GSI Global Subsidies Initiative

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A CAUTIONARY TALE:

SPAIN'S SOLAR PV INVESTMENT BUBBLE

By Pablo del Río and Pere Mir-Artigues

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LIST OF ACRONYMS

AACC: Autonomous Communities
AET: Average electricity tariff
CNE: Spanish National Energy Commission
CPI: Consumer Price Index
EC: European Commission
EEG: Erneuerbare-Energien-Gesetz (German Renewable Energy Law)
EU: European Commission
FIT: Feed-in tariff
GDP: Gross domestic product
GHG emissions: Greenhouse Gas emissions
GW: Gigawatt
IDAE: Instituto para la Diversificación y el Ahorro de la Energía
IRR: Internal Rate of Return
KW: Kilowatt
MACGR: Monthly average compounded growth rate
MANC: Monthly average new capacity
M€: Million euros
MW: Megawatt
NREAP: National Renewable Energy Action Plan
PV: Photovoltaics
RD: Royal Decree
RDL: Royal Decree Law
RES: Renewable energy sources
RES-E: Electricity from Renewable Energy Sources
TGCS: Tradable Green Certificates

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1 EXECUTIVE SUMMARY

In 2007 and 2008, Spain experienced an unprecedented boom in the deployment of solar photovoltaic (PV) modules, due in large part to a generous feed-in tariff (FIT). This was followed by a spectacular bust, as the government stepped in to reduce the unsustainable costs of the FIT. Eventually, policy changes that were considered retroactive were made, angering investors and becoming the focus of much analysis and criticism among the international policy community.

The principle objective of the FIT was to increase the deployment of solar PV. In the short term, this was indeed achieved. But failing to control costs ultimately damaged the future prospects of ratepayer-funded solar PV deployment in Spain and damaged the country's small domestic industry.

This report provides an authoritative review of the solar PV boom and bust, with an aim to derive key lessons for policy-makers in other countries. How can governments support renewable energy while avoiding similar crises? And what do they do if such a crisis emerges?

What happened and why?

Figure 1 summarizes the dramatic story of Spain's solar PV deployment: steady but low rates of installation up until 2006, a sudden massive spike in deployment in 2008, and, following a reduction in support, a subsequent plummeting of installations to zero the following year. The costs of this crisis were large: by 2009, solar PV received close to 50 per cent of all support for renewable electricity in Spain, despite providing only 10 per cent of its renewable electricity. By 2009, the total annual cost of subsidizing solar PV was €2.6 billion per year. At this level of expenditure, solar PV subsidies represented over 50 per cent of all spending on renewable energy, despite producing just under 12 per cent of all renewable electricity generation, and only 2.45 per cent of total electricity generation

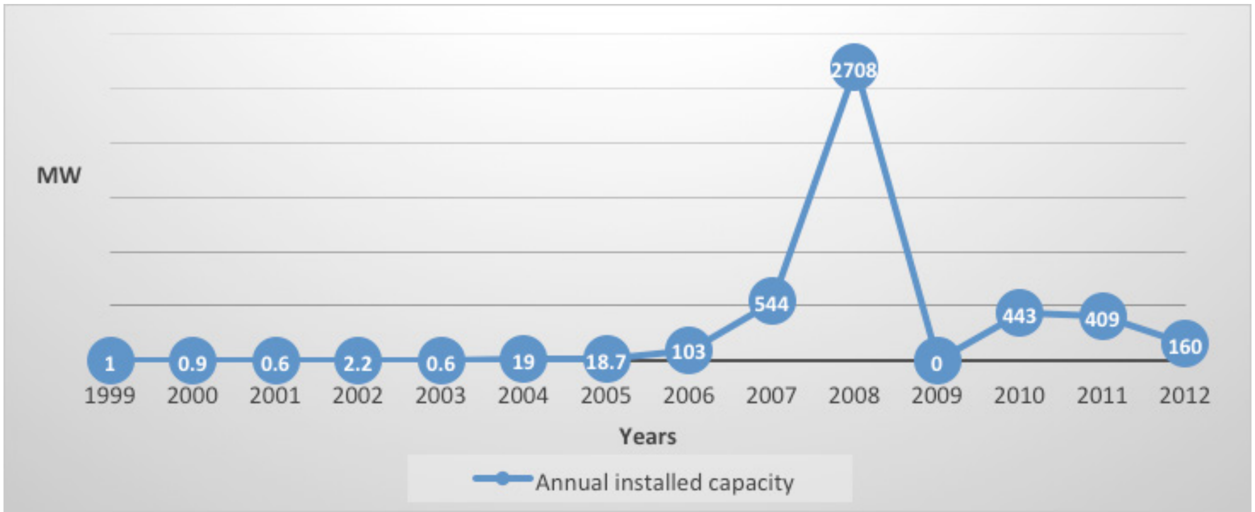

FIGURE 1. SPAIN'S ANNUAL INSTALLED SOLAR PV CAPACITY (MW), 1999-2012)

The poor design of the FIT was one of the major factors contributing to the boom, including the following design characteristics:

- An over-generous rate structure of the FIT in 2007: actual internal rates of return for projects are estimated to have been between 10 to 15 per cent, as opposed to the targeted rate of 5 to 9 per cent.
- No subsidy "degression" options, to reduce support in line with the changing costs of solar PV projects.
- An excessively long transition period between policy schemes when tariffs reductions were expected.
- A significant lag time in the reporting of investments by regional governments.

These inflexibilities resulted in a system that overcompensated solar PV and failed to reduce compensation in response to the technology's rapidly declining costs. It also failed to adjust to other external factors affecting costs: currency swings strengthening the euro against the U.S. dollar, making it even cheaper to purchase solar PV modules traded in US dollars; and financiers shifting capital from real estate into the energy sector, creating cheaper access to credit. This was particularly problematic due to the fact that solar PV is a modular technology that can be installed in relatively short timelines: investors could respond to changing conditions much faster than policy-makers. By the time that slow internal communications mechanisms made the national government aware of the scale of regional investments, the crisis was already in full swing.

How Did the Government Respond? What Were the Consequences?

The government enacted a series of regulations from 2008 to progressively slow deployment and reduce costs, culminating in a complete moratorium on support for new solar PV systems in 2012. Changes introduced in 2010—some of which were highly contested by PV investors for being retroactive—affected the treatment given to existing installations, threatening their financial viability.

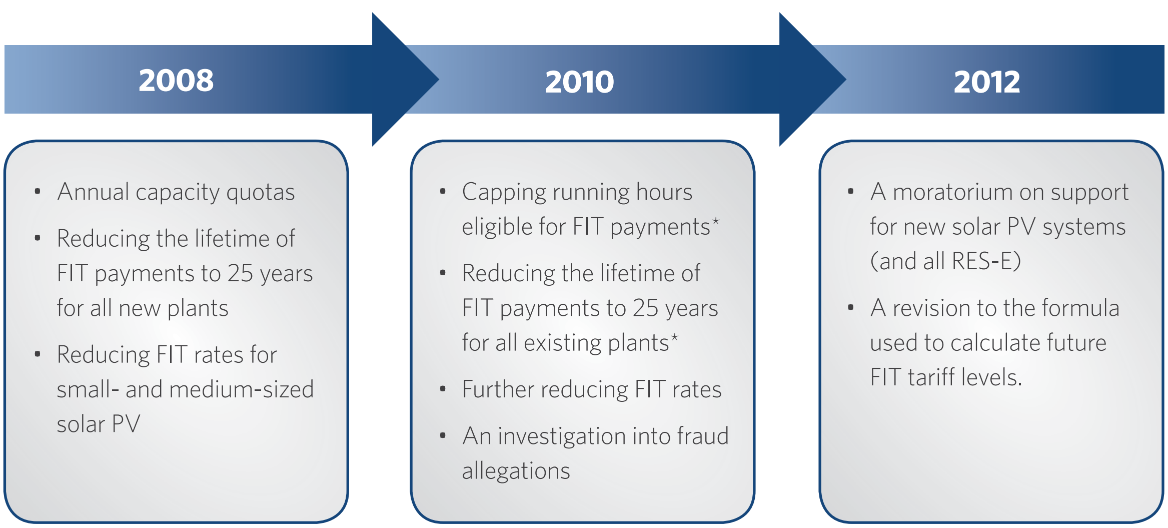

FIGURE 2. REGULATORY CHANGES 2008 TO 2010

** Changes contested by the solar PV sector for being retroactive.*

The final outcome was a lose–lose situation for almost all stakeholders. The electricity system was burdened with costly solar PV generation for years to come. The policy changes had implications for the ongoing viability of the industry, with solar PV developers feeling betrayed by the government's retroactive tariff changes. Numerous companies involved in solar PV manufacture either had to close or merge, and employment in the sector fell from a high of 41,700 reported jobs to fewer than 10,000 in 2012. Indeed, the repeated changes and amendments had wider implications for renewable energy as a whole, damaging investor confidence in the reliability of Spanish policy frameworks. And the performance of regulators and policy-makers was heavily criticized by industry associations, solar PV investors, generators and environmental NGOs.

What Lessons Can We Learn?

The biggest lesson is simply that cost control matters. A renewable energy subsidy must be designed in a way that makes it robust in the face of changing costs. This is not just a one-off risk related to the falling costs of technology. For other countries, it might equally relate to fluctuating exchange rates, falling costs of project finance or dumping due to global oversupply. Failing to take seriously the need for cost-effective subsidies may actually harm the renewable energy industry in the medium to long term.

The hardest lesson is that there is no obvious way to manage a crisis if it emerges. Mistakes happen. And when they do, there is currently no clear good practice for how to balance taxpayer or ratepayer interests against the needs of the renewable energy industry. Spain chose to cut its subsidies. Would it have been better, or less controversial, to allow the unintended costs to be charged on public budgets, particularly during a time of broader economic crisis? Clearly, most countries that find themselves in this kind of situation will seek a third way: to reduce costs, but also to minimize harm to investors as far as possible. It is difficult to derive any prescriptive guidance from Spain's experiences; each government must strike its own balance between these two competing objectives, taking into account the surrounding economic and political circumstances.

Three principles emerge from Spain's experiences. First, to design policy in a way that **avoids** any kind of cost crisis. Second, to ensure that appropriate tracking mechanisms are in place so that government can detect and **react** to problems promptly. Third, if neither of the prior two strategies have been pursued, and a crisis occurs, to at least **limit damage**.

AVOIDING A COST CRISIS

1. **Incorporate cost-containment mechanisms into subsidy schemes.** Such mechanisms depend on the scheme, and may include caps on capacity and running hours, scheduled tariff revisions, flexible degression, time-bound support measures and caps on total policy costs. All such measures have disadvantages, and a balance must be struck between policy adaptability and investor stability.
2. **Independent regulators can help ensure that support levels are appropriate and that cost control mechanisms are incorporated.** This can help prevent regulatory capture and ensure that stakeholders' information is drawn upon and their views acknowledged.
3. **Plan for the unexpected.** Support policies for renewable energy are complex instruments designed to operate over long periods of time and in different economic circumstances. Policy-makers should "stress test" the performance of renewable energy subsidies to check for design weaknesses that may only become apparent in extreme situations. Spain's experiences imply that tests should consider factors related to policy design, technological change, finance and policy administration.
4. **Create disincentives to speculation.** Speculators may bid for project development rights with the intention of selling them on to third parties. Requiring financial guarantees from project developers or introducing other anti-speculative regulatory processes can help prevent fraud and misuse, and ensure only genuine developers submit project proposals.

REACTING TO A COST CRISIS

1. **Real-time monitoring of registration for support can allow for prompt action before a crisis has peaked.** In multilevel, federal or decentralized governance contexts such as Spain, this requires communication systems between all relevant departments.

LIMITING DAMAGE

1. **Avoid excessively long transitions from one set of policy conditions to another.** If a policy is changed to become less favourable, there may be a last-minute rush to register projects under the earlier scheme. This was particularly problematic for solar PV, given the relatively easy-to-install, modular nature of the technology. Any effort intended to stimulate the deployment of a technology with such fast lead times should take this into account when implementing policy changes.
2. **Retroactive policy changes are highly damaging for present and future industry and may result in legal challenges.** Governments may still choose to weigh this cost as less harmful than no policy change, but they should not doubt the likely repercussions. If retroactive changes are considered to be necessary, damage should be limited by attempting to reduce FIT rates to a level that, as far as possible, allows existing projects to cover operational costs and pay back the costs of installation.

2 INTRODUCTION

Subsidy policies—no matter how well intentioned—are often difficult to effectively design and implement, leading to problems of ballooning costs, inefficiently achieved objectives and unintended impacts. Understanding exactly how and why subsidy policies have caused problems in one context, while succeeding in another, can be instrumental in designing effective support schemes.

This is particularly important in the case of renewable energy. An increasing number of countries around the world are establishing financial incentives to support large-scale deployment, and ongoing public support for this expenditure relies on governments being able to show that their policies are not just effective but cost-effective as well.

This study provides a detailed exploration of the events leading up to, during and after the notorious Spanish solar PV bubble—when a sudden and unexpected burst of investment in solar PV led to skyrocketing policy costs, and ultimately resulted in the government taking retroactive measures to reduce the subsidy promised to developers.

The study provides a synthesis of analysis to date, through a comprehensive literature review and insights from interviews with 18 expert stakeholders. Interviewees contacted by the research team included: public officials from national and regional governments responsible for developing and implementing relevant policies; energy experts from academia and consultancies; the "solar PV sector" (installers, investors and industry associations); and an environmental NGO. Interviews were conducted anonymously to allow for the collection of frank and open views. In addition, the study provides a comparison with solar PV bubbles in other countries.

The study is structured in two halves: first, for general readers, a qualitative description and analysis of Spain's solar PV investment boom. This concludes with a series of lessons for governments who are using or designing renewable energy deployment policies. Second, for policy researchers, is a comprehensive technical Annex, which formed the basis for the qualitative discussion, and provides a high level of detail for those interested in Spanish policy for solar PV.

3 A CAUTIONARY TALE

3.1 UNDERSTANDING THE POLICY: OBJECTIVES AND DESIGN CHARACTERISTICS

Policy Objectives

From the 1990s, the Spanish government's rationale for supporting renewable energy sources for electricity (RES-E), and solar PV in particular, was related to environmental protection, industrial policy, and employment creation. It was also part of an effort to help diversify Spain's energy mix and reduce dependence on fossil-fuel imports. In addition, supporting the deployment of RES-E was intended to help Spain comply with commitments to renewable energy and greenhouse gas reduction targets contained in international regulations, including the Kyoto Protocol, the Renewable Electricity Directive (Directive 77/2001/EC) and the Renewable Energy Directive (Directive 28/2009/EC).[1]

Spanish policy-makers chose to use feed-in tariffs (FITs) as the main policy mechanism to support RES-E development. An FIT works by guaranteeing a price for electricity generated by renewable energy developers. FITs provide a premium price over and above the wholesale market price of electricity, and do not typically fix or cap the volume of electrical output that is eligible for support. This helps renewable energy developers project their future revenue streams with confidence.

The main strengths of FITs are that:

- They only reward providers for electricity that is actually generated.
- They are, in theory, relatively simple to administer.
- They provide renewable energy developers with a stable guarantee of support over the economic life of the project.

The main criticism of FITs, when they first began to be introduced, was that they typically lacked built-in mechanisms to modify payments to match the changing conditions of the market, such as subsidy premiums being too generous or the level of installed capacity being higher than anticipated (del Río & Gual, 2004). Many countries have since mitigated this problem, however, introducing cost-containment mechanisms, including capacity caps, generation caps or flexible degression.

The Spanish government chose to use FITs based on the fact that alternative policies in the mid-1990s were considered to be performing ineffectively (such as the bidding scheme in the United Kingdom) whereas FITs were performing effectively in Germany and elsewhere.

Political economy reasons played a role as well. Social and political opposition to an FIT was regarded as unlikely by the government, given the environmental and employment benefits associated with RES-E deployment. It was thought that electricity consumers paying for the policy would be unlikely to complain, as the expected costs of the policy would not be high, at least in the short term, due to a low level of RES-E penetration, and would be paid by a large number of (captive) electricity consumers. Policy-makers also regarded FITs as less administratively burdensome than other support mechanisms and more likely to achieve energy and industrial policy goals. FITs also had the support of RES-E generators and investors, who lobbied for the adoption of such a system (Energy expert, personal communication, February 2013).

Policy Design

In the run-up to the investment boom, Spain's renewable energy policies were geared towards helping to achieve the EU target of 12 per cent of gross energy consumption coming from RES by 2010.

Spain's FIT policy began with the Electricity Sector Law, introduced in 1997 (Law 54/1997). This set up the Special Scheme or Regime (*Régimen Especial*) to provide RES-E (and co-generation) with special treatment compared to conventional electricity generation and large hydro—a preferential price for electricity fed into the grid by RES-E plants.

[1] For a comprehensive list of the stated objectives of different landmark regulations setting out support for renewable energy and solar PV, see Annex 1.

In the interim years, subsequent policies provided differentiated tariffs based on system sizes, and solar PV developers were able to choose between fixed feed-in tariffs adjusted annually or a fixed premium on top of the electricity market price. The deployment levels of solar PV were stable but low, and remuneration levels were revised annually (del Río, 2008).

In 2004, the first amendment was made, with Royal Decree 436/2004. This introduced a target of 150 megawatts (MW) for solar PV. Once the target was reached, support levels would be revised. This change came in response to criticisms from RES-E generators, who argued that annually revised support levels were not transparent and increased the risk for investors, causing a higher risk premium to be charged by lending institutions (del Río, 2008). To improve stability, support levels were set as a percentage of the electricity price, or the "Average Electricity Tariff" (AET)[2] and revised every four years rather than annually.[3] Overall, the new regulation led to a more favourable treatment of solar PV technologies, both large- and small-scale. However, it failed to introduce best-practice FIT design elements, such as a degressive FIT rate, laying the foundation for the future solar PV boom.

After a year of negotiations, Royal Decree 661/2007 entered into force in June 2007 and had a significant impact on Spain's solar PV sector (del Río, 2008). This de-linked the FIT rate from the AET because the AET had increased significantly between 2005 and 2006 (by 4.5 per cent), and the overall costs of RES-E support had therefore also increased, forcing the government to consider system reform. Solar PV installations were from this point no longer allowed to choose to receive a FIT "premium" and were obliged to instead accept a fixed FIT rate.

The tariff level for solar PV did not change, with the notable exception of the category from 100 kilowatts (kW) to 10 MW, whose remuneration increased by 82 per cent, in order to foster greater investment in larger facilities.

Other main features of RD 661/2007 and significant changes with respect to the previous regulation were:

1. **The revision of FIT rates was scheduled for once every four years**, starting in 2010,or once a given capacity target had been reached (371 MW for PV generation). Once 85 per cent of the target had been installed, any additional capacity for a period of 12 months thereafter would be remunerated at the wholesale electricity price, i.e., the FIT regime would come to an end. This transition period was designed to allow for the negotiation and enactment of a new FIT regime.
2. **Mandatory guarantees were established to prevent speculation**, at the request of the solar PV association. PV plants had to deposit guarantees of €500 per kW with relevant authorities (roof-mounted installations were excluded) on applying for grid access (and €20 per kW for other RES-E technologies).
3. **RES-E would receive priority access to the electricity grid, and renewable plants of a capacity greater than 10 MW had to be connected to a generation control centre.**[4] Furthermore, technologies with intermittent electrical output (wind and solar PV) would not receive capacity guarantee payments. The level of energy provided by wind and solar PV was restricted to no more than 5 per cent above anticipated energy output, with generators allowed to correct output predictions one hour before the opening of the market.
4. **The Renewable Energy Plan for 2011–2020 was developed further,** taking into account the revision of support levels scheduled in 2010, signalling to investors that support would continue after 2010.
5. **A cap-and-floor price system,** for installations participating in the market. If the market price plus the premium were above the cap, then RES-E generators would only receive the cap level. If they were below the floor, they would receive the floor price.

