18th International Conference on Renewable Energies and Power Quality (ICREPQ'20)
Granada (Spain), 1st to 2nd April 2020
Renewable Energy and Power Quality Journal (RE&PQJ)
ISSN 2172-038 X, Volume No.18, June 2020

Analysis of Energy Systems in Europe: The Case of Wind Energy in Spain

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Abstract. The world energy demand is increased each year so it is important to analyze how this demand is covered. As a consequence, it is imperative to accommodate the different frameworks to make that happen. Wind energy has proved itself as a generation source in which countries can rely on, so to simultaneously solve the dilemma of this type of generation - resources, technology and policy-, the renewable energy sector should be studied. The aim of this work is to analyse the current situation of wind energy in one of the main countries in the European Union within this type of generation: Spain. A brief analysis of the current situation is made, accounting the importance of wind energy in the electric generation and future plans. Moreover, the evolution of the legislative frameworks is studied with the aim of figuring out if there is a relation between them and the changes in the annual installed power. Lastly, it is concluded that Spain has an extraordinary renewable resource but planning, predictability and legal framework are needed to achieve a more sustainable energy model.

Key words. Renewable Energy, Wind, Framework, Spain, Evolution.

1. Energy Outlook in the European Union

The European Union is clean-energy, zero-emissions oriented and their support to the efficiency measures, energy savings and renewable energy proliferation is clear [1], [2] [3]. The European Energy Policies have a three-side approach: (i) Security Supply, (ii) Competitiveness and (iii) Environmental sustainability, developed by different Directives (Directive 2009/28/EC for the 2020 targets or the Renewable Energy Directive 2018/2001/EC), so the aim for a Renewable-based energy model is one of the relevant solutions available [4].

Europe installed 11.3 GW of new wind energy during 2018 (9 GW onshore, 2.7 GW offshore and 0.4 GW decommissioned) and has a total installed capacity of 189 GW (Figure 1). Wind energy is the second largest form of power generation capacity and it is likely to overtake natural gas installations during 2019. Germany installed the most wind power capacity (3.3 GW) and remains the European country with the largest installed wind power capacity (59.4 GW) followed by Spain (23.3 GW), UK (20.9 GW) and France (15.3 GW) [5].

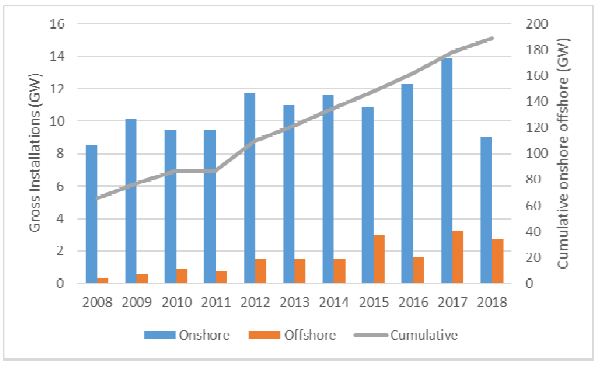

Figure 1 Gross Annual Onshore and Offshore Wind Installations and Total Cumulative Capacity in EU (GW) (Source: Wind Europe)

Although Figure 1 shows a sustained increase in power installed, there is a significant volatility in the sector going throughout Europe [4]. Particularly serious is the Spanish situation, where the investments in Renewable Energy Sources (RES) have dropped to almost zero since 2013 due to the destabilization of the legislative framework, the economic crisis and the austerity measures implemented.

On the other hand, it is important to stress-out the unexpected consequences the feed-in-tariff (FIT: constant payment per unit of electricity generated) are having across de European Union, not only for the uncontrolled growth of certain renewable sources, but also for the increased expenses that this means for the countries [6]. This problem is being addressed by some countries in the form of changes in regulatory frameworks and mechanisms such as auctions/tenders [7].

2. Energy Outlook in Spain

Spain developed its National Renewable Action Plan 2011-2020 (NREAP) [8] to achieve the 2020 targets set by the EU. One of them is an estimated share in gross final energy consumption of 22.7% by that year (Figure 2). Montoya *et al.* [9] established, in 2014, that, according to

their estimations, Spain would only achieve a 17% and, although Figure 2 shows that Spain has already reached that target (17.51% in 2017 according to Eurostat), authors such as Ramírez *et al*. [10] have concluded that it would require a tremendous effort to get to the 20% even with the auctions launched by the government in the last two years.

