

# Characterization of the Spanish Electricity Sector

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**Abstract**— In this paper, the situation of the Spanish electricity sector is analyzed. The study is situated in a framework of European decarbonization of the economy, where policies are addressing to high penetration of renewables technologies in the electricity mix. This work studies the situation of the activities in the electricity sector, specially the generation, how the wholesale market is behaving nowadays and the future trends expected for it. Then, the problems of current generators to amortize their facilities and the challenge that electricity markets will need to face regarding future investment are also discussed in this paper.

Once is analyzed all above, as well as the state of art of the technologies thanks to the tool of Levelized costs of energy (LCOE) and being conscious of the European directives, is concluded how the sector is going to move on through times, and what can be done in order to make it sustainable for the consumers.

**Key words**— Electric system, wholesale market, penetration of renewables, future trends, levelized costs of energy, windfall profits.

## I. INTRODUCTION

The concerns about climate change and security of supply in Europe, mainly, led to

approve directives that defines a new strategic framework for achieving the Community's policy objectives, in particular for the new specific objectives for the 2030 horizon (40% reduction in emissions compared to 1990, 27% share of renewables on final energy consumption, 27% of energy saving compared to consumption forecasts and 15% of interconnection capacity between member countries), which will require a profound transformation of the European energy system. In this context the electricity demand is expected to increase enormously, specially in the transport sector, doubling its share in final energy demand to 36-39% in 2050. [1] [2]

In order to comply with European directives, the Spanish state is currently developing the so-called Renewable Energy Plan 2011-2020. The goal set by EU is to reach a minimum quota of 20% of energy from renewable sources in the final gross energy consumption, nowadays the level is still in 17%. [3]

By other hand, in the year 1997, a new structure of the electricity sector was set-up in Spain, when was approved the law 54/1997, which marked the beginning of the process of progressive liberalization of the sector. The sector was divided in two groups of activities that can be differentiated as:

- Liberalized activities, or in full competence, include generation and marketing of electricity.
- Regulated activities, which are natural monopolies, include transportation and distribution of electricity.

The main goal of this liberalization was to create proper conditions for the competence that will lead to efficiency in the electrical sector, being traduce in less prices to pay by consumers.

The level of electricity consumption in Spain has been really affected because of the economic crisis of 2008, where demand decreased for the first time in history. Since this date, demand has been decreasing until year 2015, when it started to increase again, situating around demand level of 2003.

The tariff deficit in Spain has reached the quantity of 25000 millions of euro, which greatly condition the decision-making regarding the sector. Now this deficit is decreasing due mainly to the cut of premiums given to renewable and CHP facilities.

## II. GENERATION. ANALYSIS OF PRODUCTION VARIABILITY IN PEAKS OF DEMAND

At the final of 2015 the total installed capacity increased to 106247 MW, and also demand increased reaching 262931 GWh. The generation activity in 2015 has been deeply analyzed in this work, being reflected the contribution to the electricity mix and the capacity installed of each technology. [4]

In this year, the total renewable capacity installed reaches 51849 MW, representing 48,8% of the total, all this power has contributed to the mix with 262931 GWh, which represents 36,9% of total gross demand.

Must be taken into account that in 2015 hydroelectric contribution decreased 27,5% as well as wind contribution was lower with a decrease of 5,7%. This decreasing in renewable generation must have been compensated with the contribution of dispatchables, coal increased its production in 21,9% and combined cycle in 17,1%.

Must be remarked the situation of combined cycle technology, which with a installed capacity of 26670, only worked with a utilization factor of 12,9%.

In this work, the peaks of demand have been taken as reference in order to study the reliability level of the supply system. The peaks of demand in winter and summer were respectively 40726 MW and 40192 MW.

In order to make clear how the penetration of renewable technologies in the electricity mix contributes to production variability through time, was collected from Red Electrica España (Spanish Transmission System Operator) the data of power provided of each technology to peaks of demand in recent years. There is a case of study for peak demand in cold months and peak of demand for hot months, data collected are represented in the next tables 1 and 2.