[2] FIT levels were tied to AET through a formula. For example, the support level for PV installations ≤100 kW would be equal to 575 per cent of the AET for the first 25 years and 460 per cent thereafter (the economic lifetime of the solar PV plant). A decreasing support escalator was implemented, whereby the plants received a lower percentage of AET after some years.
[3] This indexation system was regarded as a more objective, stable and transparent method for setting support levels and reduced the arbitrariness of the previous system.
[4] An electricity producer being paid to keep an electricity generation asset (such as a CCGT power plant) ready to dispatch.

Policy Development

The key branches of the government involved policy development were:

- The Ministry of Industry
- The IDAE (*Instituto para la Diversificación y Ahorro de Energía/*Institute for the Diversification and Energy Saving)
- The CNE (*Comisión Nacional de la Energía/*National Energy Commission)

The central government (through the Ministry of Industry) decided on both the general goals and the design elements of the RES-E promotion policy. The IDAE is a branch of the Ministry of Industry, specifically devoted to diffusion and educative actions, technical assessment and financing of innovative projects. The CNE is the regulatory body of the energy sector, in charge of liquid fuels, gas and electricity, including generation, transport and distribution.

According to an interview with a public official conducted in the course of this study, communication channels between the Ministry of Industry and solar PV investors and generators on technical issues were ad hoc and not systematically organized, although general meetings were held between the relevant sectors connected to the PV sector and the Ministry of Industry (Public official, personal communication, December 2012). There was no framework in which information could have been shared (and issues negotiated) in the development of Spain's solar PV policy. It was also reported that, in some instances, the government relied on external consultants to contact the PV sector to obtain information. Consultants would then elaborate recommendations based on stakeholder feedback. In the case of RD 661/2007, a second public official reported that IDAE was responsible for contacting existing solar PV installations to obtain data on the economic conditions for solar PV farms at the end of 2006 (around 100 MW) in order to set FIT rates (Public official, personal communication, February 2013).

Communication between the government and other stakeholders was generally limited. Information was shared with the broader public via posts on the Ministry's and IDAE's official web site. The CNE undertook some public consultation procedures, but the participation of civil society was seen to be quite indirect in this context (Environmental NGO, personal communication, March 2013).

These testimonies suggest that robust measures were not put in place to ensure that data on technology costs was independently assessed. Instead, this was provided by equipment manufacturers and solar PV generators, often communicating directly with government agencies, resulting in the risk that those being regulated could take advantage of the regulators, due to the problem of asymmetric information availability.

Policy Context: Spain's electricity system

The electricity system in Spain has two key characteristics that are crucial to understanding how the solar PV sector and support policies developed.

First, Spain is virtually an energy island, with limited interconnection or trading with neighboring countries (about 3 per cent of electricity demand was imported in 2011) (see *Red Eléctrica de España* [REE], 2012). As a result, virtually all domestic electricity production has to be consumed within Spain, given that electricity cannot be stored. This fact, along with poor long-term planning, has resulted in the Spanish electricity system having significant excess electricity generation capacity. In 2009, installed capacity was around 93,000 MW (taking into account all technologies), while maximum peak demand was only around 44,000 MW (Bilbao et al., 2011).

Second, since 1997 successive Spanish governments have controlled electricity prices as a measure to protect consumers.[5] Figure 2 shows the proportional change in average electricity tariffs between 1996 to 2011 at nominal and real prices. Prices in 2011 had risen to around 150 per cent of their nominal value in 1996. But, in real terms, taking into account inflation as

[5] This is despite the fact that expenditure on electricity by Spanish households represents a small share of total household expenditures.

measured by the Consumer Price Index (CPI), they have remained essentially unchanged since 1996. During this period, they have usually been lower than their 1996 levels. At their lowest, in 2005, they were just under 70 per cent of their real 1996 value. However, average real tariffs have increased in the last five years.

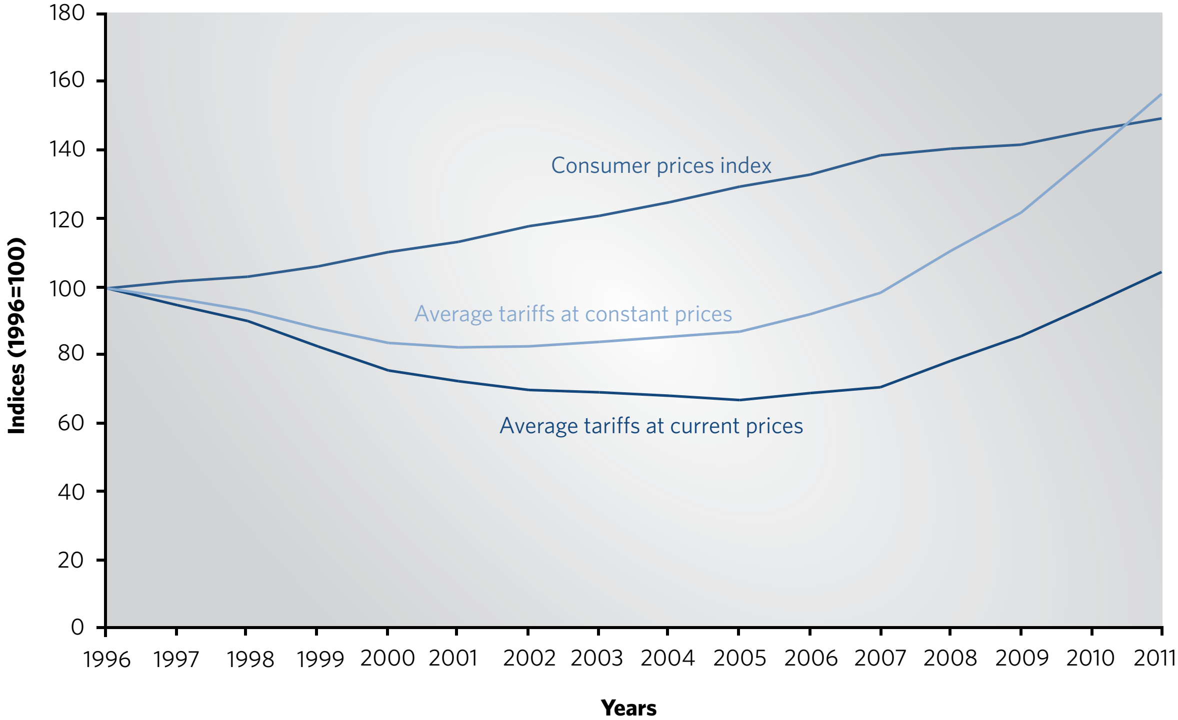

FIGURE 3. EVOLUTION OF THE ELECTRICITY RETAIL PRICE IN SPAIN, 1996-2011

Source: Author's elaboration based on Instituto Nacional de Estadística (National Statistical Office) (INE) (n.d.).

This means that, unlike many other countries, FITs for solar PV and other renewable energy technologies have not led to price increases for ratepayers. Instead, they have fed into a massive "tariff deficit," along with the cost of subsidizing conventionally generated electricity. By the end of 2012, this deficit was equal to more than €29 billion, equating to around 3 per cent of Spanish GDP (authors calculations). Given that Spain's public debt in 2012 was equal to 85.3 per cent of GDP (CIA, 2013), this is not an insignificant contribution to the country's broader debt burden.

At the present time, the deficit has gradually been securitized[6] and placed in international financial markets, first directly by utilities and, from 2010, by a specific entity managed by the Government (Mir, 2012). The full cost of subsidizing electricity has therefore still not been felt by the Spanish economy, and has been shifted onto future consumers.

[6] The debt is securitized at a 6 per cent interest rate and a 15-year amortization period.

3.2 THE BOOM

A Spike in Deployment Levels

Spain's solar PV boom began in 2007 after Royal Decree 661/2007 was implemented. Solar PV deployment levels had been trailing the official targets set out in Spain's Renewable Energy Plan (2005–2010). Royal Decree RD 661/2007 was intended to accelerate solar PV deployment rates in order to comply with those targets.

Figure 4 shows the evolution of annual solar PV capacity installations from 1999 to 2012: modest amounts of installation per year,until 2007 and 2008,when the installations rose 5-fold and 26-fold in comparison with 2006. The following year, annual installed capacity dropped dramatically, first to zero, and then back to relatively modest levels up until 2012.

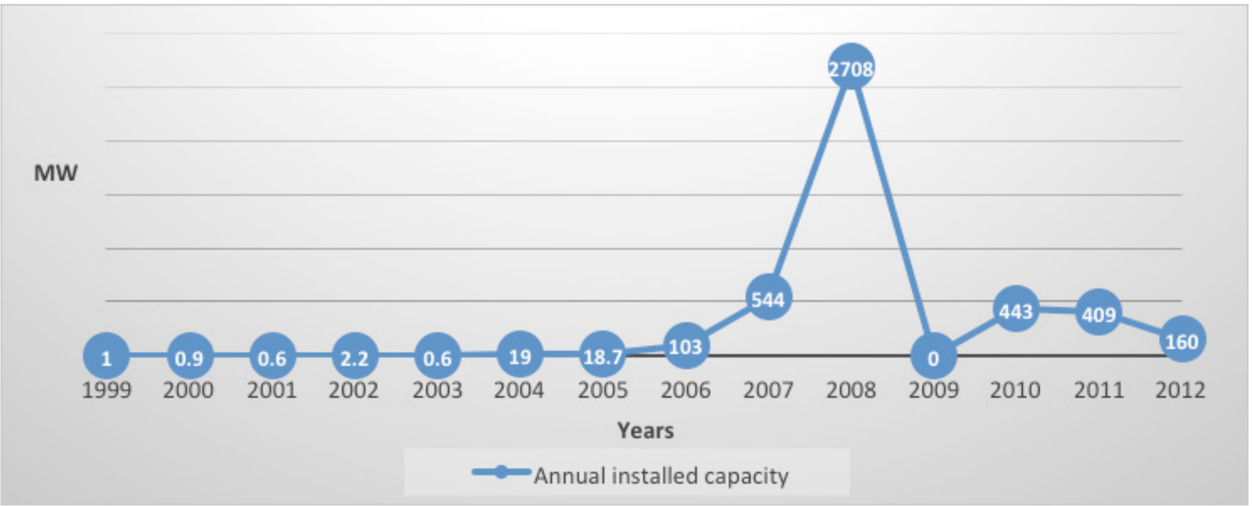

FIGURE 4. ANNUAL INSTALLATIONS OF SOLAR PV CAPACITY IN SPAIN, 1999-2012*

** Data for 2012 is an estimate.*
Source: Authors' elaboration based on Comisión Nacional de la Energía (National Energy Commission) (CNE) (2013).

From April 2007 to August 2008, the installation rate was astonishingly fast. Nearly 500 MW of capacity was installed each month between June and September 2008 (see Figure 5).

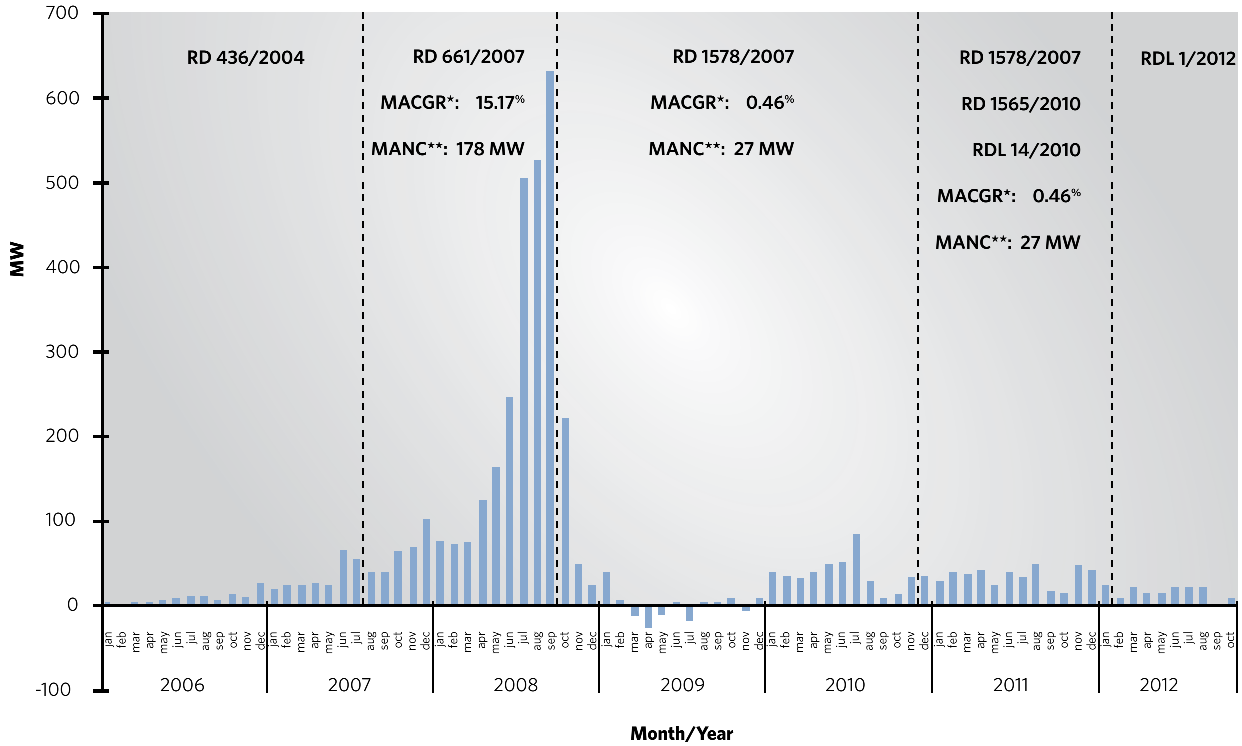

FIGURE 5. THE IMPACT OF THE BOOM AND THE COST-CONTAINMENT MEASURES ON THE MONTHLY ADDITIONAL PV CAPACITY

** Monthly Average Compound Growth Rate*
*** Monthly Average New Capacity*
Negative values stem from database corrections
Source: Authors elaboration from CNE (several years of data).

An Equivalent Rise in Costs

The exponential growth in solar PV deployment caused a corresponding growth in the costs of the FIT. Table 1 shows the evolution of these costs from 2004 to 2011. It also shows solar PV electricity generation as a share of total electricity generation across these same years.

As the table illustrates, solar PV provided a relatively small share of all RES-E, while representing a substantial portion of all RES-E subsidies. Since 2008, the tariffs received by the solar PV sector have accounted for close to 50 per cent of all support provided to RES-E, despite its low contribution of total electricity (providing about 10 per cent of all renewable energy generated and 3 per cent of overall electricity generation).

Following the boom, total subsidies paid to PV generators skyrocketed from €194 million in 2007 to €990 million in 2008 and €2.6 billion in 2009.[7]

[7] Net subsidy costs are calculated as the whole FIT rate and premiums paid to RES-E, minus the average wholesale price and multiplied by the amount of GWh of RES-E being generated. See Annex for more detail.

TABLE 1 EVOLUTION OF PV TARIFFS AND GENERATION

YEAR	TOTAL TARIFFS PAID TO THE PV GENERATION (THOUSAND EURO)	AVERAGE TARIFF COST OF MWH PV (EURO)	% PV TARIFFS WITH RESPECT TO ALL RENEWABLE* TARIFFS	% MWH PV INTO THE RENEWABLE* GENERATION MIX	% MWH PV INTO THE GLOBAL GENERATION MIX
2004	6,146	341.44	0.93%	0.08%	0.01%
2005	13,995	341.34	1.75%	0.15%	0.01%
2006	39,887	372.78	3.53%	0.35%	0.04%
2007	194,162	392.25	13.44%	1.36%	0.16%
2008	990,830	388.71	40.88%	6.09%	0.96%
2009	2,634,236	424.60	55.90%	11.72%	2.45%
2010	2,653,720	414.25	49.66%	10.65%	2.46%
2011	2,402,986	390.22	47.79%	10.46%	2.41% (2.91%)º
2012†	2,567,302	392.31	47.28%	11.98%	2.58% (2.89%)º

** Renewable sources: Hydroelectric power, wind power, biomass power, CSP and PV.*
† January to mid-December 2012
º % eligible and non-eligible MWh PV
Source: Authors elaboration from the latest official data (CNE).

The Reasons for the Boom

The dominant factors behind Spain's solar PV boom are well-known: FIT rates were too high, technology costs were decreasing and FIT rates were not changed to account for these changing costs. According to an interview with a public official conducted in the course of this study, tariffs were designed to provide developers with an internal rate of return (IRR) for their projects of between 5 per cent and 9 per cent (Public official, personal communication, February 2013). The government had set this rate allowing for a "reasonable" profitability level of 7 per cent. Actual IRRs for projects in the best locations were, however, between 10 per cent and 15 per cent.

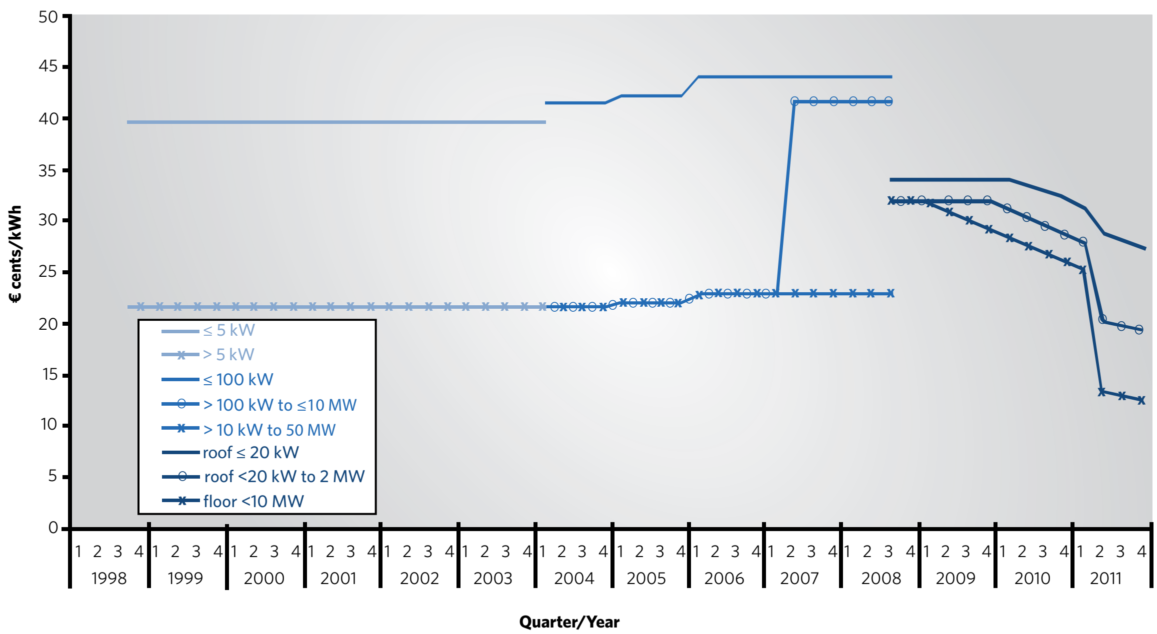

FIGURE 6. TARIFF RATES FOR SOLAR PV (€ CENTS/KWH), 1998–2011

Source: Authors' elaboration.

But this explanation is not very revealing. Every cause raises a cause in turn and in order to learn lessons we should also ask—why were rates too high, technology costs falling so fast and FIT rates not changed?

A range of factors helped create the dynamic that caused the crisis in Spain. All of them in some way relate to either profitability (the gap between FIT rates and the cost of developing a solar PV installation), the speed at which investments could take place or the extent to which costs and investments were anticipated and tracked.

