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Abstract

This article provides an interpretative overview of the ambitious and intense Spanish experience with renewable electricity support. Besides describing the varying schemes that existed in Spain since the late 1990s, the paper intends to explore the different factors that have apparently turned a successful policy story into a failure. We suggest that the demise of Spanish renewable electricity support policies is related to a combination of design pitfalls, of rapidly changing economic and energy contexts, and of shifting views on the bonanza of such schemes by major involved agents, such as utilities and large electricity consumers. The paper may thus be useful to derive good and bad lessons for countries, including Spain, interested in the future promotion of renewable electricity.

Keywords: promotion, renewables, Spain, electricity

JEL Codes: Q42, Q48

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1. Introduction

Only until 2009 Spain was a reference on how to develop a successful renewable electricity (RE) industry, and on how to design an effective and reasonably efficient RE support policy. President Obama, for example, used Spain as an example when promoting his stimulus program on energy (Environmental News Service, 2009). Indeed, Spain's RE policy has been pointed out many times (e.g. by the European Commission, 2005) as the right one to pursue. However, very soon after Pres. Obama's comments, this successful picture started to crumble down. In early 2012 the recently elected Spanish government declared a moratorium on the support for new renewable energy investments, thus closing a circle that had been largely initiated by the same political party almost 20 years ago. 2013 saw further restrictions to existing RE capacity and, as a consequence, nowadays RE investments in Spain are all but halted. RE policy is being reconsidered both by the government and the opposition, the confidence of international investors has suffered a large blow, and an increasing share of the Spanish society now see RE as a source of trouble and burdens.

What happened here? How can a beloved and successful policy become such a terrible one in less than five years? One can come with a number of answers, many of which will probably be too simple. But, as usual, the right one will not be one of those, since many factors have contributed to this outcome. And, more importantly, most of these factors do not have to do with the theoretical design of the RE policy itself, but rather of its implementation because, as usual, the devil is in the details.

The objective of this paper is to look deeper into these details underlying the apparent success of Spanish renewable energy policy, and also its eventual failure. The ultimate goal is to derive lessons to be learnt for other countries interested in promoting RE development, thus avoiding a parochial approach to the Spanish experience.

Although there are other recent and ambitious European experiences in RE promotion, namely those of Germany and Italy, the Spanish case is quite interesting because, first of all, a significant public and private involvement is behind the sizable development of renewable electricity capacity in a short time spam. Moreover, contrary to other more stable frameworks as the German, the changes in policies and in their outcomes provide a kind of counterfactual against which to assess its effects. In addition, the strong regional component behind some of the developments in Spain may prove helpful when deriving lessons for the regions or countries with strong federal structures, such as the European Union or the US.

Of course, other papers have previously looked at Spain and other countries to learn about RE policies (e.g. Woodman, 2011, or Perez and Ramos Real, 2009). This paper is different in that, first, this is not a first-best evaluation of RE policy. If it were so, we might not even be discussing about RE policy, but of a carbon price and an instrument for correcting the externalities in the innovation market (Fischer and Newell, 2008). We will not address in depth either the economic efficiency of the instruments employed, or compare them with other alternatives. There is plenty of literature about this, of which we may point out among the most recent Schmalensee (2012), Batlle et al (2011), or Del Rio et al (2011). We will take for granted the existence of an exogenously-determined and 'desirable' RE policy, and mostly focus then on political economy considerations that, in our opinion, have been stronger drivers of the final outcome. In this sense, our paper takes a broader perspective, which includes the evolution of the electricity sector in Spain, and from which more interesting lessons can be learnt.

We will also take advantage of the fact that two very different RE technologies have been significantly promoted in Spain, wind and solar PV, to illustrate how different renewable technologies may require different policy approaches, and how the same support policy may result in very different outcomes.

The contents of the paper are as follows. Section 2 briefly reviews the evolution of RE policy in Spain focusing on its most important elements, some of which belong to sub-national administrations. Section 3 evaluates the outcome of the support policies not just in terms of efficiency, but also on the aspects that are crucial to their political economy: costs and their distribution, electricity prices and grid issues, and technological evolution. Section 4 then extracts some lessons and explanations from these outcomes and connects them with the preceding policy design and implementation. Finally, Section 5 offers some conclusions and policy recommendations, including ways to address future challenges for countries with an already significant or expected penetration of renewable electricity.

2. Renewable electricity support in Spain

This section offers a very brief review of the intense policies implemented to promote RE in Spain since the late 1990s. It draws mostly from Barroso et al (2011), but more extensive and detailed descriptions can be also found e.g. in Del Río (2008).

The promotion of renewable electricity generation in Spain has been mainly driven by three policy goals: decreasing the reliance on imported fuels of a heavily energy-dependent economy, reducing greenhouse gas emissions (GHG) or the discharge of other (local or regional) pollutants, and fostering a new industrial sector that could generate jobs through internal and (future) external demand. There is no consensus on the relative strength of each objective: between 2004 and 2008 Spanish policy makers had climate change concerns as a guiding aim (even though in practical terms total GHG emissions skyrocketed in the period), energy dependence issues were especially acute at times of extremely high oil prices (e.g. during the 2006-2008 interval), and industrial issues were always in the agenda of a country with pervasive competitiveness and employment problems.