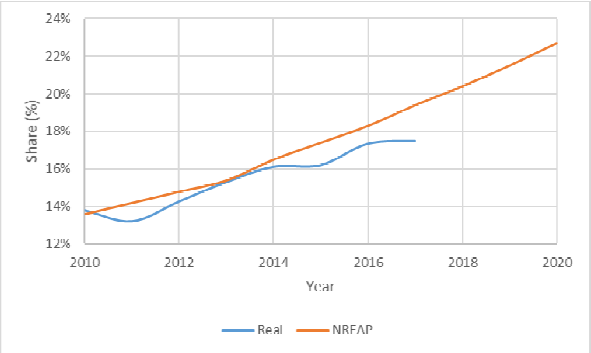

Figure 2 Spain - Share of Renewable Energy in Gross Final Energy Consumption (Source: Eurostat, NREAP)

Another mark set in the Spanish NREAP for 2020 is a share of 40% of renewable energies in the electricity market. According to data from REE and the NREAP, Spain has already achieved this objective (Figure 3), however, caution is needed, as it could be seen that the share during 2017 dropped below the target due to the variability of the renewable sources and not because of an increase in the energy demand (Figure 4).

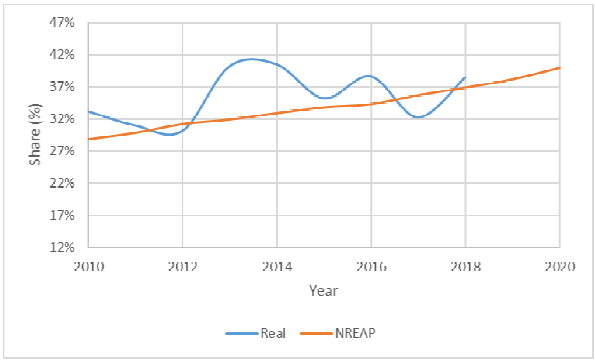

Figure 3 Spain - RES Share (%): Electricity Market only (Source: NREAP, REE)

To complete the Spanish outlook, a glance at the energy demand and how it is covered is needed. In Figure 4 could be observed how profound the impact of the crisis was, with an important reduction in the demand in 2009 and a continuous decrease until 2014, where the electric consumption was around the same values as it was in 2005. The trend shifted that year and, in 2018, the demand is at almost the same level as in 2007.

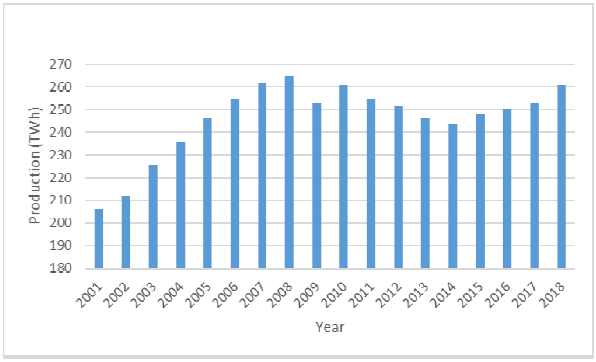

Figure 4 Spain - Net Electric Production in TWh (Source: REE)

Figure 5 shows the distribution of the total installed power (104,094 MW) and how the demand was covered (260,973 GWh) in 2018. Wind energy covered 19% of the electricity demand and ranked second only after nuclear energy (20%). This means that wind energy is an active part in Spain and has a leading role in the total renewable production.

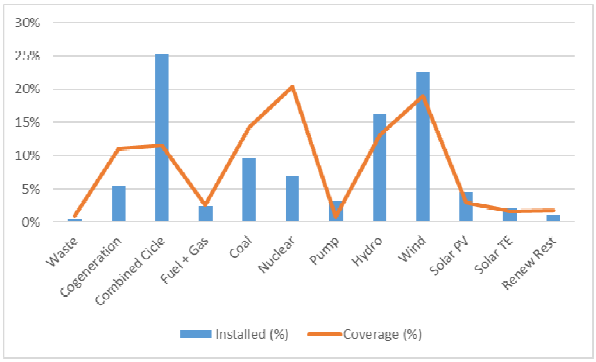

Figure 5 Spain – Installed Power and Demand Coverage (%) (Source: REE)

The importance of renewable energies is clearly seen in Figure 6 where the energy dependence is shown. During 2007 came into force the Royal Decree 661/2007 [11] regulating the renewable framework and the response was an important increase in the power installed each year. As a consequence, there was a reduction in the energy dependence that reached a minimum in 2013 (70.4%).