They are summarized in detail here and they include:

i. Policy

- A change to high tariffs for medium-sized installations
- Ability to aggregate medium-sized plants close together
- Inflexible tariffs
- Repowering of sites
- Capacity upgrades
- Anticipated policy change to less favourable conditions
- Slow policy change

ii. Technology

- Falling manufacturing costs
- Capacity upgrades
- Increasing efficiency
- Modular, easy-to-install technology

iii. Financial

- Easy access to credit
- Favourable €/$ exchange rate
- Capital flight from housing

iv. Administrative

- Fast-track permit provisions provided by regional authorities
- Poor coordination between regional and national authorities

i. Policy

Tariff rates that were set "too high" is the most commonly cited factor used to explain the boom (e.g., Mallet, 2010; Voosen, 2009). Unpacking this idea is useful. In fact, for small installations (less than 100 kW) and large installations (over 10 MW) tariff levels had not been increased significantly between 2004 and 2007, and had last been revised only slightly upwards in 2006. For two categories of solar PV application, then, tariff levels had been in place for two years, and the level of remuneration for developers had not previously proved to be excessive.

The only exception, as illustrated in Figure 6, was the FIT rate for installations between the capacity ranges of >100 kW and ≤10 MW, which was almost doubled in RD 661/2007.[8]

The change to high tariffs for this middle category of installations was important, but what was crucial was the fact that investors could take advantage of the rates, realizing that they could make more money by aggregating small-sized plants close together, rather than building one large plant. This kind of plant arrangement was allowed by law. Many such *huertos*

[8] The policy framework for developers in 2007 had lower revenue risk since support levels were no longer tied to electricity prices as they were in RD 436/2004, making the 2007 FIT slightly more attractive for investors.

solares—"solar orchards"—were set up in order to take advantage of the highest FIT rate and benefit from the economies of scale that could be achieved by aggregating smaller systems. In essence, this meant that large-scale systems were able to receive the level of the feed-in tariff intended for smaller and costlier systems. It also meant that the financial rewards of the feed-in tariff would be much larger than intended, resulting in a boom of investment.

But this was not the only reason why some systems were too generously compensated. Across the FIT system, inflexible tariffs that did not respond to changing costs were a major cause of the problem: while rates had barely changed since 2004, many other aspects of the costs of solar PV project development had gone down—as summarized in the following sections on technology and finance. This failure to recognize that profitability is a dynamic between prices and costs, and that profitability can be highly volatile in the very short-term, rendered tariffs over-generous where they had previously been sufficient.

Two other aspects of government policy played roles in helping to drive the boom.

First, some provisions enabled amendments to existing installations that essentially increased generating capacity. For example, clauses surrounding the "repowering" of sites allowed existing PV plants to install more efficient equipment in order to fall under RD 661/2007's more favorable regulations.[9] The only condition was to maintain their nominal capacity, but, because new modules were more efficient, electrical output increased, as did the amount of subsidies received per unit of capacity. In other cases, capacity upgrades took place informally. The legal capacity of a solar PV park was defined as the capacity of its inverter (Article 3.3 of RD 661/2007). Therefore, a common practice was to upgrade the capacity of the modules (that is, the sum of their peak capacities) by 15 to 20 per cent above the inverter nameplate capacity. This led to an increased amount of electricity being fed into the grid.

Second was the effect of anticipated policy change to less favourable conditions and simply slow policy change. RD 661/2007 set out that if 85 per cent of the solar PV capacity (371 MW) had been reached then a new Royal Decree with lower FIT levels would need to be approved within one year. The quota was already achieved by June 2007 and a draft of the new Royal Decree was made public in September 2007, including a substantial reduction in support levels compared to the existing regime. Solar PV developers had expected levels to be lower, but, due to the size of the decrease, there was a rush in the spring and summer of 2008 to submit proposals in order to qualify for the existing FIT scheme. It was September 28 2008 by the time that the new regulation (RD1578/2008) entered into force. Although the transition period was only one year, it was too long, given the modular, easy-to-install nature of solar PV technology. According to the testimony of one energy expert who was interviewed in preparation for this study, installation time during the boom in 2007 and 2008 could take between six and twelve months (Energy expert, personal communication, February 2013). Solar PV capacity at the end of 2007 had been only 544 MW but had reached 3,116 MW by the time the new Royal Decree was introduced. The increase in the level of installed capacity represented an enormous rush of applications during the transition year between subsidy regimes.[10]

ii. Technology

Along with a general ongoing trend of falling manufacturing costs, there were also increases in efficiency of solar PV panels that effectively increased the production of electricity for a given nominal capacity. In addition, arrays with 1- or 2-axis tracking systems were increasingly used. Both efficiency factors led to a 33 per cent increase in electricity production and consequently increased revenues for developers, thus leading to a higher burden on the government.

[9] Repowering refers to the replacement of existing PV modules with new, more efficient ones, increasing the amount of electricity being produced without elevating the nominal power of the plant. Repowering brings certain advantages compared to new projects: new places are not occupied (circumventing the problem of competition for land) and older plants are upgraded and substituted by new ones with better technologies.

[10] It should be noted that two interviewees doubted that this created the dash for solar PV. According to their view, the market was already overheated before September 2007 as a result of the high FIT level and many projects were already in the pipeline (Energy expert, personal communication, February 2013; Installer and solar investor, personal communication, February 2013.)

iii. Financial

A number of factors decreased the cost of finance, increasing the profitability of solar PV projects.

Access to credit was relatively easy, and low interest rates facilitated the financing of projects for smaller investors. Spain had taken advantage of joining the Euro currency zone and reduced interest rates in 2006. Spanish banks had a large credit capacity due to large deposits and loans from foreign banks (mostly from EU countries). According to one source, banks were financing up to 100 per cent of investments through project finance arrangements (Public official, personal communication, December 2012). Such schemes were common for projects financed by small investors whose own financial resources were insufficient to finance the upfront capital costs required for solar PV.

In addition, the U.S. dollar weakened against the euro (€) from 2006 to 2008. From June 2007 to August 2008 the average exchange rate was US$1.47 per euro. The stronger euro versus the dollar encouraged imports of solar PV cells and modules since imports were paid in dollars and were, effectively, becoming cheaper. In 2008, solar PV imports totalled €5,182.5 million (55 per cent were imported from China) while exports only amounted to €250 million (Funk Kirkegaard, Hanemann, Weischer, & Miller, 2010). Imports from China represented around 1,700 MW (~60 per cent of total installed capacity).

Finally, the housing market, which had been growing rapidly, began to show signs of stagnating in 2007, causing a flight of capital to more profitable investments. Solar PV investments became an appealing financial product because of high internal rates of return coupled with very small risks. Investors from the Spanish housing market were of course not the only actors engaged in Spain's solar PV market. A large range of international investors, from small investors to large pension and investment funds, were also operating. The influx of investing from Spanish housing did, however, serve to affect the total volume of investment on the market (Cinco Días, 6-21-2010, p.1 and 3).

iv. Administrative

Finally, administrative factors also played a role. According to one public official some regional and local governments (responsible for the granting of different administrative permits) reduced their administrative requirements to speed up deployment, although there were no specific deadlines for issuing permits (Public official, personal communication, December 2012). The eagerness to grant planning permits was in recognition of the local socioeconomic benefits of solar PV deployment (namely, economic activity and jobs, especially in rural areas).

Poor communication between Spain's Autonomous Communities and the central government led to delays in identifying the number of projects applying for the FIT scheme. Although there was a central registry for PV installations eligible for the special FIT regime, most solar PV plants were registered at regional registries.[11] Autonomous Communities were required to pass this information to the central government. The system of reporting between the regional governments and central administration was, however, considered to be antiquated by several of the experts interviewed by the authors in researching this study. In some cases there was a delay of several weeks between the regional offices passing registration information on to central government (Energy expert, personal communication, February 2013; Energy expert, personal communication, February 2013).

Up until about April 2008, it seemed that the central government did not have an understanding of the overall number of solar PV projects that were going to be deployed under the FIT scheme (Industry association representative, personal communication, February 2013). A slow response to the situation may also have been linked to the general election in March 2008, which temporarily paralyzed the central administration (Energy expert, personal communication, December 2012). Better coordination between Autonomous Communities and the central government would have improved the monitoring of the monthly registration rates for installed capacity and helped the government react more quickly.

[11] While authorization for new solar PV plants was provided at the regional level, the subsidy is paid for by all electricity consumers in Spain on a pro rata basis.

3.3 THE GOVERNMENT'S RESPONSE

Controlling the growth in solar PV capacity and setting cost-containment mechanisms were priorities for the government once the scale of the solar PV boom became evident. This led to the introduction of several new regulations, which partially amended either RD661/2007 (regulating PV plants installed before September 2008) or RD1578/2008 (regulating plants installed after that date).[12]

The main measures introduced by the government included:

- Classifying PV installations into new categories with different tariff levels.
- Introducing capacity quotas on the amount of installed capacity which could be introduced during a quarterly period.
- A subsequent reduction in tariff levels.
- Setting a maximum period the subsidy was available instead of it being open-ended (retroactively for existing solar PV plants).
- Implementing a cap on the number of operating hours facilities could deliver electricity (retroactively for existing solar PV plants).
- Introducing tighter legislation on repowering solar PV systems.
- Imposing a moratorium on new projects.
- Special electricity tax and change to system for updating tariffs.
- And a campaign against developers defrauding the subsidy scheme.

Tariff levels for solar PV systems

RD 1578/2008 reclassified PV installations into a range of categories:

- Type I, consisting ofsolar PV mounted on roofs and facades, with subtypes based on their size, including
  - subtype I.1 (< 20 kW)
  - and subtype I.2 (>20 kW but less than 2 MW)
- Type II, consisting of ground-mounted and other solar PV technologies

For the first projects under the new system, the regulated tariffs were €0.34 per kWh for subtype I.1 installations and €0.32 per kWh for subtype I.2 and type II installations.

Introducing capacity quotas

As part of RD 1578/2008, a "cupo"—or capacity quota—system for each type and subtype of PV system was adopted. This set out a maximum amount of new solar PV capacity that would be allowed to register for subsidy support in each quarter of the year. It led to creation of a registry for the pre-allocation of support, in which all solar PV installations were to be registered in sequential order up to the capacity quota.

The definitive list of solar PV plants which were authorized in the first call as part of the capacity quota was published in February 2009. In total, 392 projects were registered, with 664 being refused registration because the target (*cupo*) had been exceeded. Another 543 projects were not admitted due to incomplete or incorrect applications. The second and the third calls linked to the capacity quota were published, respectively, in April and September 2009.

[12] Note that about 80 per cent of all PV plants currently installed in Spain fall under RD 661/2007.

Figure 7 shows the evolution of registered capacity by plant type for 2009 and 2010 once RD 1578/2008 was introduced. The number of rooftop installations was below the target until the end of 2009 and the beginning of 2010. Roof-mounted installations had four calls a year of 66.75 MW each. In contrast, ground-mounted installed capacity was clearly above the allocated target even though the quota of 33.25 MW per call was temporarily increased by 25 MW per call in 2009.

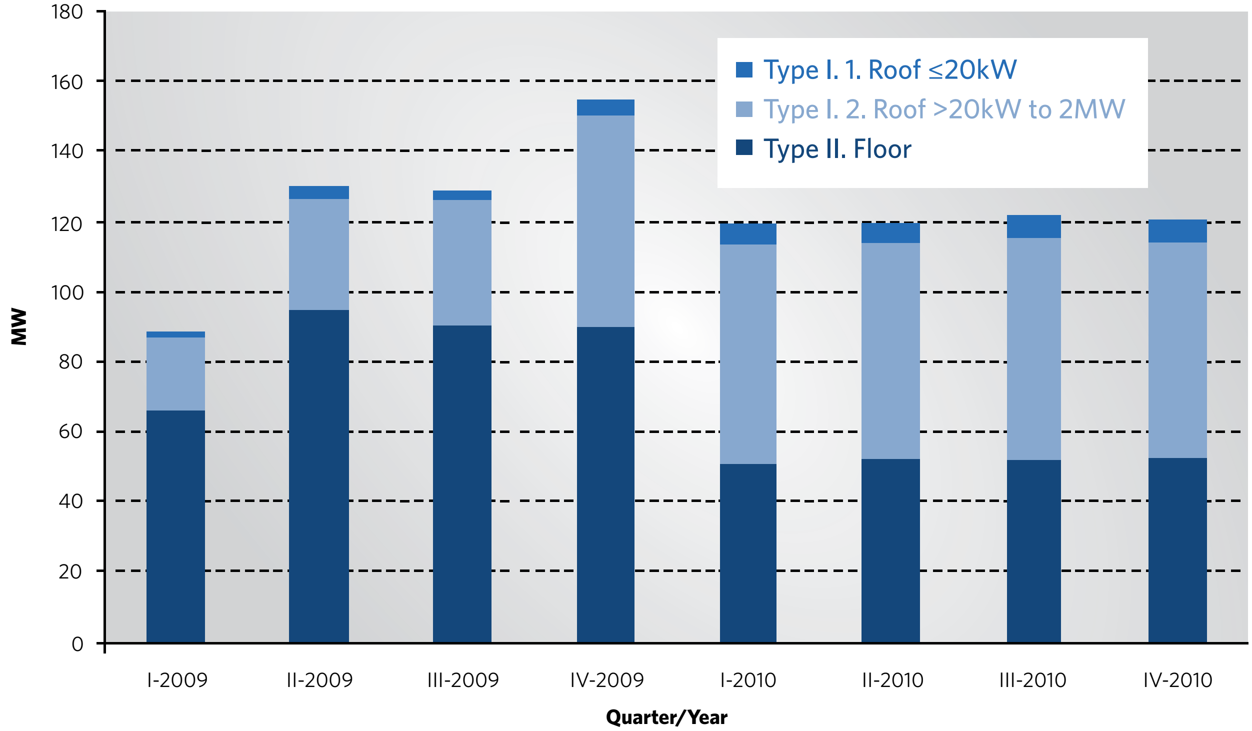

FIGURE 7. EVOLUTION OF REGISTERED CAPACITY UNDER RD 1578/2008

Source: Authors' elaboration from official data by IDAE.

Capacity under the quota was allocated to developers on a first-come first-served basis. It was also linked to the FIT rate in the following manner:

1. If less than 75 per cent of the quota was met, then the pre-established FIT level was maintained for the next call.
2. If more than 75 per cent of the quota was met, then the FIT level was reduced according to a proportion set out in a predetermined formula (see Annex). With installed capacity of 75 per cent of the quota or less, there would be a 0 per cent reduction in the FIT. With installed capacity equal to 100 per cent of the quota, the FIT would be reduced by 2.6 per cent.

Assuming that the quota was met in every quarter of the year, this means that the tariff would diminish at an inter-annual rate of 10 per cent.

The system also linked the capacity allocated for calls in the following year to tariff changes. Capacity targets for the 2nd and following years would increase if the tariff was reduced or decrease if the tariff was increased. In this way, capacity installations determined tariff changes, which in turn went on to determine quarterly capacity quotas.[13]

[13] Within RD 1578/2008 a rule for transferring quotas between the calls was also included.

Further reduction to tariff levels

The tariffs of RD1578/2008 were also subsequently reduced by another royal decree in 2010. A correction factor of 0.95, 0.75 and 0.55 was applied to type I.1 (small roof systems), type I.2 (large roof systems) and type II (ground-mounted systems) installations, respectively. Reduced levels of support entered into force in the second quarter of 2011.

In combination with the tariff reductions triggered by the new quota system, this meant that by the second quarter of 2011 tariffs had been reduced to €0.2888 /kWh for type I.1 plants, €0.2037/kWh for type I.2 and €0.1346 /kWh for type II systems. As a result, over a three-year period (from the end of 2008 to the end of 2011), tariffs were reduced by 19 per cent, 39 per cent and 61 per cent for type I.1, I.2 and II installations, respectively.

Setting a maximum period for the subsidy

The first Royal Decree introduced to control subsidy costs, RD 1578/2008, reduced the duration of support for new solar PV plants. Previously, plants had been offered subsidy payments across their entire operating lifetime. Under the new rules, newly installed plants would only receive support for 25 years.

The next Royal Decree, RD 1565/2010, was introduced at a time when the tariff deficit had increased substantially and the government had decided to take drastic measures to reduce it. The aim was to reduce electricity system costs by €4.6 billion in three years, half of which would come from cutting solar PV subsidies. One of its measures for achieving this was to extend the 25-year cap such that it applied to all solar PV plants developed under RD 661/2007. Beyond this period, plants would still be able to sell their electricity to the grid, but at wholesale prices.

This was considered a retroactive change by the solar PV sector, as RD 661/2007 had originally promised plants payments across their operating lifetime. The government's rationale was that support should no longer be provided once plants had been fully paid-off. In its subsequent Royal Decree Law, RDL 14/2010, it later increased the duration of support to 28 years, to compensate solar PV plant operators for other restrictions that had been introduced (discussed subsequently in this section) on the number of operating hours that plants would be eligible for FIT payments.

Implementing caps on operating hours

RDL14/2010's other key cost-cutting measure was to implement a cap on operating hours for most existing solar PV plants—those installed under RD1578/2008 and RD661/2007. Any electricity generated within the cap would be remunerated at the relevant FIT rate; whereas electricity generated outside of the cap could only be sold at the pool electricity price.

Operating hours for plants installed under RD1578/2008 were capped until 2013 and differentiated according to the solar radiation zone where the plant was located. A greater number of hours was allocated to solar PV plants located in places with better solar resources such as zones IV and V, as illustrated in Figure 8. The number of running hours also differed according to the type of tracking mechanism used by the plant (i.e., fixed, single-axis or dual-axis tracking). Table 2 shows the running hours allocated to solar PV plants based on their location and tracking mechanisms.

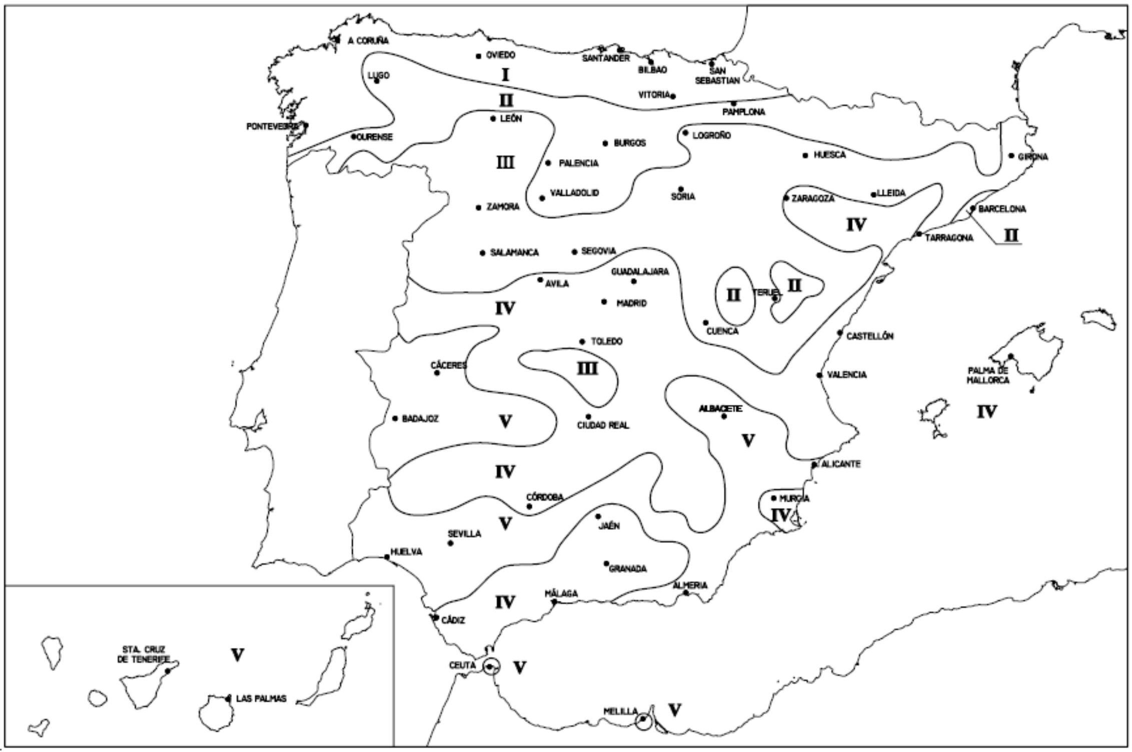

FIGURE 8. SOLAR RADIATION ZONES

Source: RD 314/2006 (Building Technical Code), published on March 28, 2006.