Actually, renewable electricity in Spain currently represents around 20% of the total power sector, which is approximately equivalent to a 7% (8 Mtep) annual reduction of Spanish energy imports and to a 5% decrease in total Spanish GHG emissions (see e.g. López-Peña et al, 2012). Moreover, some studies have shown that renewables are roughly responsible for 100,000 jobs (0.5% of the total), and 0.6% of the Spanish GDP (see e.g. Istas, 2008; Ragwitz et al, 2009). This overall positive assessment of renewables was shared by most political forces which, until recent times (more about this below) and since the first major 1994 RE support plan, were unanimously supportive of public promotion schemes.

Indeed, Spain established in 1994 the first feed-in tariff system: a modality that would constitute the most important RE support mechanism until today. Yet the system has been adjusted with time, departing from a rather standard feed-in-tariff referenced to the retail price and specific for each broad technology type. In this sense, a first change (1998) incorporated the possibility of bidding in the wholesale market for RE producers, which were actually incentivized to do so. By doing this, they would receive the market price, plus a premium. Since then – and this is an interesting feature of the Spanish support system – a large share of wind power plants bid to the market (93% in 2007 and 2008, although this number was reduced recently due to lower market prices).

In 2004, another modification guaranteed perceiving the feed-in tariff or the premium for the whole economic lifetime of the power plant (usually with a decreasing factor), instead of the initial 5 years. In addition, balancing payments were required from some of the renewable producers (e.g. wind, but not PV). Another important change was the increase of the maximum size of solar photovoltaic (PV) plants able to receive the maximum premium, which jumpstarted the building of large (up to 100 kW) PV plants. In 2007 the system was again modified by the introduction of a cap-and-floor system for wind energy producers bidding in the wholesale market. In 2011 and 2012 the scheme started to collapse: first with the introduction of a mechanism to adjust the premium for PV plants based on installed power (similar in essence to an auction), then with the revision of the income guaranteed to existing supported plants, and finally with the moratorium for the support of new plants.

The system had – in principle – a quantity control built into it: when the renewable electricity targets set in the law were achieved, the premium would be discontinued. Nevertheless, this was not accomplished for solar PV: the target was 500 MW, and it has clearly been exceeded, with more than 2,500 MW built in one year (more about this later). The same happened with solar thermal. As for the amount of the premiums, table 1 shows the average premium perceived per MWh (in some cases, calculated as the difference between the fixed tariff and the electricity wholesale price). Premiums for waste and biomass have increased, and those for solar PV have decreased much recently (down to 240 €/MWh, although this effect is not yet seen in the averages shown in the table).

Tariffs were to be updated every four years, although from 2004 no tariff has lasted long enough. Of course, this update would only affect new power plants. However, as already mentioned, in 2011 a retroactive modification was implemented for PV and wind, by which these plants would see their income reduced (indirectly through the amount of electricity allowed to receive the feed-in tariff or premium).

Table 1. Premiums for renewables in Spain (€/MWh)

	2004	2005	2006	2007	2008	2009	2010	2011	2012
Solar PV	332.52	340.40	374.06	392.14	388.74	429.33	414.25	324.35	400.71
Wind	28.08	28.92	37.37	36.35	35.97	45.70	45.47	43.64	43.90
Small hydro	31.72	29.31	36.06	35.61	31.69	44.83	44.01	38.99	40.13
Biomass	30.54	27.87	35.17	46.71	52.06	81.31	77.50	74.62	79.78

Source: CNE (2012)

But, although economic support has indeed been very important for the development of RE in Spain, it has not been the only driver. This was accompanied, as usual in FIT systems, by an obligation to distribution system operators to purchase all renewable production, except under technical limitations (e.g. grid congestion). And, sometimes more importantly, by an active role of regional governments that helped in creating favorable investment and licensing conditions.

Indeed, economic support by itself has not been able to promote some technologies, such as biomass, or even PV before 2006. In the case of biomass, logistic problems seem to be still an insurmountable obstacle. For PV, a modification of the grid connection requirements was required in a first moment (RD 1663), together with an increase in the maximum size of PV plants supported.

Regarding the role of regional governments, although not generally acknowledged, it has been one of the most powerful elements pushing the development of RE in Spain. Regional governments are the ones in charge of licensing RE plants, and also of registering them into the special regime (which in turn allows to receive the premiums or fixed tariffs). They are also the ones benefiting from the local impacts of RE (jobs in maintenance but also in manufacturing, or property or economic activity taxes). In fact, most of them have put forward their own RE development plans, which included also in some cases a tendering process to get licenses. With or without these tenders, most regions required developers to build manufacturing or assembling facilities in order to get installation licenses.