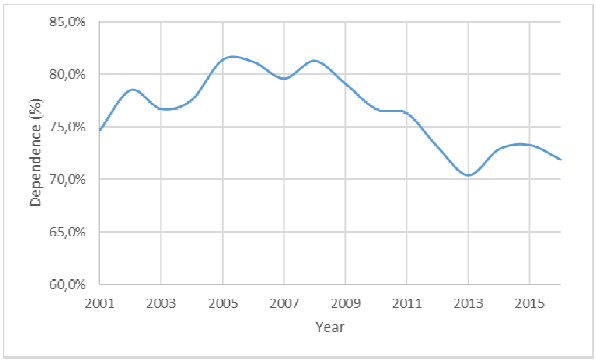

Figure 6 Spain - Energy Dependence (Source: Eurostat)

A. Wind Energy

Nowadays, Spain renewable model is based on the NREAP 2011-2020 [8]. Objectives are in line with the ones established by the European Parliament and Council Directive 2009/28/CE, with an estimation of 35 GW of

wind power installed by the end of 2019. However, this target will not be easily achieved, as it would require the installation of nearly 12 GW during 2019 (with 3 GW offshore). The Spanish Government is currently planning its strategies for the 2021-2030 period. The draft of the Integrated National Energy and Climate Plan (INECP) [12] aims for a share of the renewable energy in the gross final energy consumption of 20% with 28 GW of wind energy installed in 2020 and 42% with 50 GW in 2030.

Nevertheless, wind energy has an important participation in electricity generation. During 2018, the 23 GW of installed power covered 19% of the demand (Figure 5) and the ratio between the so-called Ordinary Regime (generation with fossil fuels and nuclear) and Special Regime (generation with renewable energies) was 62%-38%. Figure 7 shows the evolution of the mentioned ratio since 2002. An increasing percentage in the renewable generation is seen until 2013, year in which the investments on renewable power stopped and, since then, the ratio is around 60-40%. The political context and the changes in the regulatory framework Spain has suffered during the last years have led to a market uncertainty and a slum in the investment on renewable energies. This uncertainty is clearly seen in Figure 8 in which is shown that, since 2013, almost no new wind power was installed in Spain.

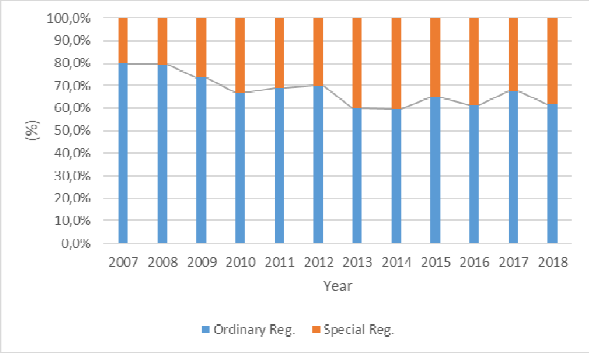

Figure 7 Spain – Ordinary Regime/Special Regime ratio in electricity demand coverage (Source: REE)

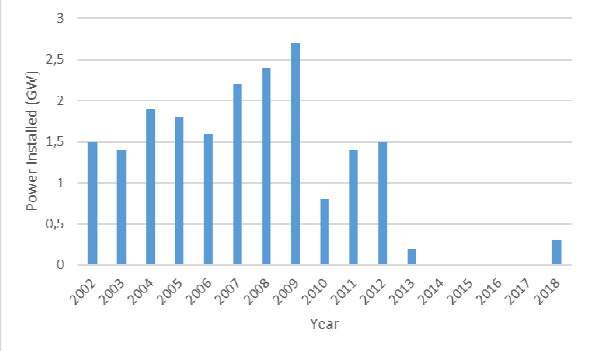

Figure 8 Spain – Annual Installed Wind Power (GW) (Source: REE)

Even when Europe is a world leader in offshore wind farms [7], Spain has no contribution at all [13], partially because of the lack of a proper regulatory framework for this technology [14], and the 2020 target of 750 MW offshore is completely out of reach with only a 25 MW project to be built in Gran Canaria.

B. Regulatory Framework – Evolution and Current Situation.

Spain had a stable regulatory framework for the renewable energies established by the Royal Decree 661/2007 [11] which created the "Special Regime". For each renewable installation, two retributive options were given: feed-in tariff (FIT) and market plus premium. The FIT scheme guaranteed a fixed price during the installation lifespan (7.3228 c€/MWh in 2006), while the market plus premium was based on a variable premium over the market prices (2.9291 c€/kWh as a reference value plus a premium between 8.4944 c€/kWh and 7.1275 c€/kWh). Those values changed every year according to different Government orders: for new projects, the price was decreased and it was increased for existing installations according to the Consumer Price Index (CPI).