Power provided [MW]	2008	2010	2012	2013	2014	2015	2016
Peak demand [GW]	43	44.1	43.5	39.9	38.9	40.7	38.2
Date	15-dec	11-jan	13-feb	27-feb	04-feb	04-feb	17-feb
Coal	7026	2287	7930	7870	1174	5644	5711
Combined cycle	12348	7383	10533	3696	2818	4154	4717
Hydraulic	5744	9910	4900	6558	9334	6300	9514
Wind	8029	9358	9289	8933	12812	14114	5977
Solar	0	0	0	0	0	159	302

Table 1. Power provided to peak demand in winter 2015. Source: Own elaboration

Power provided [MW]	2008	2010	2012	2013	2014	2015	2016
Peak demand [GW]	40.1	40.9	39.2	37.4	37	40.2	40.1
Date	01-jul	19-jul	27-jun	10-jul	17-jul	21-jul	06-sep
Coal	5821	4727	7818	7435	8540	8599	6964
Combined cycle	15367	13888	8975	3824	3290	9735	7424
Hydraulic	7284	7070	5079	7502	4390	4691	5945
Wind	1478	595	2850	2307	6500	2038	1166
Solar	2507	3109	4887	5104	5222	5181	5907

Table 2 Power provided to peak demand in summer 2015. Source: Own elaboration

Then, based on the data presented in the tables, the numbers of power provided corrected have been transformed in two graphs, next figures 1 and 2. On the one hand the conventional contribution of coal and combined cycle has been plotted; and on the other hand the renewable contribution of wind,

hydro and solar. For a particular year, these corrected numbers are obtained as the available power of each technology divided by the maximum demanded power, in this way it is possible to have a reference when comparing the numbers from one year to another.

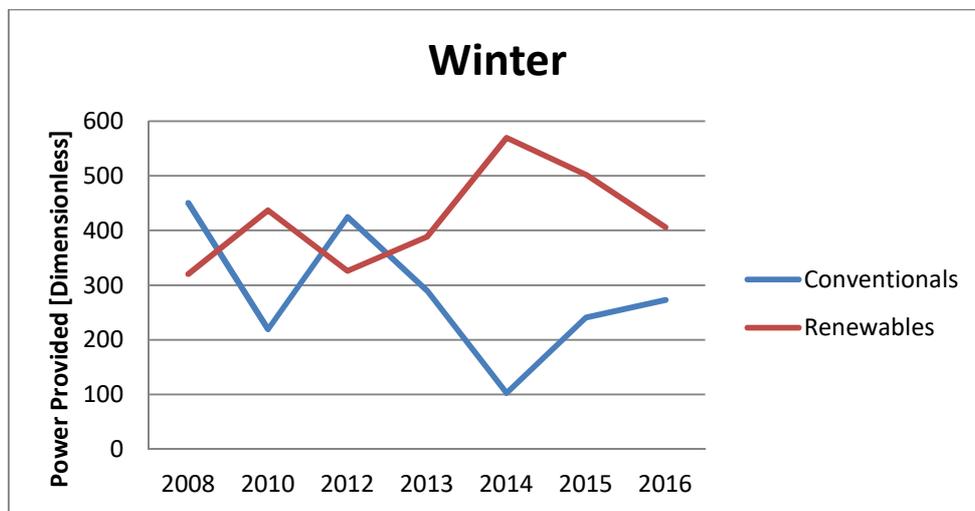


Figure 1. Provided power to peak demand during recent winters. Source: Own elaboration

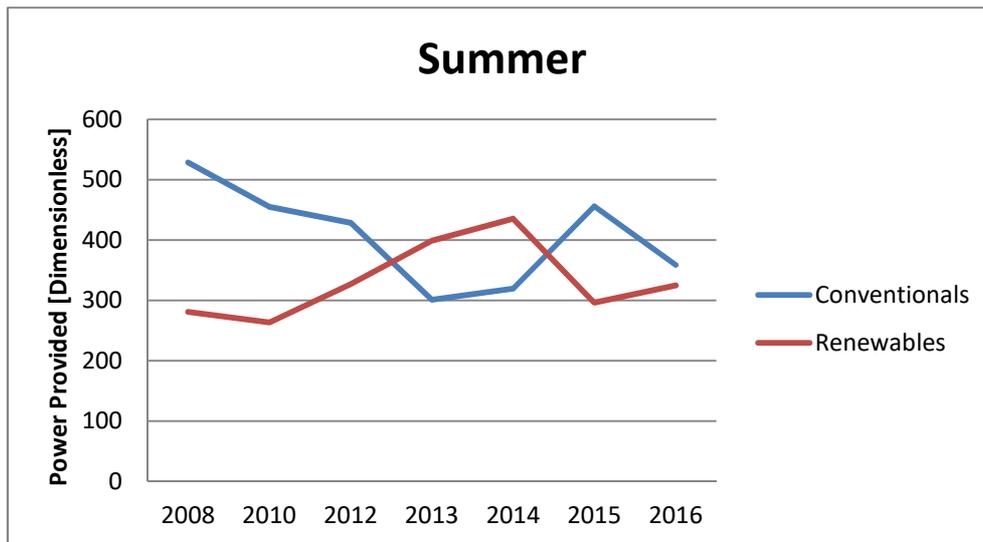


Figure 2. Provided power to peak demand during recent summers. Source: Own elaboration

As can be seen in both graphs, there is correlation between renewable and conventional technologies, when the contribution of one increases, the one of the other decreases and vice versa. Due to the strong variability of renewables, is needed continuous back-up technology in order to ensure electricity supply at all times.