TABLE 2 EQUIVALENT HOURS FOR PLANTS SUBJECT TO RD 1578/2008

TYPE OF INSTALLATION	EQUIVALENT ANNUAL HOURS ELIGIBLE FOR FITS				
	Zone 1	Zone II	Zone III	Zone IV	Zone V
Fixed	1,232	1,362	1,492	1,632	1,753
1-axis tracking	1,602	1,770	1,940	2,122	2,279
2-axis tracking	1,664	1,838	2,015	2,204	2,367

The cap on operating hours for plants installed under RD661/2007 was not differentiated according to their location within solar radiation zones. This cap was more restrictive because the operating hours that were granted were lower than those provided to the plants installed under RD 1578/2008, with the exception of RD 1578/2008 plants operating in zone I (see Table 3).

TABLE 3 EQUIVALENT HOURS FOR PLANTS SUBJECT TO RD 661/2007

TYPE OF INSTALLATION	EQUIVALENT ANNUAL HOURS ELIGIBLE FOR FITS
Fixed	1,250
1-axis tracked	1,644
2-axes tracked	1,707

Both these caps—for PV installed under RD1578/2008 and for RD661/2007—were retroactive changes, with restrictions in this respect being contained in either of the original decrees setting out the conditions under which PV systems would receive support.

Repowering solar PV systems

RD 1565/2010 also addressed repowering. It stipulated that all repowering had to involve the use of new equipment and that repowered solar PV plants would receive the current tariff. This would prevent developers from repowering systems with outdated modules, or from building "new" plants with modules that had previously been installed elsewhere.

Implementing a moratorium on new projects

The need to cut the tariff deficit led to the introduction of RDL1/2012, on January 27, 2012. This Royal Decree Law effectively deferred for an indefinite period the registration of pre-allocation applicants for new projects and abolished all types of RES-E preferential tariffs and premiums for new projects. It also declared that calls for new solar PV installations for 2012 were suspended.

Special electricity tax and change to system for updating tariffs

Two other main regulatory changes were made to the treatment of RES-E. First, a special tax on all sources of electricity generation, including solar PV plants, was approved on December 2012. Second, a new criterion that tariffs would be annually updated was approved in 2013 by Royal Decree Law 2/2013. Instead of using the consumer price index (CPI), it declared that the core inflation rate—the CPI minus the prices of food and energy products—would be used to set tariffs. The CPI increases at a faster rate than the core inflation rate, hence using the core inflation rate would lead to a slower increase in tariffs. This change was designed to lead to a freeze of FIT levels in 2013 and the likely reduction of those FIT levels for later years (in real terms).

A campaign against fraud

From late 2008 until late 2011, Spanish newspapers and other media published articles citing allegations of fraud relating to solar PV support policies. It was alleged that administrative procedures authorizing support for solar PV systems had been bypassed, with some solar PV plants falsifying the dates they had begun feeding electricity into the grid, in order to qualify for higher subsidies under RD 661/2007.

The CNE launched an inspection campaign in late 2008 with the goal of ensuring all PV installations benefiting from the RD 661/2007 scheme had actually been feeding energy into the grid prior to 28th September 2008.

The government started to enact a new royal decree (RD 1003/2010, issued in August 2010) to verify that the authorization procedures for suspect plants had been correct. The royal decree offered an amnesty for plants in breach of procedures if they would "voluntarily" resign from the RD 661/2007 subsidy framework and switch to support measures provided by RD 1578/2008. However, this was a failure as practically no plant operators chose to accept the amnesty. However, solar PV associations estimated that the capacity considered to be "irregular" was about 600 MW (Cinco Días, 5-21-2010 and 5-31-2010).

In 2011, the CNE provisionally suspended FITs to some plants which were considered to be in contravention to the provisions of RD 1003/2010. However, by late 2011, only 89 MW of solar PV plants were considered to be operating under irregular administrative conditions (see Mir, 2012).

In addition to registration fraud, there have also been rumours, since the boom, of a secondary market for the purchase of solar PV installation rights. To prevent this practice, the RD 661/2007 established that promoters had to provide a mandatory guarantee of €500/kW. This encouraged genuine developers, who had to commit financial resources to the project, and discourage speculators from securing a project permit which they could quickly sell on for a profit.

3.4 STAKEHOLDERS' REACTIONS

This study identified three broad stakeholder groups affected by the solar PV boom and subsequent policy changes:

- **Government policy-makers.** They supported (and implemented) the changes because of the perceived need to cut the tariff deficit.
- **The solar PV sector.** Industry was generally critical of the changes because of their negative impact on the viability of the sector. The sector was particularly angered by retroactive changes to legislation. This changed the revenue streams upon which project development decisions had been made and permanently affected their confidence in the stability of Spain's regulatory environment. This latter issue caused two main problems: first, increased uncertainty for project developers; and second, greater uncertainty for lending institutions, which, in turn, equated to an increased cost of capital, and an associated rise in the cost of renewable energy.
- **The general public.** Surprisingly, there was no clear sense of exactly how the general public felt about the crisis. Concerns about regime costs were largely supplied by political leaders and policy-makers. It is not clear whether or not the public would have felt particularly affected by either the initial regime or the changes, because either way the Spanish government was regulating the electricity price, and none of the policies were therefore affecting consumers' immediate living costs.

In general, communication between the key stakeholders was poor. According to interviews with representatives of industry associations, the solar PV sector felt there had been a general lack of consultation over the development of policies, both in the run up to the boom and in the government's subsequent responses. There had been periodic meetings between the government and the solar PV sector, but Spanish solar PV associations felt they had not had a sufficient say in the design of regulations and Royal Decrees were not an outcome of a negotiation process between different stakeholders (Industry association, personal communication, February 2013; Industry association, personal communication, February 2013).

According to some interviewees, the lobbying capacity of the solar PV sector had been limited, and this may have contributed to their ability to engage with government. This was due to two factors. First, during the initial years (up until 2007) the PV sector was not well organized. And, from 2007, the industry was represented by more than one association, which weakened its ability to communicate with the government in a unified manner. In contrast, the conventional electricity sector (involving traditional utilities) was much better organized.[14] Since the boom occurred, it was reported that meetings between the Spanish government and the PV sector have become more infrequent and communications less regular (Industry association, personal communication, February 2013; Energy expert, personal communication, February 2013).

Stakeholder reactions to the key post-boom government initiatives aimed at tackling the situation are described as follows:

Introducing capacity quotas

The introduction of capacity quotas as part of RD 1578/2008 resulted in a reduction in the number of projects which were accepted to receive financial support. Applications for 502 MW worth of solar PV plants were received, while only 155 MW were actually installed in 2009. A major problem was the huge number of PV projects still applying for registration when the regulation changed.

In 2009, applications for ground installations were well above annual targets (4,400 MW vs. 500 MW) (Mir, 2012). Also, 2,488 PV plant applications made it through to the pre-allocation registry in 2009, with 7,100 submissions being declined due to the quota being fulfilled or because developers had filed incomplete or incorrect project documentation.

[14] Evidence highlighting the ability of traditional utilities to influence the Spanish government was seen in the greater remuneration levels given to large ground-mounted plants (given they were developed by utilities) compared to roof installations.

The solar PV industry associations complained about the annual overall capacity target quotas (Cinco Días journal, July 21st 2008). They recognized, however, that a new regulation, more restrictive and less generous than RD661/2007, would be passed and that FIT cuts were inevitable ("Shadow Falls," 2010).

Adjusting the length of the subsidy period and modifying the level of the tariff

Policy measures introduced under Royal Decree 1565/2010, which fixed the length of the period which solar PV plants could receive FITs to 25 years, and reduced the level of the tariff downwards for Type I and Type II technologies, greatly upset solar PV investors and generators.

Reducing the duration of subsidy payments for solar PV installed under the RD 661/2007 regime (from lifetime operation to 25 years) was considered by the PV sector to be a retroactive cut to the tariff. This was strongly resisted. Industry associations filed claims against the Spanish government in different courts, including the Spanish Supreme Court and the European Court of Justice. The Spanish Supreme Court rejected calls for the suspension of RD 1565/2010.

Right before the entry into force of Royal Decree 1565/2010, a large number of applications (~4,800) for the development of solar PV systems were received. This was about 33 per cent more than the average number of applications received in previous calls. Some of the applications had already been submitted in previous calls, and many applicants feared that if an application was rejected, it could not be automatically submitted again in the following call (Mir, 2012).

Implementing caps on FIT-eligible operating hours to reduce costs

This limit on the amount of generation hours eligible for support was strongly criticized by industrial associations as another retroactive cut to tariffs. Limiting FIT-eligible operating hours was also criticized for not incentivizing plant managers to run plants as efficiently as possible—in other words, to achieve the most electrical output possible. According to the views of two solar PV investors interviewed in the preparation of this study, it was also thought to contribute to a significant reduction in revenues for project developers (up to 30 per cent); but, at the same time, it was also thought that only a few developers went bankrupt as a result, possibly due to an increase in running hours after 2013 (Solar investor, personal communication, December 2012; Solar investor, personal communication, December 2012).

Spain adjusted the level of tariff available to solar PV developers depending on the regional location of the project. Previously, a flat and consistent tariff was available to developers delivering the same per unit of remuneration (as contained in RD661) for electricity, regardless of the project site. The introduction of tariff differentiation by zones involved higher tariff levels being made available for zones receiving significant levels of solar radiation. This reduced the incentive to deploy solar PV plants in areas with low radiation levels and increased the rents for solar PV plants in better locations. A positive aspect of such a policy is that it can drive efficiency by encouraging investment in the most resource-efficient areas; but this is only of benefit to investments still being considered, and not installed plants whose location is fixed.

The solar PV sector strongly criticized the Spanish government's solar radiation map that was used to help calculate the FIT-eligible operating hour caps (Energy expert, personal communication, December 2012). The map was based on municipal-level data, with at least one interviewed investor claiming that many commentators believed the data to be outdated as it was developed in 2000 and not updated since (Solar investor, personal communication, December 2012). Since the map differentiated only five radiation levels, the actual level of solar radiation in some locations was thought by some to be clearly above the official figures (Energy expert, personal communication, December 2012; Solar investor, personal communication, December 2012). As a result, electrical output eligible for tariffs was strongly curtailed. This meant a lower level of revenue.

RDL14/2010, which capped running hours, also had a special legal status, which meant only political parties with parliamentary representation could appeal it through the Constitutional Court. This also angered the solar PV sector as it limited their right to appeal. Industry associations and individual firms sent letters to senators and deputies contesting the law, and were able to stop the RDL in the Senate, but not in Congress, where it was validated on January 26, 2011 (Industry association, personal communication, February 2013).

Implementing a moratorium on new projects

Several interviewees justified the moratorium on new solar PV plants (RDL 1/2012) due to an excess of electricity generating capacity in Spain (Public official, personal communication, February 2013; Energy expert, personal communication, February 2013).

Due to the moratorium, the future of solar PV electricity generation in Spain appears bleak given the fact that new plants will not receive FIT support and, thus, it is unlikely that a substantial amount of solar PV will be deployed in the near future. However, others felt the moratorium was too long: it should have been of a brief duration while the government addressed the problems and designed and implemented a new support scheme (Energy expert, personal communication, February 2013).

3.5 THE BUST: IMPACT ON THE INDUSTRY AND ITS FUTURE

The implementation of measures to reduce costs and curb high installation levels has had a number of knock-on effects both on the industry and Spain more generally. The main ones were to reduce the number of jobs generated by the solar PV industry, as confidence in domestic panel manufacture plummeted and demand dropped. It also resulted in a loss of confidence in Spain as an investment environment with a stable and attractive regulatory framework for renewable energy.

Domestic job losses and a contraction of international markets

Cost-containment measures drastically reduced investments in solar PV manufacturing capacity and power generation, resulting in the number of jobs in the sector plummeting (Table 4). Reduced levels of solar PV installations led to closures and mergers of companies engaged in the manufacturing of PV modules. For example, BP's Spanish solar plants closed in 2010, the pioneering company Isofotón was purchased in mid-2010 by Korean investors, and the Siliken PV company closed in early 2013. For surviving companies, the only way to grow has been to expand into the international market.

TABLE 4 NUMBER OF JOBS IN THE SPANISH SOLAR PV SECTOR

	TYPE OF JOB		TOTAL
	PERMANENT	TEMPORARY	
2001	600		600
…	…	…	…
2006		6,300	6,300
…	…	…	…
2008	15,400	26,300	41,700
2009	11,300	2,600	13,900
2010	11,000	2,100	13,700
2011	10,600	1,600	12,100
2012	…	…	<10,000

Source: Mir (2012, p. 394)

One of the consequences of the Spanish solar PV bust was also a fall in total global demand for solar panels, which negatively affected manufacturers worldwide, resulting in job cuts, pushing down the prices for solar PV modules, and exacerbating an already-existing global oversupply of modules (Gonzalez & Johnson, 2009).

The solar PV sector's outlook

According to most interviewees contacted by the authors of this study, the future of the PV sector in Spain is bleak due to the absence of financial support for new installations (after the introduction of RDL1/2012) and the legal uncertainty created by the FIT reforms in 2010. The frequent, often retroactive, changes in regulations have reduced the attractiveness of further investments in the sector. Existing generators are also wondering whether further reductions in their remuneration may occur. However, according to some interviewees, in principle two areas of the sector could be economically sustainable going forward:

1. Large solar PV plants, financed by revenues obtained through selling electricity on the wholesale market, can be profitable even in the absence of FITS, given the lower costs that result from economies of scale.
2. When sources of distributed generation—such as solar PV panels at the building level—are used to generate electricity for local consumption and also used to sell electricity back to the grid. There was a first draft of a royal decree to regulate on-site generation in Spain (made public in November 2011). However, a second one, probably definitive, was issued in July 2013. The proposed regulation does not create the best economic conditions for deployment of PV demand-side generation (Mir-Artigues, 2013).

4.0 EXPERIENCES FROM OTHER COUNTRIES

Spain is far from the only country that has encountered problems with keeping the right balance between FIT rates, the cost of solar PV and the need to provide a stable policy environment for investors. Looking at the experiences of two other countries—Italy and Germany—is useful in showing how others have coped in similar situations.

The case studies below illustrate lessons similar to Spain's: that the responsiveness of policy design is a key factor behind the success or failure of a FIT in coping with a "boom" in installation rates.

4.1 SOLAR PV SUPPORT POLICIES IN ITALY

In Italy, the solar PV boom took place during the transition from one set of FIT rules to another.

The rules preceding the boom had been in place since 2007, set out in the Second Energy Bill. They were originally due to be replaced at the end of 2010 by new regulations set out in the Third Energy Bill. However, a law extended the lifespan of the Second Energy Bill regime, so that it would include all plants completely built before December 31, 2010 and operating before June 30, 2011. This decision led to a PV investment rush in order to benefit from the more generous Second Energy Bill remuneration levels (see Figure 9 with Italy's figures in red and Spain's in black).

ITALY'S SECOND AND THIRD ENERGY BILLS

Under the Second Energy Bill, the FIT distinguished between three types of solar PV systems:

- non-integrated or ground-mounted;
- partially integrated on façades and roofs;
- and fully building-integrated.

A cap of 1.2 GW had originally been set out as the maximum capacity eligible for FITs, but it was raised as installed capacity increased. Tariffs were reduced by only 2 per cent each year.

The Third Energy Bill simplified the three-tier system by only distinguishing between systems according to whether or not they were building-integrated PV installations. However, it also introduced variable rates according to a system's capacity rating:

- 1-3 kW
- 3-20 kW
- 20-200 kW
- 200 kW-1 MW
- 1-5 MW
- and >5 MW

And it set out a much more aggressive reduction of tariffs of around 14 per cent. In addition, it established a variety of bonuses for systems built on schools and public health buildings, for all public buildings in communities below 5,000 inhabitants, for integrated systems on farms and brown-field conditions.

Source: GSE (2013).

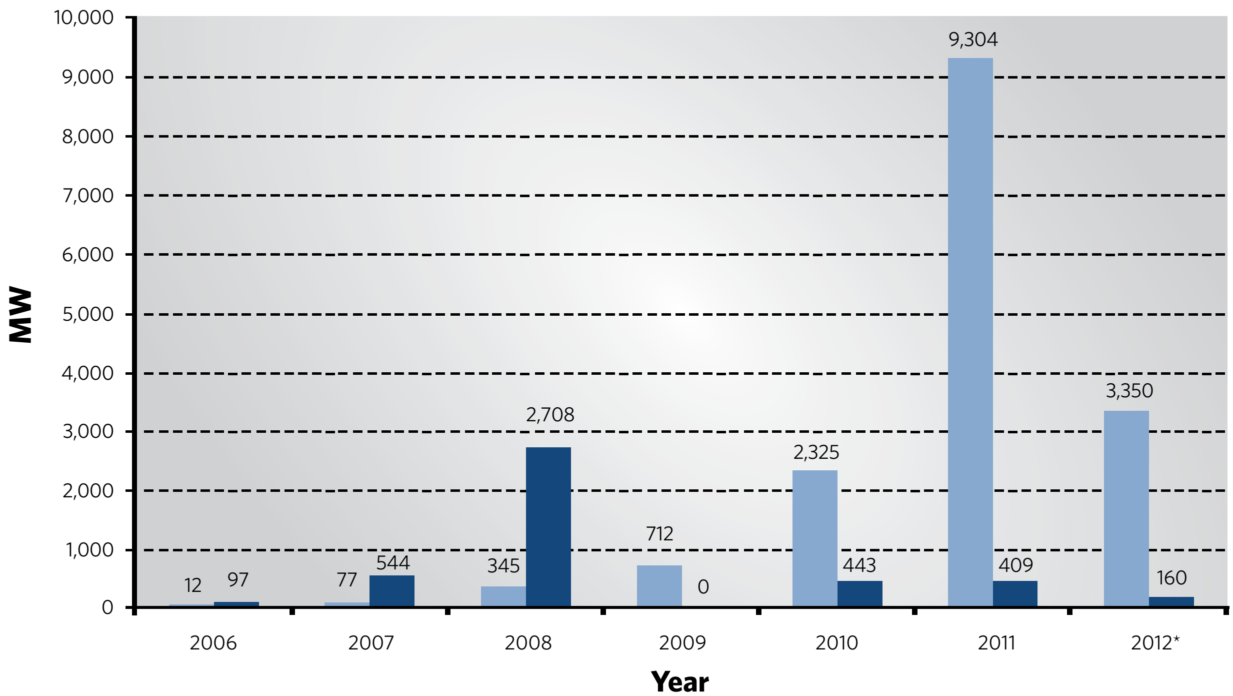

FIGURE 9. ANNUAL INSTALLED SOLAR PV CAPACITY IN ITALY AND IN SPAIN

*Note: * January-October 2012 Spain's data*

Source: Authors' elaboration from the latest available official data (CNE, October 2012).

In light of the sudden boom, a Fourth Energy Bill was quickly agreed and entered into force in May 2011, only five months after the official beginning of the Third Energy Bill. Of the 9.3 GW newly registered capacity in 2011, only 3.2 GW fell under the Second Energy Bill and around 6.1 GW was subject to the Fourth Energy Bill—none falling under the Third Energy Bill at all.

