renewable energy, as discussed below, went up in contributions from 3.9% in 2000 to 8.2% in 2010, mainly in order to replace the weight loss of nuclear energy, which share was reduced 0.8%, from 13% in 2000 to 12.2% in 2010.

Until 1997, the Spanish legislation did not provide an exclusive or specific regulation for renewable energies. Its regulation is included in the *Law 54 of November 27, 1997 of the electricity sector*, whose content is primarily to establish the conditions for access to certain public grid electricity producers who previously were unable to do so, since the access was reserved for the utilities.

The main new producers of electricity came from renewable energy supplies - hydro, wind, biomass, industrial and municipal waste, solar, and other non-renewable energy, which were auto-producers using co-generation or other forms of electricity production associated with non-electricity activities. Within these non-renewable energy sources were also included those producers that were using as primary energy waste from agriculture, livestock and service.

All these new producers of electricity of renewable and non-renewable energy became part of what is called for in Article 27 of the Act as *Special Regime of Electricity Production*, and their holders had preferential access to the network with electricity prices that substantially increased the economic conditions of supply companies under the Ordinary Regime.

#### Evolution of the electricity generation under the Special Regime in Spain (GWh)

	<u>1997</u>	<u>2000</u>	<u>2003</u>	<u>2006</u>	<u>2009</u>	<u>2010</u>
<b>Renewables (total)</b>	<b>5,061</b>	<b>9,669</b>	<b>19,608</b>	<b>31,463</b>	<b>53,563</b>	<b>61,866</b>
Hydro	3,429	3,836	4,942	4,148	5,474	6,811
Wind	620	4,462	11,720	22,837	37,401	43,355
Biomass	193	410	1,622	2,274	2,850	3,119
Industrial Waste	455	551	838	0	0	0
Urban Waste	363	409	477	0	0	0
Solar	1	1	9	102	5,999	6,719
Rest of renewables	0	0	0	2,102	1,839	1,862
<b>Non-renewables (total)</b>	<b>11,100</b>	<b>16,971</b>	<b>21,804</b>	<b>20,743</b>	<b>26,788</b>	<b>29,037</b>
Residual Heat	124	137	160	65	38	96
Coal	108	103	571	87	86	65
Oil	2,139	3,934	3,172	1,674	2,792	2,586
Gas from refinery	984	641	508	608	675	942
Natural Gas	7,745	12,156	17,393	18,309	23,197	25,348
<b>Total renewables + non renewables</b>	<b>16,161</b>	<b>26,640</b>	<b>41,412</b>	<b>52,206</b>	<b>80,351</b>	<b>90,903</b>
<b>Annual production of Spanish electrical system (1)</b>	<b>189,381</b>	<b>225,105</b>	<b>265,071</b>	<b>303,450</b>	<b>297,287</b>	<b>305,420</b>

**Table 6** Evolution of the produced energy under the Special Regime for the period 1997 to 2012 in GWh [6]

**Table 6** shows the development of the produced electricity under the Special Regime of Law 54 November 1997 by source between the years 1997 and 2010 (in millions of kilowatt-hour of electricity). The production of the total energy in these thirteen years has increased significantly: the total production has been multiplied by a factor of 5.6 and in the case of the renewable energy this multiplier was much higher, 12.2 times, as compared to 2.6 times for non-renewable energy. Among the renewables stands out wind energy which reached 43,355 GWh in 2010, followed by hydropower 6,811 GWh, solar energy 6,719 GWh and biomass with 3,119 GWh.

Regarding the non-renewable energies, co-generation (or combined heat power) stands out natural gas (that tripled its production) and oil with 25,348 GWh and 2,586 GWh, respectively.

From Table 6 it can also be observed:

- 1.) The important contribution of wind energy.
- 2.) A significant use of natural gas in combined heat power.
- 3.) The modest but rapidly growing contribution of solar energy, especially in the year 2009 due to the generous remuneration established in the Royal Decree 661-2007 that was reduced drastically with the entry into force of the Royal Decree 1578-2008.
- 4.) A clear reduction in the annual growth rate of the Special Regime in 2010, that was 10,6% compared to 18% annually in the previous three years.

However, it must be said that the development of electricity production in the Special Regime has been irregular and has contributed, through the replacement of the Ordinary Regime's electricity, to a significantly lower use of the installed power of the entire electricity sector.

The production share of the produced energy under the Special Regime (renewable and non-renewable energies) has increased between 1997 and 2010 by 21%, from 8.5% to 29.5%. To this increase of 21% accounted the renewable electricity for 17.6% and the non-renewable energy for the remaining 3.3%.

To conclude this description of the decade that evaluated statistically the implementation of renewable energies in Spain, two observations have to be made that also will be included later in the conclusions section of the new energy framework designed in 1997.

The first one is related to the significant variation in the utilization of the power among the various energies. Implementing a renewable and co-generation system requires more power in reserve to meet the contributions of these irregularities and this substitution affects the total cost of the electricity supply system.

The second observation also refers to this shift in the use of electric power, especially between co-generation and conventional power. In 2003 the use of power was 20% higher in conventional thermal power plants than in co-generation, while seven years later this load factor is a factor of two higher in co-generation power plants than in conventional ones.

## 6. Conclusions

The balance of the first decade of the 2000's in the field of electricity production is not positive, and shows little chance of improvement in the near future unless the necessary measures are taken.

The Energy Policy that has been decided at the end of the last century aimed a rapid development of renewable energy in the electricity sector to replace coal, nuclear energy and oil. Over the years it has been

shown that this was not possible, and its consequences have been a greater dependence on hydrocarbons. This does not mean that renewable energies have no place in Spain's energy supply. Probably, the error has been the choice of a wrong strategy when implementing renewable energies. The Electricity Industry Act of 1997 tried to introduce renewable energies quickly by giving them priority over the existing sources of energy production, rather than trying to introduce them gradually and adapting them to the existing electricity production. The result was a substantial increase of the cost of production and a growing increase in the tariff deficit.

Spain supports a dependence of external energy products that is extremely high, and which has increased in the last 10 years due to the policy of reducing coal consumption in power plants and the gradual decrease in nuclear share with the persistence of the moratorium in mid-the 80. Faced with these two circumstances, the energy policy that has been designed at the end of last century was clearly unable to maintain the degree of internal self-sufficiency, which also worsened the external financial stress.

As already mentioned, it is not possible to maintain a price differential between ordinary electricity supply and regulated one, as it is currently the case in Spain. The prices of the latter should be reduced, and the difference between both of them that cannot afford the electricity tariff should be supported from the General State Budget

Finally, it should be stressed that the introduction of renewable energy in Spain has lacked from the necessary central planning, whose ultimate result was the confrontation between producers and an uncontrolled financial deficit. The government should resume at the Ministry of Industry the initiative of this activity, as it did in the Energy Plan of 1975, since from its solution depends a big part of the external financial adjustment of Spain's economy.

The traditional power companies should participate in the renewable energy plan, both for their expertise and for the contribution they could make to profound alteration of the distribution that has occurred with the introduction of renewable energies. It should also not to be underestimated the financing of the energy sector during the next few years, both regarding new installation of conventional power (as e.g. nuclear power) and renewable energy projects. To be able to finance this reorganization of the electrical sector, Spain will have to rely on external funding and it have to be involved large utilities, as happened in the 1980's with the Nuclear Plan.

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