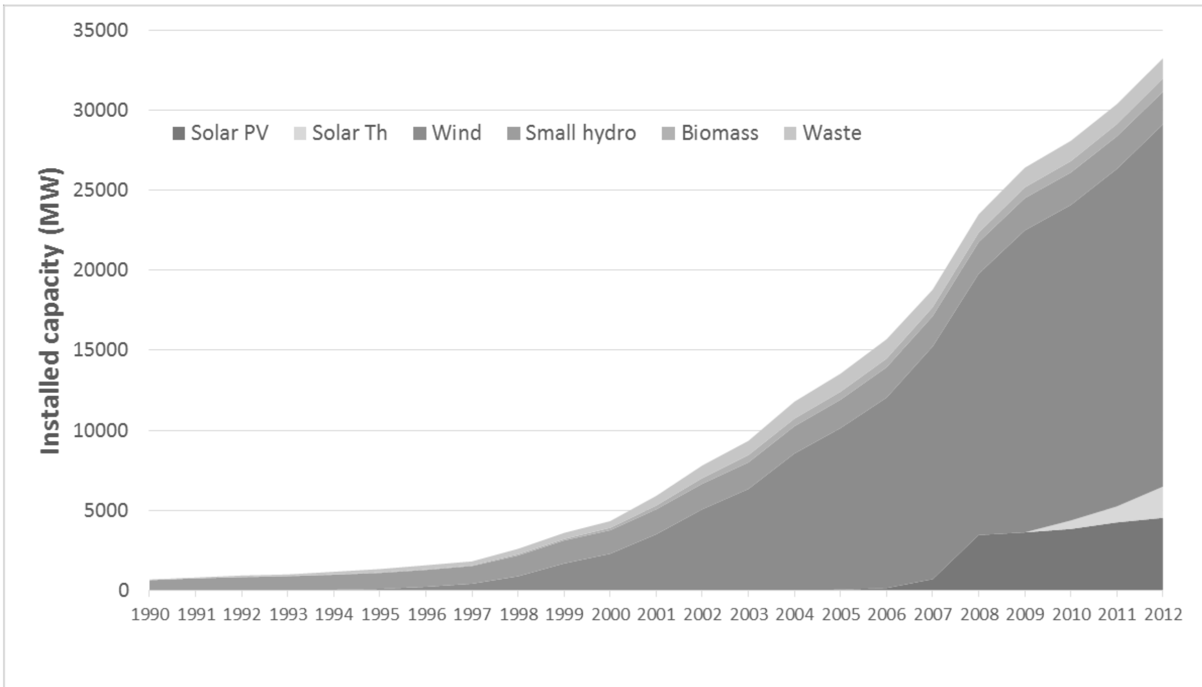
3. How has the system worked?

To answer correctly this question, one needs to distinguish between technologies, and also between the types of outcomes. We will consider the following: installed power, regional distribution, grid issues, industrial development, the cost of support and its distribution, and impacts on technological evolution. As mentioned before, we will focus mostly on wind and PV.

3.1. Installed power and energy produced

Figure 1 shows the evolution of the installed power for renewable energy in Spain.

Figure 1. Renewable installed capacity in Spain (MW)



Source: Comisión Nacional de Energía –CNE (2013)

As may be seen, the support system has resulted in a significant amount of wind installed. Indeed, Spain has become one of the world leaders in wind power, with more than 20,000 MW installed, and a contribution of 20% of the total installed power and 16% of total electricity generated in 2011. At some points in time, the Spanish power system has been working with more than 50% of its power provided by wind. In the last years (as a result of the modifications in the minimum size and connection requirements) PV also experienced a very large and explosive increase, up to the current 4,200 MW installed, largely exceeding the cap set by RE policy (500 MW for solar PV).

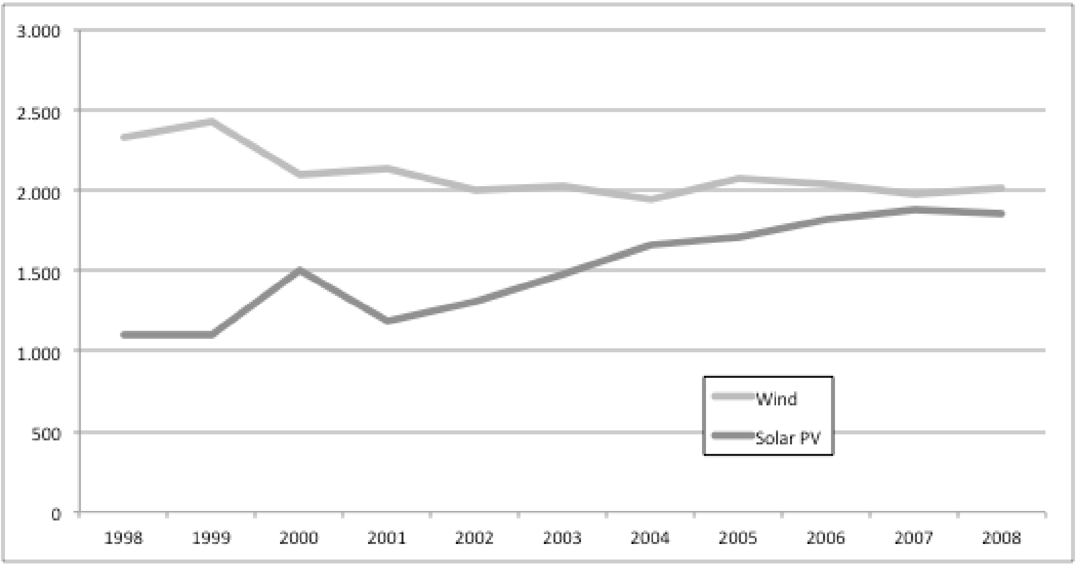
This is a remarkable aspect that deserves some attention: what is the use of a cap if it can be exceeded so much? There are some explanations for this excess that are interesting to review. Basically, it was a combination of an explosive growth for PV, ignited by a change in policy; of the fact that solar PV plants take a very short time to be built; and of the interplay between regional and central governments.