Moreover, knowing that the historical maximum demand was 44876 MW and only the dispatchable power installed is 54398 MW, can be easily figure out that there is overcapacity installed nowadays.

### III. SITUATION AND PERSPECTIVES OF THE ELECTRICITY MARKET

The trends experimented by electricity market in the recent years should be studied from two perspectives: by one hand, the retail market, which is experimenting increases in the prices, due mainly to the taxes and levies aimed at renewable technologies and cogeneration. Public aid to these technologies has been cut and is not expected to be back in the near

future. By the other hand, wholesale market, is experimenting decreases in the spot price in the recent years, due to the penetration of low carbon-technologies.

Prices are key drivers of investment decisions, as they influence potential remuneration to investors. If the electricity market price keeps on decreasing, what is expected, no facility will be amortized and will trend to stop the activity and think about closure, as is happening with some combined cycle plant nowadays. [5]

Moreover, the fluctuating prices due to the variability of renewable technology production as well as the trend to lower prices will keep the investors away from this market, since it is not sure that they will be able to get enough revenues from the market in order to cover the fixed costs together with the marginal cost of electricity production.

The tool of capacity payment plays an important role in the market as they are allowing combined cycle plants, specially, to get

the necessary revenues that are not having from wholesale market.

The High RES penetration scenario expected according table 3, show us the fact that the wholesale market will not be able to properly

remunerate each technology in order to cover the fixed costs due to low average spot price. Also only powerful companies will be able to face the risk of volatility of prices, creating barriers to entry into the market for other competitive companies. [6]

	Reference Scenario		High RES penetration		High nuclear penetration	
	2010	2030	2010	2030	2010	2030
<b>Fixed and Capital costs</b>	58%	53%	69%	80%	65%	67%
<b>Variable and fuel costs</b>	42%	47%	31%	20%	35%	33%

Table 3. Electricity cost structure. Source: European Commission

Markets are supposed to serve two functions: optimisation of resources already in place, and driving investment for the future. Whereas the electricity market serves the first function well, it is not clear whether the current electricity market design will be sufficient to convey the right long term investment signals, threatening, mainly, the investment in combined cycle technology.

Currently, the levelized cost of energy, table 4, as well as the politic framework let us think that the future installed capacity will be mainly wind and PV. These technologies have reached a point of technological maturity that makes them competitive in the wholesale market.

Comparing the LCOE with the average wholesale market price in recent years, which is 43.4 €/MWh according to OMIE data, is easily noted that the prices are not sufficient to cover the costs of a new generating facility.

By the other hand, the historical power plants already amortized, are having windfall profits from the market since 2006, when they stopped receiving benefits from the plan “Costs of Transition to Competition”.

Coal and nuclear technologies has not been included in the table 4 as they are expected to disappear from the system in the next decade.

Technology	LCOE [Euro/MWh]		
	3%	7%	10%
PV – residential rooftop	91,07	124,87	154,92
PV – large, ground-mounted	79,34	100,52	120,18
Wind onshore	73,23	94,88	110,79
Biomass turbine	138,02	159,61	175,57
CCGT	94,30	99,01	103,73

Table 4. Levelized costs of electricity for generating plants in Spain in 2015. Source: International Energy Agency

#### IV. CONCLUSIONS

The main conclusions of the work may be summarized as follows:

- There are no electricity supply problems today, there could be problems in the medium term, due to the volatility and decreasing trend of prices, what would endanger mainly the availability of despatchable technology in the system.
- Historical power plants are having windfall profits since years, then an audit of producers would lead to generate incomes in order to tackle tariff deficit, avoid windfall losses and attract new investments.
- The design of the current wholesale market is outdated, as it will not be able to generate enough revenues for existing facilities, create competitiveness and provide clear price signals for new investments.
- There is no capacity of competition between zero marginal cost technologies and the high costs ones. Another design of market must be drawn in order to face the emerging challenges that are engaging Europe.
- A new market design becomes necessary, one that trends to remunerate each technology based on its energy production costs. This requires complete, clear and transparent information on the activity of all generators.

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