The arrival of the financial crisis in 2008 had no direct impact on the renewable market until 2009-2010 when it merged with the tariff deficit. The tariff deficit is defined as "a shortfall of revenues in the electricity system, which emerges when the tariffs for the regulated components of the retail electricity price are set below the corresponding costs borne by the energy companies" [15] and, in 2013 rose near 30,000 million euros. As a consequence, the European Commission recommended to the Spanish Government the implementation of structural reforms [16]. Such measures affected drastically to the energy market – and wind market particularly.

Although programmed, the first of those changes felt like a seatback for the renewable market. The pre-assignation registry was established by the Royal Decree Law 6/2009 [17], in which quarterly power quotas were created to regulate the new installed capacity so and uncontrolled growth could be avoided. This is one of the reasons behind the installed power in 2010 (Figure 8). The others were the high amount of applications the Government received, making it impossible to solve them on time, and the investors' increasing difficulties for getting financial support due to the lack of knowledge about the electricity prices the new installations would get.

2011 and 2012 were two years where the situation seemed to normalize but, during 2012, the Government approved the Royal Legislative Decree 1/2012 [18], which put an end to the pre-assignation process and set a 7% tax over the renewable electricity generation. This also led to a breakpoint in the market: existing installations would keep its current payment scheme, but new ones were obliged to choose the market plus premium option. The entry into force of this Decree is the main reason for the 200 MW of wind energy installed during 2013: these were the last projects in the pre-assignation process, meaning that the investors did not find the new framework attractive. According to investment data from AEE, several companies renounced to install up to 928 MW of wind power that year [19].

In February 2013, the Government approved the Royal Decree-Law 2/2013 [20] introducing new and important modifications to the payment framework that affected the wind farms feasibility. Those changes were: (i) the disappearance of the pool plus premium scheme, leaving

FIT or market-only as options for new installations; (ii) price updates were no longer linked to de CPI but instead, a new reduced CPI was set to minimize the increase of the tariff deficit; and (iii) this new system had effect since January 1st 2013, even when it came into force in February.

In July 2013, a new law was approved: the Royal Decree-Law 9/2013 [21], also known as the Energy Reform. A new payment framework was established and applied over all, new and existing, installations. This mechanism was fully developed through Royal Decree 413/2014 [22] and the Order IET 1045/2014 [23] and came fully into force in June 2014. The core problem of this last movement was that it was retroactively applied, meaning that from July 2013 to June 2014, renewable energies were paid under an invalid regime and were obliged to refund part of their income. As this new framework affects to all the existent installations, an important number of them have suffered feasibility problems, as some investments were not fully amortized.

The payment framework created by the Royal Decree-Law 9/2013 [21] introduced the concept of "Installation Type" to typify every single renewable project according to its generation source, power and construction year. As a result, a list of 2,070 installation types was created, each one having different parameters used to calculate the economic retribution. This *Specific Retribution Regime* (SRR) is the sum of the pool price, an investment factor (granted via auctions negotiated between the producers and the Government; it works as a premium over the market price) and a performance-operation factor to be applied during the whole installation lifetime or until it reaches a *reasonable feasibility threshold* set in a 7.39% over the total investment. The aim of those changes is to allow investors to compete at the same level as the rest of the generation technologies.

The entry into force of all this new legislation in such short period of time created a legal uncertainty in Spain that lead to a total cease of the investments in the renewable sector. After several years (since 2013) without new investments, this new payment method allowed renewable investors to obtain additional incentives over the market prices. The first electricity auction was held by the Government in January 2016. It was the first time this framework was applied and all the 700 MW auctioned were allocated (500 MW for wind technologies and 200 MW for biomass). The investment factor negotiated (part of the SRR) was 0 €/MW installed for both technologies.

During 2017 the Government held two more auctions in May and July. The first one allocated nearly 3,000 MW (2,779 MW of wind energy, 1,037 MW of photovoltaic and 19.3 MW of renewable technologies different than wind and photovoltaic). The investment factor negotiated was, again, 0 €/MW installed and a guaranteed market price of 41.5 €/MWh. The second one ended with 1,128 MW of wind energy and 3,909 MW of photovoltaic with the same investment factor as the previous auctions and a market price of 32 €/MWh.

3. Future Perspectives

Several factors have taken Spain to its current position, but the changes in the regulatory framework have been the main reason. It is vital to have a stable regulatory framework for the development of RES and to maintain the entrepreneur's trust [24].