The change in policy allowed larger PV plants to receive subsidies, which in turn materialized significant economies of scale and therefore cost reductions. Combined with stable tariffs this created large rent prospects for investors, who jumped quickly to this new business. Given that a PV plant can be built in months, more than 2,500 MW were built between 2007 and 2008. But why did not the cap prevent this? The reason is that the cap was managed by the central government, whereas the building licenses, and the registration into the special regime (the one that allows receiving the premiums) were managed by regional governments. Regional governments were interested in building as much renewables as possible (because they could keep some of the rents created, see later), so they did not have any incentive to flag increasing amounts of installed PV. But the central government only channel to be informed about installed power was through regional governments. Instead of having a race between developers to install before reaching the cap, we had a totally opposite effect.

Besides the problems created by this explosive growth on the costs of the system, and on the credibility of the policy, it also had consequences on industrial development, which will be described later.

Regarding energy produced, it is interesting to remark that the equivalent hours for wind farms (or energy generated per MW installed) have been fairly stable (accounting for annual natural variations), probably meaning that technology improvements have compensated the increasing scarcity of well-endowed sites. Solar PV shows a certain increase, which is natural given that the sun is a much less scarce and more evenly distributed resource in Spain, so technology improvements will have a larger weight. Figure 2 shows the evolution of equivalent hours with the annual vintages of installed power.

Figure 2. Equivalent hours produced by different vintages of power plants (equiv. hours per year)



Source: Comisión Nacional de Energía –CNE (2012)

3.2. Regional distribution

The regional distribution of RE power plants has two important implications. First, it allows us to assess whether RE policy has resulted in the installation of RE plants in the best places (that is, those with the best resource or lowest cost), or if it has been distributed evenly across the regions. The first would result in a higher efficiency, whereas the second would bring about more social acceptability (and also a broader redistribution of the local benefits of RE plants). The second implication has to do with political economy considerations: more installed power means more rent perceived by regional governments, through local taxes, local component obligations, or even through more exotic requirements (some regional governments included the construction of public facilities or houses for the elderly as positive factors for awarding wind licenses). Table 1 shows the installation of wind and solar PV farms in Spain by 2011.

Table 2. Wind and solar PV installed power in Spain per region, 2011

	Solar PV		Wind		
Region	Installed power (MW)	% of total	Installed power (MW)	% of total	% of total surface (km^2)
Andalucia	789	19%	3,037	14%	17%
Aragon	142	3%	1,723	8%	9%
Asturias	1	0%	386	2%	2%
Baleares	63	1%	4	0%	1%
Canarias	137	3%	144	1%	1%
Cantabria	2	0%	35	0%	1%

Castilla La Mancha	881	21%	3,698	18%	16%
Castilla y Leon	453	11%	4,795	23%	19%
Cataluña	228	5%	1,020	5%	6%
Comunidad Valenciana	298	7%	1,083	5%	5%
Extremadura	532	13%	0	0%	8%
Galicia	12	0%	3,291	16%	6%
La Rioja	85	2%	448	2%	1%
Madrid	47	1%	0	0%	2%
Murcia	397	9%	191	1%	2%
Navarra	148	3%	976	5%	2%
Pais Vasco	22	1%	194	1%	1%

As may be seen, installed power has been shared quite evenly among regions, although some interesting facts may be highlighted:

For wind, the distribution has not followed exactly the quality of the resource: Galicia is clearly the best-endowed region, and accordingly has more wind installed per km2 than others; but the rest is more mixed. Well-endowed regions have little wind (Canary Islands or Aragón), a very big region (Extremadura) has no wind at all, and Castilla-Leon and Castilla-La Mancha probably have more wind installed than what their resources would imply. Interestingly, the premium for renewables in Spain does not depend on the amount of resource (contrary to what happens in other countries), so developers have a clear incentive to build where the resource is larger. But this did not happen in all cases.

This points (together with information about regional wind development plans, too lengthy to be included here) to the fact that regions have played a very active role, sometimes bigger than the quality of the wind resource, in determining the amount of wind installed.

For PV, the outcome is clearly different: installations have followed the solar resource, with the sunnier regions getting more installed PV per km2 (with some anomalies, such as Navarra).

How can we explain the difference between wind and PV? Several aspects can be mentioned:

- First, the potential job benefits of wind are much larger for regions than those of PV. It is easier to set up a wind turbine or blade factory in any region because of the lower technological requirements compared to PV.
- Second, the licensing process is more demanding for wind than for PV (due to the bigger size of typical wind farms). Or, to say it otherwise, the ability of regions to influence it is larger.
- Third, the speed of the building process is different: for wind, it allowed regions to develop plans, whereas for PV they did not have time to react.

- Finally, the volume of the rents to be captured for wind was much bigger, at least in the first moment, than for PV.

That is, some regions understood wind energy development as an opportunity to create an industrial policy financed by the electricity consumers in the country (who paid for the premiums), and acted accordingly, granting licenses in exchange for assembling factories (or, as mentioned earlier, for other facilities) and becoming attractive places for installing wind farms. Others, in turn, had a lower priority for this type of development (because they already had a strong industry, or a bigger concern for losing tourists, or ultimately, a large amount of electricity consumers) and installed less wind power than would correspond to their wind resource. Hence, political economy considerations within the regions played a significant role in the way wind energy was developed. This did not happen for PV, which followed a more efficient distribution.