The Fourth Energy Bill maintained the Third Energy Bill's two-tier system and six size classes, several types of bonuses (one of them related to the domestic content of systems) and the tariff rates that were focused on concentrated PV and innovative building-integrated PV installations. But otherwise it made support much less generous: tariffs for 2011 would decrease monthly and involved a 31 per cent average annual reduction with respect to the Second Energy Bill. Tariffs for 2012 and thereafter were also reduced.

The Fourth Energy Bill also established targets on spending and installed capacity, especially for ground-mounted plants. For example, for the second half of 2011, the feed-in budget target was set at €300 million and the expected capacity was set at 1.2 GW, whereas for the whole year of 2012 these figures were €280 million and 1.49 GW, respectively (*Gestore Servizi Energetici* [GSE], 2013).

A project registration procedure, coupled with a system for ranking projects by priority, was created to ensure a fair distribution of payments under the Fourth Energy Bill's spending and capacity caps. However, this mechanism was announced at the beginning of 2012, and the excessive demand in 2011 had already exceeded both caps (PIN, 27/3/12). As a consequence, the budget for the second half of 2012 was reduced to zero. Registrations of large plants could be cancelled (Sarrocco, Steinhauer, & Vesco, 2012; GSE, 2013), although the definition of "large installations" excluded rooftop installations below 200 kW and ground-mounted installations below 1 MW using the net billing system. The installed capacity was still growing at a significant rate fueled by relatively high tariffs. Therefore, additional measures were required.

Towards the end of 2011, Italy's political situation was also changing. On November 16 Mario Monti was appointed Prime Minister with an objective of controlling the country's large public deficit—with implications for solar PV, since the cost of Italy's FIT is paid from the public budget. On January 20, 2012, a liberalization package was adopted that ended all incentives for new ground-mounted solar PV plants on agricultural land. This decision strengthened the previous restrictions on solar PV support.

Later, on July 5, 2012, a Fifth Energy Bill was issued (GSE, 2013). This decree established an expenditure ceiling for 2012 of €6.7 billion (covering all PV installations), although Italy did not manage to stay within this limit. By September 2012, this amount had already been spent (PIN, 18/9/2012). The Fifth Energy Bill also began setting up a feed-in tariff system for 2013, in lieu of the previous feed-in premium. The amount of capacity installed in 2012 was around one third of the capacity installed in the previous year.

Italy's experience with solar PV was similar to Spain's: a boom took place, followed by a bust due to the country's cost-containment measures. The Italian boom, however, took place slightly later and involved a greater level of installed PV capacity. As in the Spanish case, a key problem was that the transition period between regulations was too long to prevent a rush of applications for solar PV plants. While the Fourth and Fifth Energy Bills tried to bring some order to what was described as a chaotic market, the increases in solar PV capacity were still too significant from mid-2010 to mid-2011, during the last months of the Second Energy Bill and the short-lived Third Energy Bill.

4.2 SOLAR PV SUPPORT POLICIES IN GERMANY[15]

Like Spain and Italy, Germany also used an FIT to support solar PV. However, it did not experience the same boom and bust crisis, despite facing the same international market conditions for purchasing solar PV equipment.

From 1999 to 2012, the annual PV capacity installed in Germany and Spain was very different (see Figure 10). The most striking difference comes from the cost-containment measures implemented in Spain after the 2008 boom. The Spanish PV market was greater than the German market in terms of annual installed capacity in 2008, but practically vanishes thereafter. By contrast, the years from 2010 to 2012 saw the largest annual capacity additions to the German solar PV sector.

[15] Source: Authors' elaboration from Fulton et al. (2011) and Fulton, Capalino and Auer (2012).

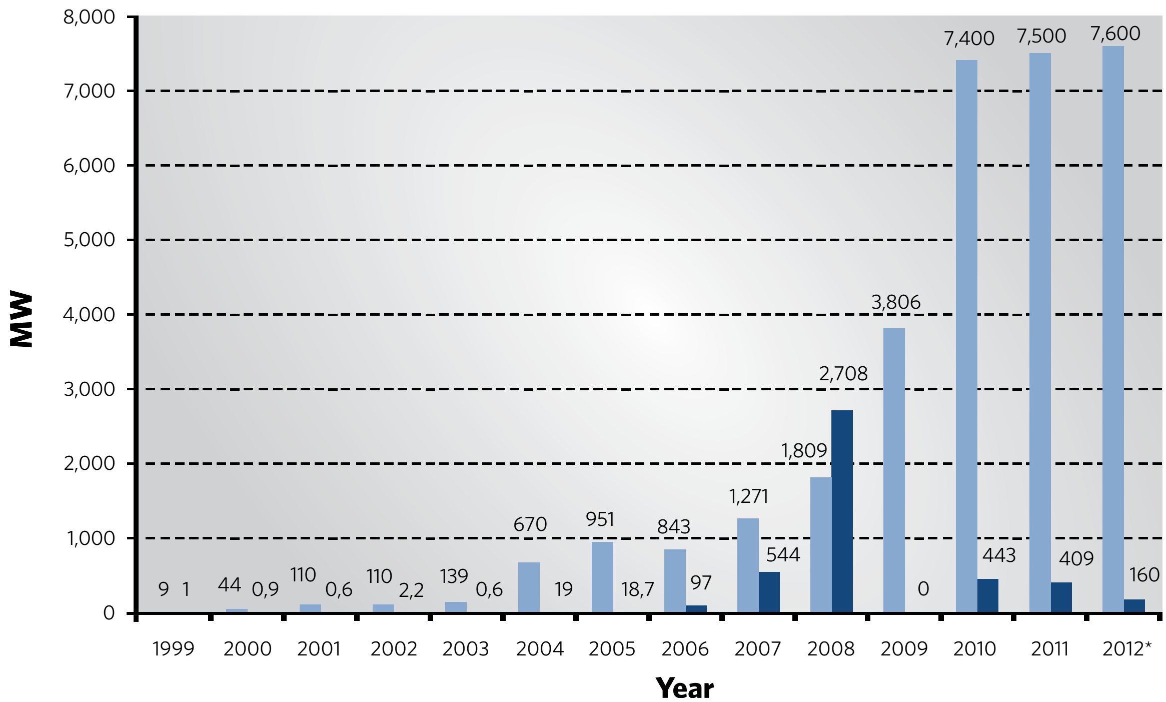

FIGURE 10. ANNUAL INSTALLED SOLAR PV CAPACITY IN GERMANY AND SPAIN

*Note: * January-October 2012 Spain's data*
Source: Authors' elaboration from the latest available official data (CNE, October 2012). See also Fulton et al. 2011 and Fulton, Capalino and Auer (2012).

Germany has had a FIT system since 2000, when the Erneuerbare-Energien-Gesetz(EEG) was first introduced. Although a number of amendments were made to the EEG up to and including 2008, its basic structure in this period remained relatively stable from 2003: a tariff rate paid for by increased consumer bills, with tariffs differentiated by technology size and by application (façade, ground-mounted, etc.). Since its inception, the EEG also contained a design feature known as "degression," whereby tariff rates were set to be reduced by a predetermined amount every year. A degression rate of 5 per cent was established for solar PV in 2003 and raised to 6.5 per cent for ground-mounted plants in 2008.

Following rapid increases in solar PV deployment in 2008, the first major modification was made to the EEG in 2009: the introduction of a "corridor" system.

The corridor system was designed as an attempt to respond to the rapid decreases in solar PV prices. It established a new, flexible degression system, whereby the degression rate for the following year would be set according to the volume installed in the previous year (or some months thereof). This meant that the larger the amount of capacity installed, the greater the degression rate would be.

The range of the corridor and the associated change in the degression rate was set by a political decision based on expectations about the PV experience cost curve and a forecast impact of solar PV subsidy policies on electricity bills. The corridor was established to allow a range of tariff reductions between 5.5 per cent and 7.5 per cent.

However, the price of solar PV modules fell by around 40 per cent in 2009 alone and the projected additional capacity of 1,500 MW was easily exceeded. As a result, some non-scheduled adjustments—in other words, ad hoc and larger changes to degression rates—were introduced.

In July 2010, the degression rate was immediately increased to 13 per cent for building-mounted systems and from 8 per cent to 12 per cent for freestanding installations. In October 2010, an additional 3 percentage points were added to all systems' degression rates. This interim revision included a 1 per cent additional increase to the 2011 rate for each GW installed in excess of the 3.5 GW baseline in 2010. In July 2011, another revision took place: for each GW over 3.5 GW to be installed in 2011, 3 additional percentage points would be added to the degression rate for the second half of the year. In other words, the interim revision accelerated the degression rate up to a maximum value of 15 per cent (Fulton et al., 2011).

On June 30, 2011 the German Parliament adopted EEG 2012, which came into force on January 1, 2012. The feed-in tariff was replaced with a market premium system, where RES-E generators sell their electricity directly into the wholesale market and, in addition to the pool market price, they will receive a premium. This premium is equal to the difference between the feed-in tariff available at any given month (which is decreasing over time according to a given corridor) and a reference price (calculated on a monthly basis) which has two components. The first one is the average of the spot market prices for the previous month. The second one, called the "management premium," is a proxy for the additional costs that RES-E generators incur for accessing the pool, including the stock exchange admission and the trading connection fees. The amount of the "management premium" for solar PV generation was set at €0.012 cents per kWh in 2012 and to decline thereafter (Fulton, Capalino & Auer, 2012).

The preferential prices in 2012 declined by 24 per cent due to the huge capacity installed in 2011. However, since the authorities wanted to maintain the target corridor at between 2,500 and 3,500 MW, the EEG 2012 was amended again in the middle of 2012. It was then decided solar PV remuneration rates would be adjusted on a monthly basis. Furthermore, monthly degression would be adjusted every three months according to the capacity installed during the previous 12-month period, with the switch from the old to the new corridor system lasting until August 2013. The 2012 amendment also introduced a 52 GW threshold for PV capacity in order to be eligible for support under the EEG. It is expected that, if the target corridor holds, this capacity could be achieved between 2019 and 2022 (Fulton, Capalino & Auer, 2012).

4.3 COMPARISON OF COUNTRY EXPERIENCES

Figure 11 compares Italy and Germany's average solar PV feed-in tariffs with those in Spain. It shows that Italy and Spain have generally had much higher FIT rates than Germany. This is striking, considering that Germany receives much lower levels of solar radiation than either Italy or Spain.

Of the three countries, Italy's tariffs have remained high the longest. Italian solar PV appeared to ignore the downward trend in PV module prices in 2009 and 2010, and, despite a small reduction in 2011, average tariffs remained 31 per cent higher than in Germany and Spain in that year. In addition, Italy shielded small- and medium-sized PV installations from caps on capacity and financial levels of support.

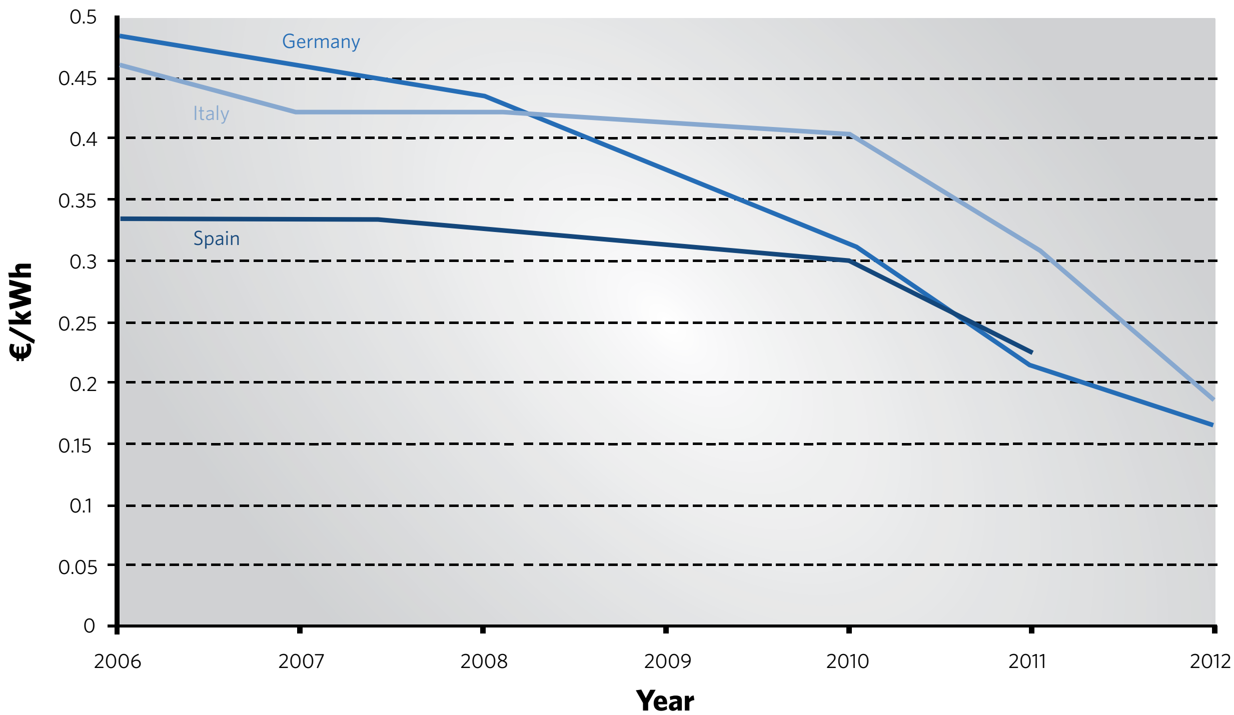

FIGURE 11. AVERAGE FIT RATES IN GERMANY, ITALY AND SPAIN

Source: Authors' elaboration from data available at www.gse.it.
Notes:
1) Average tariffs in Italy's case have been calculated combining upper and lower tariffs across solar PV technology sizes (BIPV, not integrated, etc.) at a given moment, generating the annual average of the resulting values. All types of bonuses and tariffs for innovative and CPV plants have been excluded.
2) In 2012 there was no RES-E support policy in Spain.

This strongly supports the case that both Italy and Spain set tariffs that were too generous, especially given their solar assets, relative to the changing costs of solar PV—both incentivizing a boom and over-remunerating capacity installed during the boom. Furthermore, sudden policy changes in Spain and Italy led to an installation rush to capitalize on the generosity of the new subsidy regime before shifts in policy could take place.

Figure 11 also shows that Germany's rates have had the steadiest rate of decline over the past six years. This strongly suggests that Germany's degression system made the German FIT perform more efficiently as the costs of solar PV changed. Neither Italy nor Spain set up an effective tariff degression rate system and the consequences of this on their tariff development are clear. The relatively slower—and more uncertain—process of agreeing new tariff rates via new energy laws only incentivized developers to install solar PV before new rates and laws take effect.

While its degression rate had several important virtues—being automatic and transparent, giving the market clear expectations—Germany's experience was, however, not entirely without challenges. The rate of reduction of module prices was much faster than the period within which the tariff rate was being changed—which unexpectedly happened in 2009–2011, and continued to happen even under the new corridor system, under which levels of installed PV in some years were more than double those being targeted. Germany did, however, respond quickly to policy problems, suggesting that quick and effective policy change when needed is perhaps just as important as built-in degression measures. This was seen with both the introduction of the corridor framework in 2009 and when solar PV prices plummeted so fast that the corridor adjustment period had to be shortened. Some rushes did indeed take place in between these policy changes, such as those occurring right before July 2010 (2.1 GW was rapidly installed) and December 2010 (1.2 GW was added before the new

FIT scheme was implemented in January 2011), but these were limited. Ultimately, German policy-makers had to introduce non-scheduled mid-year price decreases. This led to decreased transparency and decreased investor certainty, but could be regarded as the price to pay to avoid putting the overall RES-E policy at danger or making retroactive policy changes.

By contrast, in Spain, a constant level of support provided via the FIT was the status quo before the boom, ignoring the experience and cost curves known to be occurring for modular solar PV technologies. The transition periods between revisions of Spain's FITs were too long, and disregarded the modularity and ease of installation for PV technologies. After the boom in Spain, the government attempted to control growth in capacity through a flexible degression rate, coupled with a small capacity cap and other cost-containment measures, such as non-scheduled FIT reductions and non-eligible generation hours for FITs. It was, however, arguably too late, given that the ultimate step was to cancel the whole RES policy.

It should be noted, however, that policies in different countries are not always directly comparable. While Italy, Spain and Germany all experienced solar PV booms, the characteristics of each country make it hard to simply transplant lessons from one to another. For example, Spain is an energy island, with very limited interconnections, whereas Germany is not. Second, macroeconomic dynamics are different in Spain and Italy as compared to Germany. Spain's large accumulated tariff deficit and Italy's need to reduce budgetary expenditure put additional pressure on policy-makers to rapidly limit costs. In Germany, by contrast, where renewable energy costs are passed on to energy consumers directly through their energy bills, it was relatively easier to maintain subsidy support and expenditure.

In particular, comparing Germany with Spain, it is clear that policy choices were also greatly influenced by the fact that Germany was willing to pay for much larger amounts of solar PV capacity than Spain. In Spain's biggest "boom" year, 2008, additional PV capacity was equal to 2,708 MW, and thereafter sharply declined, with net installation from 2008–2012 being 3,720 MW. By contrast, Germany's policy allowed for 1,089 MW and 3,806 MW to be installed in 2008 and 2009 respectively, and an average of 7,500 MW in each of the three years thereafter, accumulating to a total of 27,395 MW from 2008-2012. In other words, solar PV installations in Germany have been over seven times the amount installed in Spain during the boom and bust period.

5 LESSONS LEARNED

The clearest lesson from the experiences of Spain—and other countries—is simply that cost control matters. Spain's feed-in tariff was very effective in its initial stages by kick-starting the solar PV market, but its ability to drive deployment came at a high overall cost when the policy failed to adjust support levels downwards in response to technology cost reductions. A renewable energy subsidy must be designed in a way that makes it robust to changing costs. This is not just a one-off risk related to the falling costs of technology. For other countries, it might equally relate to fluctuating exchange rates, falling costs of project finance or dumping due to global oversupply. Failing to take seriously the need for cost-effective subsidies may actually harm the renewable energy industry in the medium to long term.

A hard lesson also sits at the heart of this tale: mistakes happen, and, if a crisis emerges, there is no obvious best way to manage it, though a fast response makes a difference. Spain chose to cut its subsidies. Would it have been better, or less controversial, to allow the unintended costs to remain as a burden on public budgets, particularly during a time of broader economic crisis? Clearly, most countries that find themselves in this kind of situation will seek a middle path: to reduce costs, but also to minimize harm to investors as far as possible. It is difficult to derive any prescriptive guidance from Spain's experiences. Each government must strike its own balance between the competing interests of citizens and the renewable energy industry, taking into account the surrounding economic and political circumstances.

Three principles emerge from Spain's experiences: First, design policy in a way that **avoids** any kind of cost crisis. Second, ensure that appropriate tracking mechanisms are in place so that government can detect and **react** to problems promptly. Third, once a crisis has occurred, **limit damage**.

AVOIDING A COST-CRISIS

1. Incorporate cost-containment mechanisms into subsidy schemes.

A combination of quantity and price controls may be necessary for high-cost technologies, such as solar PV, which have large potential for technical improvements, cost reductions or significant changes to profitability deriving from other factors.

In Spain, the likelihood of significant cost reductions was not taken into account when setting FIT remuneration levels in 2007. The absence of a mechanism reducing remuneration downwards in line with cost reductions was a key problem in the Spanish case.

There are, however, advantages and disadvantages to cost-containment mechanisms. Some of the most important issues are summarized below.