However, is not sustainable to invest in renewable sources the way it has been done until now although authors such García-Álvarez *et al* [25]. have concluded that the use of FIT schemes in the development of onshore wind energy is the most successful method to achieve European targets. One of the advantages of the FIT schemes is that everyone can participate, from individuals to communities and small companies and are more attractive for investors. That does not happen when the machine is an auction, as they tend to favour big companies. So diversity is lost when moving from one scheme to another. On the other hand, the risk of FIT schemes appears when the regulator is not able to set the appropriate remuneration level. Nevertheless, the solution is not clear and maybe a complete restructuration is needed with new financial support mechanisms to soften the investments.

In addition to the foreseen development of the renewable market, new infrastructures will be needed and they will have to take into account the future system needs [26], [27]. Research and development will also be vital [28] [29] for cost reduction and for the implementation of more efficient technologies such as hybrid-renewable energy systems [30], multi-objective optimization models [31] or even energy storage technologies for wind power applications [32]. Those hybrid systems such as the ones based on concentrated solar power in combination with biomass, geothermal or wind technologies, could have an important role in the mid-term, as they can become cost-competitive with natural gas with coal-based by 2050 [33]. Investing in low-emissions fuels is interesting, but those "renewable-fuels" will only play a significant role if CO_2 taxes, intensified R&D and technological learning are strategically implemented [34].

4. Conclusions

Spain had a stable regulatory framework for the renewable energy systems until 2009, the year in which the Government started to make important changes in the laws. There were many reasons for that, but the main one was the unexpected increase in the photovoltaic energy that led to an uncontrolled increase in the premiums for this technology.

Apart from that, Spain was truly harmed by the enormous impact the financial crisis had. This brought to light several structural weaknesses that had remained unnoticed until that moment such as the inexistence of an explicitly-defined energy policy approved by general agreement. It is necessary to develop new plans which the analysis is taken further than ten years and based on studies of the current situations and the lessons learned from the past.

As a consequence of all the regulatory changes, Spain is facing a transition. This transition meant the end of the Special Regime, a renewable moratorium and, lastly, the beginning of a new investment auction-based phase. There are no technical reasons behind this stagnation point in

which Spain is stuck (with 23 GW of total installed wind power since 2013), but a political one. The renewable-paralysis decreed by the Government harmed not only the industry but the path set to achieve the European goals.

The reason behind the new energy auctions to increase the renewable energy power, is the fulfilment of those objectives rather than the convincement that these technologies might work as a key factor in the economy. It looks like the only matter is the tariff, but there are several other questions affecting the economic growth and related to the renewable energy sources – such as employment generation, the development of a strong, competent and exporting industry or the fixation of the population on rural areas-, that are not being taken into account.

There are also other things that need improvement: specific auctions for each technology or the auctioning complexity itself, and even the uncertainty of not fixing the reasonable feasibility for the installation lifespan.

Yet another problem is the new method to assign installed power that will lead to the installation of more than 7 GW of renewable energies before the end of 2019. Of course, it will be impossible to achieve that goal but a consequence of this could be a market saturation. Therefore, it would have been more reasonable to install yearly quotas of about 500 MW so the construction and absorption of those installations could be gradually achieved.

Spain has an extraordinary renewable resource but planning, predictability and legal certainty are needed to achieve an energy transition to a more competitive, clean and sustainable energy model. It is important to point out that the fact that some of the regulatory changes the Government made, were applied retroactively, jeopardizing a great number of investments and losing the entrepreneurs' trust. There is nothing clear about the future of the renewable energy technologies in Spain right now. Following years will be extremely important to see what will happen.

The solutions Spain could apply should be based on planning where all the generation sources are taken into account as well as the distribution networks. An exhaust analysis of the current situation it is also needed, so that more precise objectives can be set for the future. More transparency is desirable in certain aspects surrounding the electric system such as the billing and the real generation costs.

As a final conclusion and seeing that the European Union aims to eliminate the FIT schemes, it may be necessary to reconsider the electric market working mechanism which is based on the weather (renewable energy sources have priority). Under these conditions, even when this priority could be seen as an advantage, it is not. The energy price decreases when the production comes from these sources, so the companies with other generation technologies (sometimes, the same as the ones with the renewable sources), get harmed in the process.

In the same way, if a renewable-based system is desirable, the re-design of the transmission grid is needed as long as the current one was developed in a fuel-and-nuclear-based model, meaning a sustained, controlled production, which is the opposite to the current situation, where the renewable sources have an important penetration.

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