3.3. Grid issues

One of the most positive aspects of RE penetration in Spain has been its integration in the grid. The System Operator (SO) has been able to handle quite well the intermittent nature of wind, working sometimes with more than 50% of the electricity provided by wind. Interestingly, there were no explicit incentives for the SO to maximize the integration of RE. On the contrary, the SO issued different requirements for wind farms (such as controlling for voltage dips) that were not straightforward to apply, and to which the industry reacted promptly, given the incentives to do so.

In the last couple of years, however, some wind spillage has taken place, due to need to keep running nuclear power plants and the low demand levels. But this points more to a technical problem rather than to a lack of willingness by the SO to incorporate wind.

Here the role of the central government in prioritizing grid investments, and in signaling their interest in having this large integration of RE, has been probably very important. Regional governments also have helped with the licensing of new power lines, following their support for wind energy (see previous section). An additional factor that has surely contributed to this success is that in Spain there is a single transmission system owner and system operator, which clearly minimizes transaction costs and ensures the clarity of signals.

Indeed, we should mention that connection charges in Spain are not that favorable to RE: developers must pay the full cost of the connection to the transmission line (shallow cost approach). As may be seen, this has not been an obstacle.

We do not cover here the complex issue of transnational interconnectors. Spain is almost an electricity island, so the lack of connections only has an indirect effect: demand is less flexible, and therefore renewables have a harder job to adapt their variable production. More interconnections would of course facilitate grid integration, but do not change the essential elements of the discussion presented here.

3.4. The cost of support and its distribution

The large development of wind, and particularly of PV, has of course come at a non-negligible monetary cost for consumers. This should of course be balanced against the reduction in system costs because of reduced fuel consumption, and also against non-monetary benefits such as security of supply, environmental improvements, or R&D progress. However, estimating these benefits is difficult (Borenstein, 2012), with the consequence of not being considered by consumers or policy makers, much less being incorporated into the tariffs consumers pay.

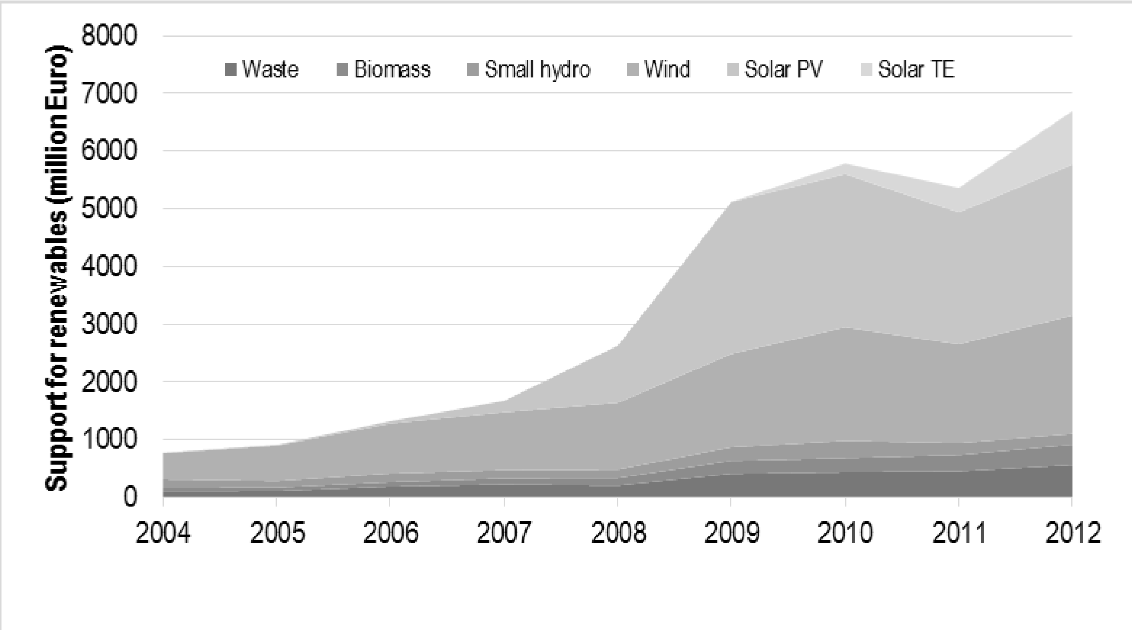
Therefore, the significant support received by PV, and the large amount of wind energy produced, have both contributed to a relevant fraction of the total electricity tariff. In 2011 the total support for renewable electricity was 5,000 million € (18% of the total cost of the power system in Spain). To this we should add the extra cost to the system of managing a large share of intermittent power. This may not be that high for Spain, given the large amount of regulating hydro. But it still increases start-up and maintenance costs for natural gas combined cycles, and reduces their lifetime.

This significant amount makes some problems more salient: where does the money come from; how is it distributed among technologies, among regions and central government, or between consumers and producers. We address these points below.

3.4.1. Cost distribution by technology

As may be seen in Figure 2, more than half of the total support corresponds to PV. Many deem excessive the support received by this technology, given the large reduction in PV panel costs that was not accompanied by a reduction of the tariff. The figure also shows the large growth in support costs for PV, compared to wind (which was much more stable). The retroactive measures issued in 2011 are also easily observable in the figure.

Figure 2. Monetary support for renewables in Spain (million Euros)



Source: CNE (2013)

It is illuminating to put these numbers in context, comparing them against the share of electricity demand. As may be seen in Table 3, the impact on system costs is not balanced per technology, with solar PV and also solar thermal accounting for most of the unbalance.