Quantity controls: capacity and cost caps

i. **Total capacity limits per technology (or quotas)** were implemented in RD1578/2008 to limit growth and thereby costs. Caps may provide an incentive to increase the efficient use of technologies in order to improve the electrical output of an installation over a fixed period, including better placement of technologies in order to maximize output under a cap structure. However, they can also reduce investor certainty over whether it will be possible to have projects registered before the quota is full. If an auction system is used, an additional incentive is typically created for project developers to bid at their lowest installation cost, which in theory ought to improve policy cost-effectiveness. Disadvantages have been observed with many such auction systems in practice—for example, bidding below cost to secure development rights, and then being unable to carry forward projects—but much is down to tender design.

ii. **A cap on total costs,** whereby a total amount of support is available and granted on a first-come, first-served basis, or through auction, effectively transforms a FIT scheme into a tendering/bidding process.

iii. **Limiting the amount of solar PV generation eligible** for the FIT, as implemented in Spain for existing solar PV plants under RDL 14/2010, effectively puts a cap on the revenues received by single installations and, thus is also a form of cap on costs. However, this does not provide an incentive for the plant manager to maximise production, and thus does not incentivize efficient functioning of the plant.

Scheduled revisions vs. degression options

i. **Scheduled revisions of support levels** for new installations, such as those undertaken annually in Spain between 1998 and 2004, allow for support levels to be adjusted as costs come down. However, revisions are subject to strong lobbying from industry and increase regulatory risk for investors, as support levels can be significantly reduced, affecting the profitability of projects in the pipeline.

ii. **Traditional degression** is a fixed percentage reduction of government support for new plants over time. The main advantage of the traditional degression mechanism is that it provides a mechanism to adjust support levels downwards in line with costs, thereby not over-compensating investors and reducing the cost burden to electricity consumers, at the same time as incentivizing further cost reductions in response to lower subsidies. It also offers investors a highly predictable understanding of how support levels will change. In practice, however, governments have a poor record of being able to accurately predict cost reductions over time. In addition, fixed reductions in support levels are too rigid and do not adequately correct for sharp declines in costs or temporary volatility. This means that fixed degression rates are likely to result in a system where support reductions are too big, discouraging investments in new capacity, or too small, providing investors with unreasonably high returns.

iii. **Flexible degression** controls the overall costs of support by linking support levels automatically to predetermined levels of installed capacity. This helps mitigate the problem of asymmetric information, allowing the market to indicate the real costs of the technology, while continuing to incentivize technological innovation. However, this also creates uncertainty for potential investors regarding the level of support they will receive in the future.

iv. **Hybrid systems** appear to be able to combine the best features of several degression options. Germany has implemented a hybrid system called a growth corridor. In this regime, reductions in support levels over time have a fixed element, as in traditional degression, and an element linked to levels of installed capacity, as in flexible degression. For a technology where cost reductions can be very fast-paced, such as solar PV, it may also be necessary to supplement such a scheme with frequent scheduled reviews, to ensure that the system is operating as intended.

2. Independent regulators can help ensure that support levels are appropriate and that cost-control mechanisms have been incorporated.

Spain's regulatory body, the CNE (*Comisión Nacional de la Energía/*National Energy Commission), has only a consultative function in the design of energy regulations. Its reports and proposals are non-binding vis-à-vis the Spanish Ministry of Industry, which is the key government body responsible for setting energy policy objectives. As a consequence, a number of the experts interviewed in the course of this study argued that the procedures governing the development of regulations were not sufficiently transparent and open to public scrutiny. There is the risk that this kind of regime can open Ministry staff to pressure from lobbying groups or other forms of regulatory capture, which cannot be mitigated through public debate and accountability. At the same time, during the crisis, there were also perceptions that there was insufficient communication between the government and the solar PV industry, resulting in anger and resentment at the cost-control mechanisms that were incorporated.

As is commonly the case in other EU countries, information on energy regulations and the responsibility for monitoring their implementation should be the competency of an independent regulator. Such a body should have a mandate to assess independent data, publish technical information and potential tariff levels, thereby improving transparency relating to the policy development process and acting as a catalyst for effective information exchange between government actors, representatives of the PV sector and the general public.

In particular, such a process would have broadened public consultation, allowing other actors to have their say via public submissions. Governments with highly transparent policy-making frameworks generally publish public submissions and respond to questions or issues raised by stakeholders. The government then benefits from receiving information from a range of stakeholders and not just information obtained via bilateral conversations with solar PV generators. A system of public submissions also allows solar PV companies that are being regulated to provide input into the policy- making process via information in the submission. Several interviewees pointed to the U.K. government's comprehensive public submission and consultation process as a potential model.

3. Stress-test RES-E policies.

RES-E support policies are complex economic instruments that are designed to operate over long periods of time and in different economic circumstances. Policy-makers can usefully assess the design adequacy of policies by conducting "stress tests." Such theoretical exercises examine how the policy would perform in various extreme scenarios outside of business-as-usual expectations. This can help identify aspects of policy design that pose no risk in a business-as-usual scenario but could prove highly problematic in various possible futures. In Spain's case, the following factors contributed towards the boom, and could be usefully considered when testing policy design:

- Policy: over-generous tariffs, gaming the rules of the system (such as rules around aggregating many medium-sized applications, repowering and module capacities) and lead time for the introduction of scheduled policy changes.
- Technological: rapid changes in manufacturing costs or technology efficiency, modularity of the technology.
- Financial: increasingly cheap access to credit, fluctuating exchange rates and large shifts of capital into the energy sector.
- Administrative: rapidly decreasing window periods time for project investment and the speed of monitoring systems on actual policy impacts.

4. Create disincentives to speculation.

Particularly when subsidy regimes are offering generous compensation, speculators may bid for project development rights with the intention of selling them on to third parties. Requiring developers to deposit guarantees with the government when submitting a project for approval may mitigate—although possibly not remove—the risk of speculation. In the case of Spain's boom, such action might have helped reduce the size of the secondary market that sprang up involving speculators. Other regulatory processes may also be able to ensure genuine developers are submitting bids.

REACTING TO A COST CRISIS

1. Ensure coordination and information flows between different administrative levels.

In Spain, information should have been communicated more rapidly between the regions and the central administration. While the regions had the competency to give administrative permits to PV plants, and these plants were mostly registered in the regional registry, a national overview was required to ensure that the overall cost burden was reasonable. In practice, the lack of real-time monitoring of registration for support prevented the government from taking prompt action when the crisis began. Countries that have a similar quasi-federal administrative structure and organization could usefully create systems to ensure that real-time monitoring is possible at a national level.

LIMIT DAMAGE

1. Avoid excessively long transitions from one set of policy conditions to another.

One of the reasons leading to the Spanish boom was the 85 per cent threshold for the solar PV target which, once reached, would result in a new royal decree one year after. Investors rushed to have new solar PV installations approved before September 2008 in order to receive the FIT level provided under RD 661/2007, as future support levels provided under the new decree were expected to be lower and therefore less profitable. This rush was exacerbated by the modular nature of solar PV technology which allowed developers to secure registration under the earlier subsidy regime and install the technology before the one-year transition period ended. In general, excessively long transitions from one set of policy conditions should be avoided, particularly if a market is in the midst of a boom and it is fairly predictable that less-favourable support systems will be introduced.

2. Retroactive changes are highly damaging for present and future industry and may result in legal challenges.

Retroactive adjustments to support levels negatively affect the revenue of operating plants. This approach is drastic and contradicts investor expectations that a fixed rate of support is available to them for a pre-agreed length of time. Retroactive cuts to tariffs also increase the country's risk-premium for investments in solar PV, making future deployment more costly. Ideally, changes to the policy framework over time should be gradual and predictable, with governments avoiding situations where retroactive measures are necessary. Governments may still choose to weigh this cost as less harmful than no policy change, but they should anticipate the likely repercussions. If retroactive changes are considered to be necessary, damage should be limited by attempting to reduce FIT rates to a level that, as far as possible, allows existing projects to cover operational costs and pay back the costs of installation.

TECHNICAL ANNEX

A1. POLICY ANNEX

In Spain, public support for solar PV deployment dates back to the 1990s, when a feed-in tariff scheme providing guaranteed tariffs above electricity market prices, was adopted. This policy Annex provides an overview for the reasons motivating this support (Section i) and an overview of the different regulations themselves (Section ii).

(i) Rationale for solar PV deployment policy in Spain

The rationale to support RES-E in general and solar PV deployment in particular in Spain is mostly related to environmental protection, industry and employment creation and diversification of the energy mix (lower dependence on fossil fuel imports). This was the case with the regulations introduced in the 1990s. In addition, complying with the targets set in international regulations, including the Kyoto Protocol, the renewable electricity Directive (Directive 77/2001/EC) and the renewable energy Directive (Directive 28/2009/EC) provided the main justifications.

Initially, the emphasis was put on deployment, i.e., on how to kick-start the market. This also led to an emphasis on ensuring security for investors (i.e., the 2004 and 2007 FIT reforms). Other issues were addressed later, such as technical aspects relating to integrating RES-E into the grid and, most importantly, responding to the significant and increasing costs of support. The latter issue led to the implementation of regulations and design elements within the FIT scheme to contain the costs of the policy. As shown in the next table, the justification for RES-E support has shifted over the years, although there are some common factors, the relevance of these factors may have changed over the years or, at least, the emphasis has shifted.

TABLE A1 MAIN OBJECTIVES FOR INTRODUCING KEY REGULATIONS FOR THE SOLAR PV SECTOR

REGULATION	JUSTIFICATION / OBJECTIVES
RD 2366/1994	• Reduce conventional primary energy consumption, environmental protection. • Maintain the appropriate profitability of projects and ensure costs for the electricity system don't lead to excessive electricity prices.
Law 54/1997	• Guarantee the quality of electricity supply at the lowest possible cost. Environmental protection. • Target: a 12% share of RES in energy by 2010
RD 2818 /1998	• Improve energy efficiency, reduce energy consumption, environmental protection (GHG emissions). Internalize environmental benefits. • A 12% share of RES in energy demand by 2010.
PFER 1999	• A 12% share of RES in energy demand by 2010 • RES contributes to the main goals of national energy policy: diversification of primary energy sources to guarantee the security of supply (reduction in foreign energy dependency), environmental protection (meet commitments under the Kyoto Protocol and reduce local pollutants), support the development of RES industrial sectors.
RD 436/2004	• Environmental protection, guarantee a high-quality electricity supply to all consumers. • A 12% share of RES in energy demand by 2010. 1/3 of electricity demand met by RES with high efficiency technologies, without leading to an increase in electricity production costs.
PER 2005–2010	• Reduce dependence on foreign energy, improve security and quality of electricity supply. • Environmental protection (benefits in terms of GHG-emissions reductions to comply with the Kyoto Protocol and the National Allocation Plan under the Emissions Trading Directive (Directive 87/2003/EC)). • Non-fulfillment of RES targets contained in the Renewable Energy Plan (1999–2010) (i.e., lower deployment than expected) justified additional policy efforts. As electricity demand increased above expectations the deployment of RES-E needed to be increased in order to comply with the 12% target for 2010. • To comply with the Renewable Electricity Directive targets for 2010 (Directive 77/2001/EC).

RD 661/2007	• Reduce dependence on foreign energy, and improve the exploitation of available energy resources. • GHG-emissions reductions according to Kyoto Protocol commitments. • Address technical issues to promote the growth of renewable technologies, safeguarding the security of the electricity system, guaranteeing the quality of supply and minimizing the restrictions on RES-E production. • Promote market prices by delinking remuneration for developers from the Average Electricity Tariff (AET). • Comply with the Renewable Electricity Directive's indicative target (Directive 77/2001/EC), i.e., that RES contribute 29.4% to gross electricity consumption in 2010.
RD 1578/2008	• Concerns about greater-than-expected growth in solar PV installed capacity. • Provide continuation for industrial investments in solar PV technology and a progressive pathway for the deployment of solar PV was deemed necessary. • Compliance with targets contained in the 2005–2010 and 2011–2020 Renewable Energy Plans. • Promote timely adjustment of support levels in order to reduce high costs of technology deployment. • Set support levels for solar PV at reasonable levels and avoid excessive remuneration leading to costs passed on to electricity consumers. Reduce support levels based on the evolution of technology costs. • Guarantee a minimum market for the development of the solar PV sector while simultaneously ensuring the continuity of the support scheme.
RD 1565/2010	• Set up technical requirements for the plants.
RDL 14/2010	• Correct the tariff deficit while ensuring a high-quality electricity supply. Guarantee the right of consumers to electricity supply under fair conditions. Ensure compliance with RES and energy efficiency targets. • Not to negatively influence the financial balance of firms in the sector. • Ensure that renewable energy firms receive a sufficient and reasonable remuneration.
RDL 1/2012	• Reduce the tariff deficit

Source: Authors' elaboration.

(ii) An overview of solar PV deployment policy in Spain

Support for solar PV deployment in Spain started in the 1990s. The following figure illustrates the timing of those regulations which are closer to the period this paper focuses on, i.e., the solar boom and bust (2007-2010).

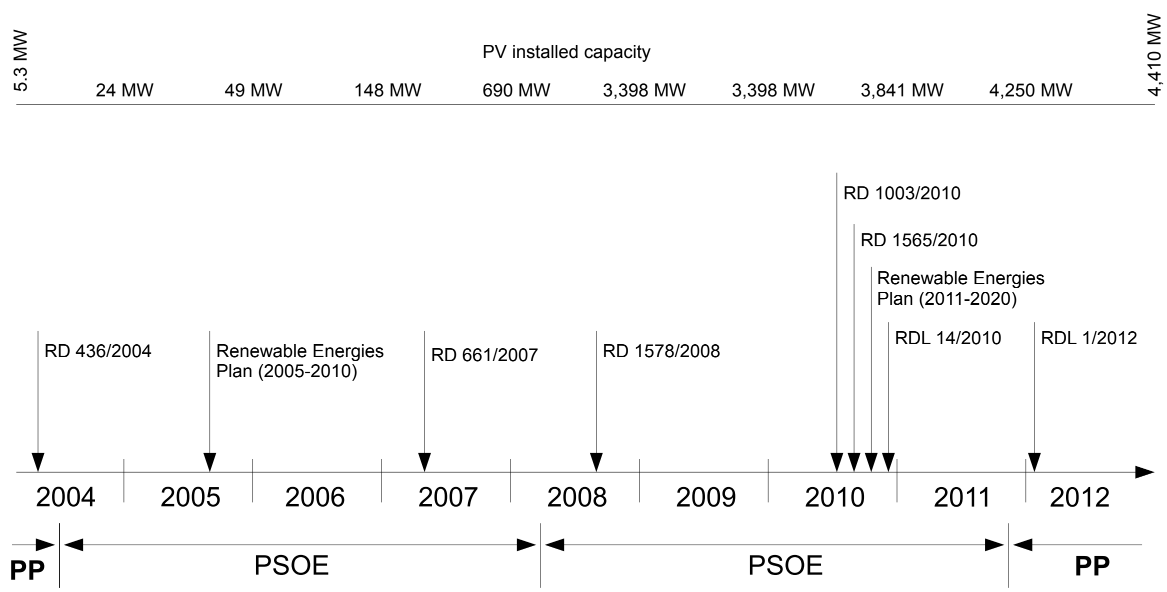

FIGURE A1. TIMING OF REGULATIONS

Note: PP stands for the Partido Popular (Popular Party) which is a conservative party, and PSOE stands for the Partido Socialista (Socialist Party) which is the social-democrat party. The acronyms above refer to the period in which these parties were governing. Bold type means absolute majority in Parliament.
Source: Authors' elaboration.

- **Royal Decree on electricity produced by hydro sources, cogeneration and RES (R.D. 2366/1994)** established the basic contractual relationship between RES-E producers and distribution companies. Plants with an installed capacity lower than 100 MW could sell their surplus electricity to distributors, who were obliged to buy it, at a price dependent upon electricity prices and other factors.
- **Law of the Electricity Sector (Law 54/97).** Concerning RES-E, its relevance is threefold (APPA 2003):
    - With the aim to achieve the EU target of 12 per cent of gross energy consumption coming from RES in 2010, it establishes a "Special Regime" (different from the conventional, "Ordinary Regime"), in which RES-E is given a special treatment. It provides the basic framework for RES-E support, developed by Royal Decree 2818/1998.
    - Guaranteed grid access for RES-E producers.
    - Price support for RES-E producers. RES-E plants lower than 10 MW will receive a premium set by the government (art. 30.4). The price of electricity paid to these plants would be within a range of 80 per cent to 90 per cent of the average electricity price.[16]
- ***Royal Decree on Special Regime (RD 2818/1998)*** developed the administrative procedures and conditions of the plants to access the Special Regime. RES-E generators could choose between two alternatives:

    i. *A fixed premium on top of the electricity market price.*

    ii. *A fixed total price (fixed feed-in)*, also adjusted annually, which allowed generators to know their revenue in advance regardless of changes in the market price.

    Prior to 2002, these tariffs were factored into high bills paid by consumers.[17] Generators supplied the electricity to the distributor, who paid the premiums but passed these costs onto the Comisión Nacional de la Energía (CNE) and, finally, to the end consumer. Table 6 provides the main design elements of this regulation.

- **The 1999 Plan for the Promotion of Renewable Energy (PFER)** included a detailed set of measures to reach the RES-E Directive target for Spain in 2010 (29.4 per cent of electricity from renewables), with national targets per technology. The Electricity and Gas Infrastructures Plan 2002-2011, adopted in 2002, set even more ambitious targets for wind and biomass electricity. The Renewable Energy Plan was updated in 2005 (PER 2005-2010), with new targets for RES-E (30.3 per cent in 2010), thermal applications and biofuels.
- **Royal Decree 436/2004** represented relevant changes with respect to RD2818. As in RD2818/1998, RES-E generators were allowed to sell their electricity to distributors or directly to the market. In both cases, however, and unlike RD2818, support was tied to the Average Electricity Tariff (AET). Although the AET was still being set annually through a government decision, the calculation of the support was less discretionary than before. The RD436 encourages the participation of RES-E in the wholesale electricity market and addresses the concerns about the impact of an increasing share of intermittent RES-E generation on the stability of the grid (i.e., deviations in projected electrical supply, regulation of voltage drops, grid stability etc.).

    First, support was tied to the average electricity price (AET), decreasing over the lifetime of the installation but guaranteed for the project's lifetime.[18] Second, tariff revisions would take place every four years and without retroactivity (i.e., they would not affect previous investments). Third, support was guaranteed for the whole lifetime of the plant. Fourth, the capacity threshold below which solar PV installations would receive the maximum support level was increased from 5 kW to 100 kW.

[16] This Law states that support levels will be determined according to the effective contribution of RES-E to environmental protection, primary energy savings, energy efficiency and investment costs so that "reasonable" profitability rates with respect to interest rates are attained.
[17] The costs of FIT support were shared equally across electricity consumers.
[18] The RD436 provides more security about the support level than its predecessor because such level is the result of multiplying the AET by the corresponding percentage (90 per cent for wind, 300 per cent for solar thermal etc.). Although the AET changes, it does so to a very limited extent and, thus, the annual change in the support level is also modest.

Other elements of the reform include:

- *Participation in the electricity market:* A key element to encourage the financial participation in the electricity market was introduced in RD436: Those RES-E producers opting to sell their electricity in the market would receive a "market incentive" (in addition to the market price plus the premium). This corresponded to 10 per cent of the AET.
- *Access to the grid:* RD436 did not provide priority access for RES-E to the grid nor did it create a mechanism to share the costs of grid reinforcements amongst distributors and RES-E generators. These issues were later regulated under RD661.
- *Modulation of support depending on the size and age of the installation.* Support differed not only by technology (as in RD2818), but also by technology band and/or size of installations, with lower support levels provided for larger installations. In addition, a decreasing support escalator whereby after some years plants received a lower percentage of the AET. In the regulated tariff option, solar PV<100kW received 575 per cent of the AET for 25 years and 460 per cent thereafter and solar PV >100kW received 300 per cent for 25 years and 240 per cent thereafter.

  In contrast, support was not adjusted according to the RES-E potentials of different locations, which is a positive element of a stepped FIT. In a stepped FIT, different support levels are provided to different technologies and locations. In the latter case, a lower support level is provided to plants in places with better renewable energy (solar radiation) resources and a higher support level is granted to plants in places with worse resources.

  RD436 did not introduce elements of a degressive FIT, as in Germany, where reductions in support levels for new plants are linked to cost reductions generated by economies of scale and learning effects.
- *Deviations:* A payment was required for deviations (20 per cent for solar and wind and 5 per cent for the rest) in option "A" (i.e., sales to distributors). RES-E generators were required to inform the grid manager 30 hours in advance about their expected production facilitating the integration of RES-E generation into the grid. The costs of deviations were calculated as 10 per cent of AET multiplied by the sum of deviations over specific tolerance thresholds. Plants selling to the market were subject to the costs of deviations for plants in the Ordinary system.
- *Regulation of voltage drops:* A special payment (5 per cent of AET for four years) was set for RES-E generators which had to bear drops in voltage.
- *Targets:* The RD436 set targets for RES-E. These were absent in RD2818, although a generic target of 12 per cent share of RES in energy consumption by 2010 had been adopted. In addition to the 12 per cent target, the RD436 adopted the targets of the PER 1999 and the revisions of those targets made in 2002 (by the Electricity and Gas Infrastructures Plan) for some renewable electricity sources, including solar PV (target of 150MW). Once these targets were reached, support levels would be revised. The target for solar PV, however, was later increased to 400 MW by the updating of the Renewable Energy Plan in 2005.

- **Royal Decree 661/2007** which entered into force in June 2007, decoupled RES-E support from the AET. Updating of support was tied to the evolution of the Consumer Price Index (CPI). A cap-and-floor system for RES-E support levels was implemented.

  RD661 states RES-E priority access to the grid, requiring plants (>10 MW) to be attached to a generation-control centre. Furthermore, technologies with fluctuating production (wind and solar PV) will not receive the payment for capacity guarantee. New wind farms are required to be connected to the grid after voltage drops (tension changes). Finally, the regulation for deviations in anticipated electricity generation to the grid becomes more restrictive for wind and solar, with tolerance thresholds being restricted to 5 per cent for all RES-E (it was 20 per cent for wind and solar before RD661). However, generators are allowed to correct their predictions one hour before the opening of the market.

The major change of RD661 with respect to pre-existing regulations in Spain and to FITs in other countries was the **cap-and-floor price,** which only applied to option b) (i.e., installations participating in the market). If the market price plus the premium were above the cap, then RES-E generators would only receive the cap level. If they were below the floor, they would receive the floor price. This cap-and-floor system does not apply to solar PV; however, since solar PV installations were only subject to the sales to the distributor option (i.e., regulated tariff, not a market price plus a premium).

Other significant changes related to RD661 with respect to the previous regulation were:

i. Updating of support levels was tied to the evolution of CPI (minus 0.25 per cent until 2012 and minus 0.5 per cent afterwards).

ii. Revisions of support levels would take place every four years starting in 2010.

iii. Mandatory guarantees. The developers of solar PV plants should deposit a 500€/kW guarantee when asking for grid access.

iv. Renewable Energy Plan for 2011–2020. Its elaboration would start in 2008 and its targets would be taken into account in the revision of support levels in 2010.[19] This would provide a signal for investors that support would continue after 2010.[20]

v. Transition period. RES-E plants selling to the distributor could opt to be subject to the support levels of RD436 for the remaining life of the installation. Existing solar technologies are subject to RD661 (i.e., no transition period for them).

- **RD 1578/2008.** The current, relevant, regulation was enacted in 2008 under this Royal Decree. RD 661/2007 led to a boom in solar PV deployment. Capacity increased ten-fold within barely a year, with a parallel increase in the costs of support (see data below). Given such concern about policy costs, capacity growth and cost containment became priorities in the new regulation, i.e., RD 1578/2008, which regulates the economic regime of solar PV plants installed after 9/28/2008. Two main features of this royal decree should be highlighted:

i. A capacity quota (*cupo*) system for each type and subtype of installation was adopted. This gave rise to the creation of the Registry for the pre-allocation of support, in which all the PV installations should be registered in sequential order to meet the allowed additional capacity.

ii. The RD classified installations into type I (roofs/facades) and the rest. In turn, type I installations are further classified according to their size into subtype I.1 (< 20 kW) and subtype I.2 (>20 kW but less than 2 MW). For the first call, the regulated tariffs were 34 cent€ /kWh for subtype I.1 installations and 32 €cents/kWh for subtype I.2 and type II installations.

First year (2009) calls had the following associated capacity targets: 267 MW/year for roofs (10 per cent for type I.1 and 90 per cent for type I.2) and 133 MW/year for floors (divided into four quarters). Additional capacity targets for floor installations were included: 100 MW in 2009 and 60MW in 2010. Thus, the targets for 2009 and 2010 were 500 MW each year.

[19] In turn, the setting of targets for each renewable energy technology will take into account the evolution of national energy demand and the development of the electricity grid to allow the maximum integration of RES-E in the system while meeting conditions relating to the security of supply.
[20] Notwithstanding, this signal is probably less relevant than the 20 per cent RES-E EU target for 2020.

- Capacity was allocated on a first-come, first-served basis. There were four calls (and quotas) during the year:

  i. If less than 75 per cent of the quota ($\bar{q}$) is met, then the pre-established FIT level is maintained for the next call. That is, if $q_{k-1} \leq 0{,}75 \cdot \bar{q}_{k-1}$
  tariffs do not change, i.e., $p_k = p_{k-1}$
  where *k* stands for "quarter."

  ii. If more than 75 per cent of the quota is met, then the FIT level is proportionally reduced (0 per cent reduction with 75 per cent and 2.6 per cent reduction with 100 per cent). That is, if

  $$q_{k-1} > 0{,}75 \cdot \bar{q}_{k-1}$$

  then,

  $$p_k = p_{k-1} \cdot \left[\frac{\left(1 - 0{,}9^{1/4}\right) \cdot \left(\bar{q}_{k-1} - q_{k-1}\right)}{0{,}25 \cdot \bar{q}_{k-1}} + \left(0{,}9\right)^{1/4} \right]$$

As it is observed, the tariff diminishes at a 10 per cent inter-annual rate. Moreover, capacity for the annual call (V_n) and the change in the tariff in the previous year (p_{n-1}) move in opposite directions, that is,

$$\Delta V_n = V_{n-1} \cdot \Delta p_{n-1}$$

In other words, under this cupo (dynamic quota) system, capacity growth and support levels were set in a circular way over time. Targets for the second and following years would increase or decrease (with respect to the targets for the first year) according to the reduction or increase in the tariff levels in the previous year, which in turn depend on the evolution of capacity in the previous year with respect to quarterly targets.

Within RD 1578/2008 a rule for transferring quota between the calls was foreseen. In addition, this royal decree had other design features: there was a requirement for a guarantee obligation (€500/kW) for those registering in the *cupo* system in order to avoid speculation in trading deployment rights. The duration of support was set at 25 years and support was adjusted for inflation over time (minus some basis points as an incentive for efficiency improvement).

In spite of the reductions of support levels over time, the total costs of PV promotion increased (see main text and Technical Annex). Successive governments struggled to contain the increasing total costs of support and, hence, energy bills. This led to several new regulations, which partially amended either RD661/2007 (for PV plants installed before September 2008) and/or RD1578/2008 (for plants installed after that date).[21]

- RD 1565/2010 introduced the following changes:

  i. Most importantly, the duration of support for plants under RD 661/2007 was capped at 25 years (instead of the lifetime of the project), although it was later increased to 28 years in RDL 14/2010 (see below). Since under RD 661/2007 support was granted for the whole lifetime of the plant, this point was considered retroactive by the sector. It should be pointed out that plants under RD 1578/2008 have their support capped at 25 years from the beginning. Afterwards, plants could receive the wholesale price for the electricity fed into the grid.

  ii. The tariffs of RD1578/2008 were reduced. A correction factor of 0.95, 0.75 and 0.55 was applied to type I.1 (small roof), type I.2 (large roof) and type II (ground-mounted) installations, respectively. Reductions of support levels entered into force in the second quarter of 2011. Tariffs were reduced to €28.88 /kWh (type I.1 plants), €20.37/

[21] Note that, although any new PV plant is subject to RD1578/2008, about 80 per cent of all PV plants currently installed in Spain fall under RD661/2007.

kWh (type I.2) and €13.46 /kWh (type II). It can be argued that, although more flexible than its predecessor, RD1578 was still rigid in the sense that it included a fixed reduction in the tariff. The reduction of the tariff margins of solar PV investors and generators together with the reduction in international prices due to the end of the poly-silicon (p-Si) crisis led to costs being reduced by more than 10 per cent. The tariff had been reduced by 19 per cent, 39 per cent and 60 per cent for type I.1, I.2 and II installations, respectively, over three years (from the end of 2008 to the end of 2011).

iii. The pre-registration of small roof installations no longer requires that these plants have a building permit.

iv. In addition, it was stated that the equipments should be new in order for a plant to be included in the Special Regime. Likewise repowering, which for the first time was addressed, required the use of new equipment.

v. Solar PV plants should comply with the requirements to bear tension hollows. Otherwise, they would not receive the tariff.

vi. All plants with a rated nominal capacity higher than 10 MW should register with a control center. Otherwise, they could not receive the tariff.

- *Royal Decree Law (RDL) 14/2010*. The purpose of this regulation was to reduce the expenditures of the electricity system by €4,600 million in three years. Half of this amount would come from a reduction of solar PV revenues. Four main aspects of this RDL are worth mentioning:

  i. RES-E generators would have to pay a €0.5/MWH fee for the use of the grid. According to the sector, this reduced the revenues of ground-mounted PV plants by 0.2 per cent and those of roof installations by 0.3 per cent.

  ii. The number of hours of operation of a solar PV plant that could receive the tariff was capped. This applied to plants subject to RD1578/2008. A plant could generate electricity for an amount of hours exceeding the cap. But those hours above the cap would only be remunerated at the electricity market pool price. The number of equivalent annual hours of operation of a given plant that were eligible for the tariff differed according to the solar radiation zone where the plant was located (greater number of hours for plants located in places with better solar resources, such as zones IV and V) and the types of tracking mechanism of the plant (fixed, 1-axis or 2-axis tracking).

  iii. The duration of support for plants under RD661/2007 was extended from 25 years (as established in RD1565/2010) to 28 years. Compared to the flat tariff for all zones, set in RD661, the tariff differentiation by zones reduced the incentive to deploy solar PV plants in zones with lower radiation levels and increased the rents for plants in better locations.

- **Renewable Energy Promotion Plan (REP) 2011-2020.** This Plan was approved by the Government on November 11, 2011. It sets targets according to Directive 2009/28/CE.
- **RDL 1/2012.** Finally, on January 27, 2012 the new government approved this Royal Decree. Addressing the need to curb the accumulation of the tariff deficit, this norm put off for an indefinite period the Registry for the pre-allocation of new projects and abolishes all types of RES-E preferential tariffs and premiums. This norm also stipulates that PV calls for 2012 are suspended.
- **RDL 2/2013.** This Royal Decree set a new criterion for the annual updating of the tariffs. Instead of using the consumer price index (CPI), the core inflation rate—i.e., the CPI minus the prices of food and energy products—is used to set the tariffs.

The following tables compare the design elements of different regulations.

TABLE A2 COMPARING THE DESIGN FEATURES OF FITS FOR RENEWABLE ENERGY SOURCES (INCLUDING SOLAR) IN SPAIN UNTIL 2008

DESIGN ELEMENT	RD 2818/1998	RD 436/2004	RD 661/2007
Setting the support level	Two alternatives for RES-E generators, both updated annually by the government: a) Fixed Premium (on top of the electricity price). b) Fixed total price (fixed feed-in).	Two alternatives: a) Sale to the distributor. A regulated tariff is received, set as a % of the annual average electricity tariff (AET). b) Sell to the daily electricity market. The market price plus an incentive to participate in the market plus a premium are received (the latter two as a % of AET). Support levels (%) fall some years after the plant starts operation.	Two alternatives: a) Sale to the distributor. A fixed tariff is received. b) Sale to the electricity market. The generator receives the market price plus a premium. Cap-and-floor price system for (b) (see text). Solar technologies can only apply for (a). Levels are differentiated according to the time of the day for a) and only for biomass and hydro support (peak vs. off-peak hours).
Guaranteed duration of support	A generic "No time limit" was included in the introduction, but not formally in the text.	Support is guaranteed for the whole lifetime of the plant, declining after some years: solar (25 years), wind (5-15 years), geothermal (20 years), small hydro (25 years).	Support is guaranteed for the whole lifetime of the plant, declining after some years: solar (25 years), wind (20 years), small hydro (25 years).
Decision on support levels	Annual decision.	% of AET. AET is set annually, according to the calculation method defined in RD 1432/2002.	Regulated tariff or premium set in RD661 in 2007.
Annual updating of support levels	Annual updating by the government at the end of the previous year.	Annual updating is tied to AET.	Annual updating is tied to the CPI minus 0.25% until December 31, 2012 and minus 0.5% afterwards.
Revisions of support levels	Every four years according to the evolution of the market price of electricity, the share of RES-E in electricity demand and its impact on the technical and economic management of the system.	Every four years since 2006 and only for new plants according to the same criteria as in RD2818 costs and/or when technology-specific targets are reached.	Every four years since 2010 and only for new plants (according to the targets set for 2010) and the same criteria as in previous regulations.* Reasonable profitability levels are ensured. Once 85% of the target is reached for a technology, the maximum period over which plants may receive the support will be set.
Complement for reactive power (voltage control)	Applied to the aggregation of market price and premium	5% of AET for four years.	€ cent 7.8441/kWh applied to a percentage representing the capacity factor of the electricity fed into the grid.
Payment for capacity guarantee	Unregulated. Only available for plants bidding in the electricity market.	Only available for plants selling directly to the market.	Only available for plants selling directly to the market and not available for "non-manageable" RES-E (wind, PV and wave).
Payment procedure	The distributor pays the support to the generator, passes them to the CNE and, finally, to the end consumer in electricity bills.	Unchanged	Unchanged
Treatment of existing installations (transitions)	Transition period for plants subject to the previous system (i.e., RD2366/1994).	Transition period for plants under RD2818. The economic regime of RD 436 will not apply to them until December 31, 2010 (except costs of deviations).	Transition period for plants under RD436 (except for solar technologies). Plants commissioned before January 1, 2008 may choose: a) to be subject to the regulated tariff of RD436; b) to opt for the regulated tariff under RD661; c) to sell their electricity in the market. In this case, the support levels of RD436 will be applicable until December 31, 2012.

DESIGN ELEMENT	RD 2818/1998	RD 436/2004	RD 661/2007
Targets	Generic: 12% of primary energy consumption from RES in 2010.	12% of primary energy consumption and 29.4% of electricity consumption from RES in 2010. Target of the 2000–2010 Renewable Energy Plan: 150 MW for solar PV in 2010. Update of targets in 2005–2010 Renewable Energy Plan: 363 MW for solar PV in 2010.	30.3% of gross electricity consumption from RES in 2010. Targets of the PER 2005–2010.
Access to the grid, and share of the costs of grid connection and reinforcements	a) RES-E generators will notify the distributor their preferred connection point and connection conditions. The distributor will accept this proposal or provide alternatives. The public administration mediates if the generator rejects these alternatives. b) Grid-connection costs will fall on RES-E generators. c) If the distributor grid has characteristics impeding RES-E absorption, then the public administration will set a deadline to correct them. The costs will fall on RES-E generators.	Same as RD 2818/1998	Priority access and connection to the grid of RES-E explicitly stated. A procedure to share the costs of grid reinforcements is established.
Costs of deviations	Unregulated	10% (AET * Σ deviations over tolerance limits). Tolerance limits: 20% for solar and wind, 5% for the rest.	No costs incurred if deviations are below 5%. Costs of deviations are those of the conventional system.
Other issues	**-Access of RES-E to the electricity market.** RES-E generators have the right to access the bidding system of the electricity production market. **-Minimum duration contracts.** Guaranteed purchase (five years min.) and measures facilitating the access of RES-E to the distributors´ power lines (agreement on grid connection for five years min.). **-Premium of 1 peseta/kWh (€ cent 0.6k/Wh) for RES-E plants >50 MW.**	**-Representative.** The RES-E generator may participate in the market through a representative. **-More favourable treatment for PV.** Capacity threshold to receive maximum support level increased from 5kW to 100kW. Conditions for grid connection are simplified.	**-Control centre.** Obligation for generators to connect their plants >10 MW to a generation control centre in order to receive the support. **-Announcement of a new PER for 2011–2020.** The new targets will be considered when revising the support levels for 2010. **-Mandatory guarantee** of €20/kW for all plants (€500/kW for solar plants) in order to access the distribution grid. -Support for **hybrid plants** mixing technologies or fuels), **co-combustion** (using biomass or biogas) and **RES plants > 50 MW** (except hydro). -Support for **repowering of wind farms** (€ cent 0.7/kWh for installations registered before December 31, 2001, maximum 2000 MW).

Source: del Río (2008).
** However, changes in support in alternative b) would also affect the premiums paid to already existing plants.*

TABLE A3 COMPARING THE DESIGN FEATURES OF FITS FOR RENEWABLE ENERGY SOURCES (INCLUDING SOLAR) IN SPAIN SINCE 2008

DESIGN ELEMENT	RD1578/2008	RD1565/2010	RDL14/2010
Setting the support level	It regulates the remuneration for solar PV plants installed after November 28, 2008 Cupo system (see text)	Correction factors for plants under RD 1578 (0.95, 0.75 and 0.55).	Cap on the number of hours eligible for support.
Guaranteed duration of support	25 years	Plants under RD661: 25 years (instead of lifetime) Plants under RD1578: 25 years.	Plants under RD661: 28 years (instead of lifetime) Plants under RD1578: 25 years.
Decision on support levels	Cupo system (circularity between capacity additions and support levels).	RD661, RD1578 (correction factors)	RD661, RD1578
Annual updating of support levels	Annual updating is tied to the CPI minus 0.25% until December 31, 2012 and minus 0.5% afterwards.	Annual updating is tied to the CPI minus 0.25% until December 31, 2012 and minus 0.5% afterwards.	Annual updating is tied to the CPI minus 0.25% until December 31, 2012 and minus 0.5% afterwards.
Revisions of support levels	"Remuneration to solar PV plants can be changed during 2012 in view of the technological evolution of the sector and the market and the functioning of the remuneration scheme"	RD661, RD1578	RD661, RD1578
Complement for reactive power (voltage control)	-	Complement or penalty for maintaining (or failing to maintain) a given capacity factor. This complement is set as a percentage of 8.2954 c€/kWh (as set in Annex V).	-
Payment for capacity guarantee	-	-	-
Payment procedure	Unchanged	Unchanged	Unchanged
Treatment of existing installations (transitions)	This RD does not apply to installations registered before September 28th 2008.	-	-
Targets	Cupo For the first year: 267 MW (type I installations), 133 MW (type II installations).	Cupo	Cupo
Access to the grid, and share of the costs of grid connection and reinforcements	Unchanged	Unchanged	Unchanged
Costs of deviations	Unchanged	Unchanged	Unchanged
Other issues	Guaranteed obligation (€500/kW). Possibility to set an obligation to bear tension hollows in order to receive public support (art. 13). New definition of capacity: plants very close to each other are considered to be a single installation. Maximum capacity of projects eligible for support: 2 MW (type I plants) or 10 MW (type II).	-New equipment. -Registration to a Control Centre for plants >10 MW. -Obligation to bear tension hollows (for plants >2 MW). -Obligation to send telemeasures to the system operator for plants >1 MW	Payment for the use of the grid (€0.5/MWh)

A2. MAIN STAKEHOLDERS AND COMMUNICATION CHANNELS

(i) Relevant government ministries and independent agencies involved in managing the deployment of the technology

Energy issues, including policies involving the promotion of RES-E, are managed by the Ministry of Industry, which is also responsible for other policy areas, including Tourism, Commerce, ICT and R&D. Within the Ministry, the State Secretary for Energy is in charge of Spanish Energy policy, through the General Directorate of Energy Policy and Mines.