Table 3. Share of renewable energy in total electricity demand and system costs for 2011 (%)

	Share of total system costs (%)	Share of electricity demand (%)
Wind	5	15.6
Small hydro	1	2.0
Biomass	1	1.4
Solar PV	7	2.7
Solar Th.	1	0.7

Source: CNE (2012)

This large unbalance between technologies has indeed helped fuel some of the discussions and public reactions that resulted in the moratorium for RE, and it also divided the RE field: instead of lobbying jointly as before, different RE technologies started to propose different solutions given their different interests.

3.4.2. Consumers vs. conventional energy producers

The introduction of RE at a significant level also started to create very relevant interactions with the electricity market. Two effects must be mentioned here: the impact on market power, again with implications on the prices paid by consumers and received by electricity generators; and also the impact on wholesale prices, which resulted in a different distribution of the cost of RE between consumers and conventional energy producers.

The first effect has been identified by Batlle et al (2011): the way RE support was implemented in Spain, as premiums over market prices instead of fixed tariffs, created a strong incentive for conventional electricity market players to exert market power, given that RE power was inframarginal, that is, it always received prices higher than their marginal cost. Therefore, powerful players were much interested in investing in RE to maximize the profitability of their portfolio, at the expense of course of consumers, for whom therefore renewable support came at an extra cost.

The second effect has been already discussed in literature (see e.g. Würzburg et al, 2013 for a recent survey and estimation): given that most renewable electricity is bid at a null price, increasing the share of renewables should decrease market prices, therefore reducing the revenue received by conventional electricity producers. This results in a transfer of money from these conventional electricity producers to consumers, who pay less for their electricity. Of course, this impact should be only a short-term one: in the long term, the signal for investment is reduced and therefore power becomes scarcer and prices increase again. In addition, the existence of market power may counteract this effect (see above). However, different studies in Spain (Gelabert et al, 2011) have shown that the reduction in market prices has been real and relevant, although decreasing in time.

Finally, these two effects should be analyzed together with two other important factors. The first one the implicit cap on electricity tariffs existing for many years in Spain: in spite of the liberalization efforts of the European Commission, and for reasons that have been studied elsewhere, governments in Spain were not willing to let rates move freely and account for all costs, but instead tried to cap their increases. This was the final drop in the bucket: if the total revenue was fixed, then transfers from producers to consumers would be even more painful (in fact, the revenue was not enough to cover costs, more about this later on).

The second factor is the outstanding overcapacity in natural gas combined cycles in Spain. What started in the late 1990s as a real need for power ended in the 2010s with a large amount of unused capacity of natural gas combined cycles. Part of this may be explained by the sudden economic crisis, but also probably by mistakes by electricity companies when interpreting government signals, when estimating demand, or when previewing the investment of other companies. This overcapacity has made the system less efficient, and has also increased the cost of renewables (López-Peña et al, 2012).

If we combine all these factors: lower electricity prices, a cap on tariffs, and significant overcapacity with reduced demand, what we find is that this transfer from producers to consumers creates cost-recovery problems, as has happened in Spain: prices were reduced, and the operating hours for combined cycles decreased drastically (from 6,000h to 2,000h), thus compromising the return on these investments.

As a result, conventional producers, which initially benefited from the introduction of RE in that they were able to increase their inframarginal rents, then saw how the return on their investments in combined cycles was seriously compromised. As Schmalensee (2012) says, who bears the short-run cost of RE support determines largely the political attractiveness of the system. In the case of Spain, electric utilities, from being active supporters of renewables became fierce opponents. As mentioned before, this was not only a consequence of RE support: the reduction in electricity demand due to the economic crisis, the overcapacity in combined cycles, and the cap on electricity tariffs were the triggers for this situation.

3.4.3. Consumers vs. Consumers

A second explanation for the change in support for RE policies comes from the distribution of the costs among consumers, which is in turn related to the "tariff deficit". The tariff deficit is the difference between the actual cost of electricity and the cost paid by consumers. Although this is an issue that clearly exceeds RE policy, it has many implications, moreover when RE support has been identified by many as one of the reasons for this deficit.

The deficit arises when the government caps electricity rates: since it cannot control the costs of the system, sometimes these costs may be higher than the rates, creating a deficit in the revenues of the system. This deficit is financed by future increases in the electricity tariff. Utilities are allowed to securitise the debt, with the guarantee of the government.

This scheme results in that the costs of the current system (including RE support) are shifted to future consumers, something that would be good for RE support. Unfortunately, the deficit has increased enormously, and has added to the debt problems of the Spanish government (although in fact the deficit is funded by future consumers, it is the government who guarantees its recovery). This has put a lot of pressure on the elimination of the deficit, which should result, among other consequences, in a significant increase of electricity tariffs. This potential increase in turn has pushed large electricity consumers against renewables. Large consumers, which were protected from these increases before, have experienced in the last years increases in their bills as a result of the liberalization of the electricity market (and the consequent removal of subsidized tariffs). The elimination of the deficit would add another nail to the coffin of some threatened industries. Again, previously protected, and therefore indifferent towards RE support, large consumers are now active opponents of these policies.

3.4.4. Regions vs. Central government

Finally, the distribution of costs between regions is also important. As seen in section 3.2, some regions understood RE policy as an opportunity to extract rents to finance industrial or social policy objectives. This extraction of rents took place in two ways: by requiring investments in the region in exchange for licenses, or by creating new taxes on RE plants (as one might expect, these taxes were created once there was already a significant amount of these plants, and applied to existing ones, see e.g. Gago et al, 2007). Although the law says that electricity consumers in the region should pay for increased costs of electricity due to regional requirements (such as the taxes mentioned), this has not (yet) been the case. Given that wind has been installed mostly in less developed regions, this has resulted in a transfer from richer, more populated areas (with more electricity consumers paying for RE support) to less populated ones.

This is not to say that this transfer may not be equitable: after all, the result will probably be progressive, and the payment of a rent for the use of natural resources (such as wind) has some justification. But the problem is that the transfer is not explicit or coordinated with other policies, but in the exclusive hands of the regions that decide whether to extract these rents or not. And it has clearly created incentives for richer, more populated regions to place themselves against RE support.

3.5. Technological evolution

Besides from the deployment of a local industry, RE support schemes are purportedly designed to decrease the costs of these technologies. Indeed, the best support scheme is one that makes itself not necessary, by allowing these technologies to become competitive. Has this been the case with the Spanish support scheme?

Answering this question is not so easy: the technology market for renewables is global. Some of the PV modules subsidized in Spain or Germany have been actually manufactured in China by US companies. Therefore, RE support in Spain or Germany may have stimulated technology development elsewhere. Indeed, according to Dechezlepetre and Glachant (2012) this has been the case for patents. We also look at the evolution of technology prices and their correlation with the existence of RE support schemes, or with installed power. In this case, we should of course look at global installed power, because that will be the real driver for cost reduction, and not the amount of power installed in a specific country. Here the picture is mixed when we compare wind and solar PV.

(Figure: evolution of wind installed power and investment costs)

For wind, prices have not decreased with the amount of power installed. In fact, they have rather increased. In Spain in particular prices have increased significantly, what may be an indication of the effort to capture the rents provided by the support scheme, but also of the fact that the windier locations have already been used, and of the increase in the size of wind turbines (among others, because of environmental reasons) that increases in turn specific cost. In that sense, RE policy has not been successful.

(Figure: evolution of solar installed power and investment costs)

For solar PV the evolution has been totally different. The cost of PV modules has been reduced hugely in the last years, very much correlated to the large markets created by German and Spanish support schemes. The bigger markets and competition between developers resulted in the first PV-grade silicon factories being built, and to large economies of scale in the manufacturing of the modules. Therefore, for PV the policy has clearly borne fruit.

However, one very interesting issue related to the international political economy of renewables is that, although PV costs have decreased partly thanks to the funding of Spanish electricity consumers, they will probably not be the ones who profit from it in the short term, moreover given the bleak prospects for Spanish industries. Clearly, R&D spillovers are too large for a country like Spain to expect benefits from this, unless some accompanying measures are taken.

4. Major lessons learnt

We will now try to derive some lessons from the analysis presented in the previous sections, based mostly on political economy considerations. Most of them apply to liberalized electricity markets, but some may also be applicable across the board to any country trying to achieve a large deployment of renewables.

4.1. Policy design

First, regarding the regulatory aspect, the Spanish experience has shown that policy is not quick enough to adapt to quick technological changes, such as those shown by PV. This helps create boom-and-bust cycles that do not allow for the creation of national industries, one of the stated objectives of RE policies. Or, in the worst case, they will induce policy-makers to resort to retroactive changes, something that clearly erodes the credibility for investors.

A derived lesson from this first one is that it does not make sense anymore to have a single renewable support policy: the circumstances related to each technology are very different, and this creates problems when the level of deployment is large enough. In that sense, many in Spain think that the rest of renewable technologies have paid for the mistakes in regulating PV. Probably, if each technology have had its own regime, it would have been easier to spot and address the problems earlier.

This includes using different policy instruments for different technologies. FIT, that was hold by many (e.g. OPTRES) as the best instrument for supporting renewables, resulted in Spain in rent capture by regions and manufacturers, and was not effective in reducing the cost of wind. It seems necessary to look for other instruments, among which a revised design of auctions may be particularly interesting (Del Río and Linares, 2012).

4.2. Funding

The way RE support is financed has also created unnecessary frictions: funding RE from the electricity tariff will always put large industrial consumers against renewables (of course, only in liberalized markets). Combining this with a tariff cap also creates enemies within the generation sector. In that sense, it may be more reasonable to move at least a part of the support to other sources, such as the general budget. Although this countered by some as creating more uncertainty, the Spanish case has proved that the uncertainty does not lie in the specific scheme, but in the government itself (the retroactivity of the support is much more pernicious than the uncertainty of the budget approval). In addition, it may be also fairer to share the cost of renewables among other agents in the energy sector when the renewable target affects not only electricity, as in most of Europe (see e.g. Batlle, 2012). Green tax reforms, if not yet implemented, may provide an interesting opportunity in this regard.

4.3. Market interactions

The interaction of renewables with the wholesale electricity market is also a very relevant issue, although less difficult to address: the introduction of renewable energy into wholesale electricity markets will always depress demand, and thus also reduce prices and revenues for existing power plants. However, as mentioned before, this will also reduce the long-term signal for investments and hence prices should get back to their original levels. Here the critical element is predictability: if renewable targets are set with a long-term view, market agents will be able to adapt. And by long-term we mean the horizons considered when deciding on new power plant investments, at least 15 years.

There is a second interaction mentioned, the effect of inframarginal plants on the possibility to exert market power. Of course, the obvious lesson here is that market power should be prevented. If not, the way to avoid this is to decouple renewable revenues from market prices, as in feed-in-tariffs.

These interactions with the wholesale market are also very much dependent on demand growth, and on eventual tariff caps. If there is enough money for everybody, the rest of the electricity sector will not complain. However, demand reduction and tariff caps result in a zero (or negative-) sum game, with the consequent loss of support for renewables within the electricity sector.

4.4. Coordination between sub-national and national governments

Given the strong implications, already described, of the lack of coordination between national and sub-national governments in RE policy (mostly on rent capture, but also on an efficient distribution of RE), this should be an essential element in any country or region with a powerful sub-national administration (good examples are the US or the European Union).

This would require first to make explicit the distributional elements, such as the transfer of money from consumers to regions, and the creation of economic activity in the different regions. Second, to have all parties participate in the design of the policy. The latter might include the regional distribution of RE targets, and also the funding of the support scheme, based on the distribution of the costs and benefits previously agreed upon. This coordination is also essential if there are grid interconnections involved, an issue we have not discussed in the paper.

4.5. Industrial development and R&D

An important lesson from Spain is that renewables support has not resulted in industrial development in all cases, and even less in the development of powerful technological players. Indeed, we argue that the main driver for the deployment of a certain industrial activity in some regions was the proactivity of the regions themselves, rather than the support scheme alone.

This confirms the view that market-pull policies may not be the best way to promote industrial or technological development in a country, even less in a globalized world. It is very difficult for governments (unless they resort to explicit local component requirements, as in China) to ensure that the industrial or R&D benefits of a RE support policy stay at home. And there may be incentives for rent capture by manufacturers.

Therefore, if the development of a leadership in renewable technology is among the objectives of the policy (clearly the case of the European Union), this will require probably using more specific industrial or R&D policies (the classical Tinbergen argument).

5. Conclusions and future challenges

This paper has provided an overview of the successes and failures of the Spanish RE support system since 1998 until its moratorium in 2012. We believe that the analysis of this experience is very useful to understand the problems that underlie the end of the political support for RE in Spain, and also to anticipate and correct accordingly the future of RE support in many countries, in which RE is not anymore a niche policy, and therefore the consequences of which become more salient, and its failures more relevant.

Indeed, a first element that should be acknowledged is that, although the policy worked well in the beginning, it was not adjusted appropriately when the environment and the technologies changed. Also, and to be fair, we should be aware that sometimes policies fail not because of their intrinsic problems, but of external, unexpected events. In the case of Spain, one of the major drivers for its eventual elimination was the reduction in electricity demand induced by the economic crisis. In this sense, it is not that the costs of supporting renewables became unsupportable, such as the case with PURPA. Instead, we believe that the system failed basically because the electric utilities did not back RE support anymore, large consumers started to see RE as a threat, and the elimination of the tariff deficit (caused only in part by renewables, PV in particular) became a much more pressing priority.

Nowadays, the Spanish renewable support system is at a crossroads. It is being challenged at the political level basically because of the loss of support from large consumers or electricity market agents, both very powerful lobbyists. Small consumers are also very sensitive to electricity rates, so, in spite of many expressing some willingness to pay for renewables (tu paper con María Loureiro), no big political party would seriously consider increasing rates to pay for renewables. It is also starting to approach technical limitations for grid integration, with some wind production curtailing in off-peak hours (which of course may be solved with appropriate grid management). Therefore, a careful analysis should take place before making decisions about the future.

The most important lessons learnt have to do with the sharing of the cost of RE support, with the coordination between national and sub-national governments, and with the interactions with electricity markets. All these aspects need to be carefully addressed if RE wants to enjoy again the same level of political support it had in the 1990s at a much higher level of deployment.

Indeed, the future requires further increases in renewable electricity production in order to comply with EU targets (or, in the longer term, with the European Energy Roadmap 2050). Renewable electricity is expected to contribute to 42% of total electricity demand for 2020. This may be achieved either by increasing renewables, or by reducing demand. It seems that the latter alternative may be more affordable and present other advantages. As for the former, two issues seem critical. First, developing an effective and efficient (lower-cost) support system, which may require being more selective about technologies, and also designing different support systems for different technologies (for example, thinking again about auctions). An added complexity for Spain is the interaction between national and regional governments, which may require a specific approach when designing the support system. Second, there is need in advancing in the integration of intermittent energy sources into the system. Here several aspects may be considered, among which the improvement of interconnections is probably the most relevant, but also addressing adequately electricity market interactions

In addition, there are more lessons that can be learnt from the Spanish experience. First, many problems could have been avoided with a more stable, orthodox and long-term regulation (loud, long and legal, as proposed by XXX). Second, policy makers should realize that, if they want their country to become competitive at the technological level, RE support policies in a globalized world will not deliver, but instead other alternatives, more focused on the appropriation of the spillovers from R&D, are needed.

Another one is that we should not be talking anymore about RE in general: RE technologies differ a lot in terms of cost and its evolution, of implementation requirements, etc.; so it makes no sense to keep designing RE policies and evaluating them under a common framework, but rather we should design technology-specific policies, and carry out technology-specific assessments.

Finally, all these elements should be coordinated into an integrated energy policy that goes beyond renewables, that considers its interactions with other related policies (such as climate or energy-efficiency policies), and that gives the long-term stability required to invest in new technologies and in their development.

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