Under the political guidance of the Minister of Industry, the State Secretary for Energy has the following tasks:

1. Design and promote any legislative initiative and regulatory proposal affecting the energy sector, either the conventional utilities sector or the special scheme of electricity generation that encompasses the RES-E and co-generation plants.
2. Define international relationships in energy matters, particularly with the EU.
3. Control and analyze energy markets, such as the wholesale electricity market or MIBEL (*Mercado Ibérico de la Electricidad*/Iberian Electricity Market) which was created by Spain and Portugal in 2004. Since 2011, MIBEL is managed by the OMI (*Operador del Mercado Ibérico*/Iberian Electricity Market) which is an entity encompassing two parent or holding companies with cross-ownership: the Portuguese section operates the forward market and the Spanish one, or OMIE, the spot market. This later company also manages the so-called CESUR Auctions (*Contratos de Energía para el Suministro de Último Recurso*/Energy Contracts for the supply of last resort). This market was created in 2009 with the purpose of determining the last-resort electricity tariff, that is, the tariff paid by residential and small commercial ratepayers (large consumers negotiate the price of the kWh directly with utilities).

The Central Government (through the Ministry of Industry) decides both the general goals and the design elements of the RES-E promotion policy. The fiscal measures are decided and designed by the Ministry of Finance. The Governments of the regions (Autonomous Communities, or AACC) are in charge only of administrative issues. With respect to RES-E projects, they check whether investment proposals meet technical requirements and solve disputes between promoters and the distribution companies (Spain follows the "deep connection charging rule"). Finally, even though local governments have no competencies in RES-E promotion policy, they can require RES-E plants and electricity lines to comply with urban regulations.

The Ministry responsible for environmental issues and policies (Ministry of Agriculture, Food and the Environment) has no involvement in RES-E promotion policy issues.

The CNE (*Comisión Nacional de la Energía*/National Energy Commission) is the regulatory body of the energy sector, in charge of liquid fuels, gas and electricity (both generation, transport and distribution). It was created in 1998 and its competencies have been modified several times. With respect to RES-E promotion policy, its role is merely consultative. Thus, the CNE has to report and give its opinion on every regulatory change and every new decree which is elaborated and promulgated by the Ministry of Industry should be reported by the CNE. However, its opinions are not binding and therefore may not be accepted. The CNE plays a relevant albeit limited role regarding energy planning and the setting of tariffs, charges and payment terms for energy-related activities, as well as in supervising the electricity markets (ruled by the OMIE). The CNE acts as an advisory body for the authorisation of energy facilities and in case an Autonomous Region takes measures regarding the quality of the electricity service. Perhaps the most important role of the CNE is to manage the permanent costs of the electricity system: it collects the access charges paid by electricity ratepayers and redistributes this money amongst the Transmission & Distribution companies, the RES-E generators, etc. and pays the debt service coming from the securitized deficit tariff. The CNE has an Executive Board whose members are designated by the Government according to the proposal of the Ministry of Industry and after a hearing at the Parliament. The budget of the CNE is fed by the access charge paid by electricity grid users and customers.

Another significant component of the Spanish electricity sector is the transmission system operator and manager of the transmission grid. This is the responsibility of the public company Red Eléctrica de España, which was founded in 1985.

Finally, a relevant institution is IDAE (*Instituto para la Diversificación y el Ahorro de la Energía/*Institute for the Diversification and Energy Saving). It is a branch of the Ministry of Industry specifically devoted to diffusion of information and educational activities, technical assessments, financing of innovation projects, and so on. It was created in 1974 as a centre for energy studies. Several Governments of AACC have similar centres for the improvement of energy efficiency and to encourage the deployment of renewable energy projects in their territories. The AACC have the competency to authorise the installation of RES-E plants in their territory. This is virtually the only competency that AACC has in the energy realm.

(ii) Other relevant stakeholders: Industry associations

In Spain, there are three main industry associations regarding renewable energy and solar PV in particular. These are:

- *Asociación de Productores de Energías Renovables* (APPA): http://www.appa.es
- *Asociación Nacional de Productores e Inversores de Energías Renovables* (ANPIER): http://www.anpier.org
- UNEF (*Unión Española Fotovoltaica*): http://www.unef.es

APPA

APPA has about 500 members from the renewable energy sector. Since its founding in 1987, it has been a traditional actor in the sector. APPA has three different tasks: 1) to increase public awareness on the benefits of renewables; 2) to maintain a dialogue with public and private entities on the different aspects of the renewable energy business; 3) to coordinate with teaching institutions at all levels regarding dissemination activities on renewable energy sources.

APPA is the umbrella association for renewable energy technologies. It is an association for the small renewable energy technologies. It started as the small hydro association and later widened its scope. APPA is part of UNEF (see below).

APPA belongs to the following European Renewable Energy Associations, including the European Biomass Association (AEBIOM), the European Biodiesel Board (EBB), the European Geothermal Energy Council (EGEC), the European Photovoltaic Industry Association (EPIA), the European Renewable Energies Federation (EREF), European Small Hydropower Association (ESHA), European Forum for Renewable Energy Sources (EUFORES), European Ocean Energy Association (EU-OEA), the European Wind Energy Association (EWEA) and the Geothermal Implementing Agreement (GIA).

ANPIER

This recently created association mostly includes small solar PV investors. It was set up “in order to represent and defend the interests of solar PV producers and investors.” It has 3,800 associates belonging to the solar PV sector. Its main current challenge is to “re-institute the regulatory security in the renewable energy sector, which was broken down by the retroactive changes of Royal Decree 1565/2010 and Royal Decree Law 14/2010.”

UNEF

UNEF was created in May 2012 from the merger of three solar PV associations: the *Asociación Empresarial Fotovoltaica* (AEF), the solar PV section of APPA and *Asociación de la Industria Fotovoltaica* (ASIF).[22] 330 firms and entities are associated to UNEF. The main task of UNEF is to provide institutional representation and promote the solar PV sector at national and

[22] The Association of the Solar PV Industry (ASIF) was traditionally the main solar PV association until a group of large firms left the ASIF and created the *Asociación Empresarial Fotovoltaica* (AEF) in 2009.

international levels. An additional key goal is "to defend the regulatory stability and regulatory security in the sector, avoiding retroactive changes in the regulations." UNEF is really a federation of associations, which mostly includes large solar PV firms.

(iii) Mechanisms used by government to monitor the performance of the subsidy program

Two registries were set up in order to monitor the accumulation of RES-E capacity: one at the national level and other at the regional level. The national registry is different from that related to conventional plants. RES-E promoters select one of the registries (whether national or regional) to provide the required documentation. Most preferred the closest administrative offices, i.e., the regional ones. Therefore, the role of the central register office was mostly to develop statistics, based on information provided by regional ones. During the years of the PV boom (2007–2008), figures for installed capacity were transmitted very late to the central registry by some regional registries. For this reason, the registering system was reinforced in 2010, with greater coordination between both registries. With respect to the performance of the RES-E plants, data on electricity production were collected by the distribution companies and transferred monthly to the CNE. As has been pointed out, the CNE manages the financial streams of the electricity sector, which includes payments for the electricity generated by the RES-E plants.

(iv) Modalities for adjusting the support policy

Adjustments of the support policy have taken place after open consultations between the Ministry of Industry and the different stakeholders. The CNE also undertook some consultations as required by law. However, after the boom most of the decisions taken by the Ministry of Industry were executive ones. Even though there were meetings between the authorities and the PV associations, reaching an agreement was usually impossible. It is interesting to add that in the Spanish legislative procedures there are royal decrees (enacted directly by the Government) and royal decree laws (which need to be ratified by the Parliament). The latter are more difficult to challenge in court. In short, adjustments to support policies were somewhat dependent upon the information flows between the relevant stakeholders and the government, an issue that we discuss in more detail below.

(v) Main channels of communication

There are three main aspects related to communications: between the AACC and the central government, between the Ministry of Industry (responsible for enacting regulation and the setting of support levels) and solar PV investors and generators and between the government and other stakeholders (society in general). They all suggest significant room for improvement.

1. **Communication between AACC and the central government.** A major communication problem related to the information flowing from the AACC to the central government. There were delays in the regional registries reporting to the central administration and a lack of coordination between the regional and national authorities in providing the required information. Although there is a central administration registry for Special Regime installations, most plants were registered with the AACC registries. Most administrative formalities were carried out at the regional level. The AACC had to communicate to the central government the solar PV capacity being registered, but this was passed on after long delays according to some interviewees. This led the central government to realize in April 2008 that a solar PV boom was taking place. The central government did not know the overall amount of solar PV that was about to be deployed. Obviously, better exchange of information between AACC and the central government would have represented a big improvement. Note that, while authorization of PV plants is provided at the regional level, support is provided by all electricity consumers in Spain on a pro rata basis.
2. **Communication between the Ministry of Industry and solar PV investors and generators.** Communication channels and information exchange on technical issues were performed on an ad hoc basis and not systematically organized. A stable negotiation framework was absent. For some, the issue was left to consultants, who contacted the sector and made recommendations. In the design of RD 661/2007, it was IDAE which contacted existing solar PV installations

to obtain data on the economic conditions of the solar PV farms by the end of 2006 (around 100 MW). Still, data were provided by the equipment manufacturers and the solar PV generators. There were some consultations with the sector and general meetings with the Ministry of Industry, which takes advice from the CNE (the report from the CNE is mandatory but not binding). In turn, CNE can open public consultations to obtain information. The Ministry may not necessarily choose a course of action according to CNE's advice.

Although there have been periodic meetings with the sector, representatives of solar PV associations stated that they felt they did not have a say in the design of relevant regulations and that those meetings had been even more infrequent in recent times. According to several interviewees contacted in researching this study, communication channels are less dynamic or open at the moment than they have been in the past. For the solar PV sector, the Royal Decrees cannot be regarded as the outcome of a negotiation process between different stakeholders. Although PV investors and generators inform public authorities about their claims, there is no systematic organization of this communications and no real consultation process.[23]

The process by which information is exchanged between stakeholders could be improved by making an independent body analyze the costs of the technologies (this role could be played by CNE). Thus a document with the required technical information and suggestions on levels of tariffs, i.e., independent data, could also be developed. Later, this document could be used in discussions between the government and representatives of the sector, organized by the former. This achieves two aims. First, it mitigates the classical problem of asymmetric information, i.e., the possibility that the regulated parties take advantage of asymmetric information. The government has information provided by a wide range of stakeholders other than just solar PV generators in bilateral conversations. In addition, it allows the regulated parties to have a say in the information provided into the policy-making process. This also increases the transparency of the whole process. In reality, the development of such a document should be broadened, and a public consultation procedure (where other actors also have a say) should be organized using Internet media. All comments or submissions made on the development of such a document should be published and the government should respond by indicating how it planned to address those comments. Several interviewees point to the United Kingdom's public consultation process as an example of best practice in this regard.

3. **Communication between the government and other stakeholders (society in general).** The communication between the government and society in general on the use of FITs to support solar PV deployment has been quite opaque. The main form of communication with the public apparently has only been through information posted in the Ministry's and IDAE's webpages. The CNE can open a public consultation process, but the participation of civil society is quite indirect in this context. For example, different types of stakeholders, (including environmental NGOs) take part in the so-called *Consejo Consultivo de la Electricidad* (Consultative Council on Electricity, or CCE). New drafts of regulation are discussed within this group. However, the records of the meetings of the CCE are not made public.

[23]According to some interviewees, the lobbying capacity of the PV sector has been limited. This was due to two factors. First, during the first years (until 2007), the sector was not well organized. Since 2007, the existence of different solar PV associations has fragmented the efforts and prevented a unified focus. In contrast, the conventional electricity sector (traditional utilities) is much better organized, and its lobbying capacity has offset the influence of the solar PV sector. Its lobbying capacity may show in the greater remuneration levels for ground-mounted plants compared to roof installations.

A3. TECHNICAL DATA

TABLE A4 EVOLUTION OF NET SUPPORT COSTS FOR ALL RENEWABLE ENERGY TECHNOLOGIES (THOUSAND €)

YEAR	TECHNOLOGY	INSTALLED POWER (CUMULATIVE) MW	ENERGY GENERATED GWh	NET SUPPORT COST** THOUSAND
2004	Solar#	24	18	6,146
	Wind power	8,532	16,087	451,667
	Biomass	470	1,799	54,932
	Hydroelectric	1,705	4,752	150,459
	Total Special Regime*	17,480	46,900	1,243,203
2005	Solar#	49	41	13,995
	Wind power	10,095	21,190	612,785
	Biomass	500	3,816	111,863
	Hydroelectric	1,762	2,120	59,094
	Total Special Regime*	19,230	51,685	1,245,612
2006	Solar#	148	107	39,887
	Wind power	11,897	23,168	865,815
	Biomass	541	2,136	75,132
	Hydroelectric	1,891	4,144	148,303
	Total Special Regime*	21,509	52,145	1,784,690
2007	Solar#	705	495	194,162
	Wind power	14,537	27,607	1,003,640
	Biomass	557	2,173	101,514
	Hydroelectric	1,909	4,115	145,736
	Total Special Regime*	24,799	58,249	2,283,647
2008	Solar#	3,463	2,549	990,830
	Wind power	16,323	32,131	1,155,818
	Biomass	587	2,488	129,669
	Hydroelectric	1981	4,640	147,033
	Total Special Regime*	29554	68,867	3,374,974
2009	Photovoltaic	3522	6,187	2,629,739.5
	CSP	108	17	4,496.5
	Wind power	18,821	38,232	1,619,203
	Biomass	670	3,024	224,542
	Hydroelectric	2,016	5,444	234,063
	Total Special Regime*	32,261	81,793	6,173,795
2010	Photovoltaic	3,841	6,406	2,653,720
	CSP	532	692	184,872
	Wind power	19,710	43,127	1,964,246
	Biomass	707	3,141	243,453
	Hydroelectric	2,030	6,747	296,958
	Total Special Regime*	34,121	91,251	7,124,890
2011	Photovoltaic	4,250	6,158 (7,422##)	2,402,986
	CSP	999	1,779	426,901
	Wind power	21,059	41,861	1,710,865
	Biomass	763	3,751	281,366
	Hydroelectric	2,034	5,279	206,029
	Total Special Regime*	36,503	91,303	6,925,473
2012†	Photovoltaic	4,410	6,544 (7,347##)	2,567,302
	CSP	1,778	3,118	843,147
	Wind power	22,014	37,940	1,597,279
	Biomass	827	3,447	280,003
	Hydroelectric	2,033	3,565	141,684
	Total Special Regime*	38,453	83,757	7,416,484

** In addition to renewable energy technologies, the Special regime also includes support for cogeneration and power production from urban solid wastes.*
*** Net support cost is calculated as the whole FITs and premiums paid to RES-E minus the average wholesale price multiplied by the amount of GWh of RES-E being generated.*
 # Solar includes solar PV and concentrated solar power (CSP) generation. However, the later was negligible at the time.
Eligible and non eligible solar PV power.
† Provisional data from January to mid-December
Source: Authors' elaboration from National Energy Commission (CNE) (2012).

TABLE A5 EVOLUTION OF SOLAR PV FEED-IN TARIFFS (€CENTS/KWH)

ROYAL DECREE	YEAR	QUARTER/S	TYPES OF PV FACILITIES							
			≤ 5 KW	> 5 KW	≤ 100 KW	> 100 KW TO ≤ 10 MW	> 10 TO 50 MW	ROOF ≤ 20 KW	ROOF ≤ 20 KW TO 2MW	GROUND ≤ 10 MW
2818/1998	1998	IV	39.6	21.6						
	1999	I-IV	39.6	21.6						
	2000	I-IV	39.6	21.6						
	2001	I-IV	39.6	21.6						
	2002	I-IV	39.6	21.6						
	2003	I-IV	39.6	21.6						
	2004	I	39.6	21.6	41.4414	21.6216	21.6216			
		II-IV			41.4414	21.6216	21.6216			
	2005	I-IV			42.1498	21.9912	21.9912			
	2006	I-IV			44.0381	22.9764	22.9764			
436/2004	2007	I			44.0381	22.9764	22.9764			
		II-IV			44.0381	41.75	22.9764			
661/2007	2008	I-II			44.0381	41.75	22.9764			
		III			44.0381	41.75	22.9764	34	32	32
1578/2008		IV						34	32	32
	2009	I						34	32	32
		II						34	32	30.72
		III						34	32	29.91
		IV						34	32	29,09
	2010	I						34	31.17	28.1
		II						33.47	30.31	27.32
		III						33.06	29.52	26.55
		IV						32.2	28.68	25.86
1565/2010	2011	I						31.35	27.89	25.17
		II						28.88	20.37	13.46
		III						28.1271	19.8353	13.0324
		IV						27.3817	19.317	12.497

Source: Authors' elaboration from CNE (2012).

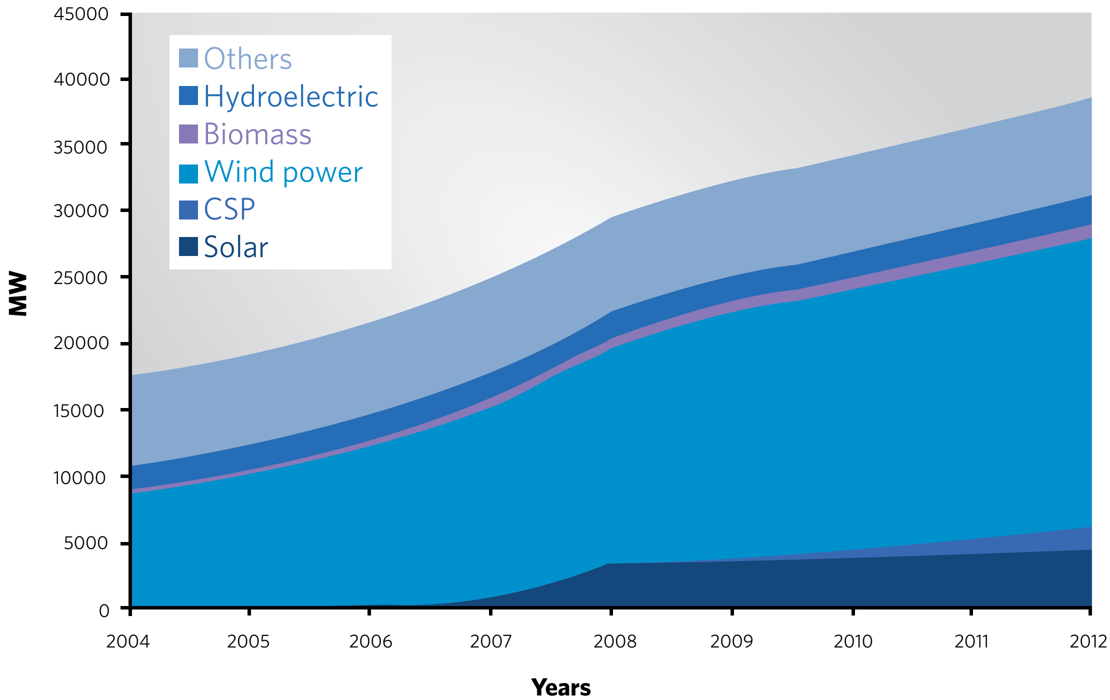

FIGURE A2. CAPACITY INSTALLED (MW)

Source: Authors' elaboration from CNE (2012).
**Provisional data from January to mid-December.*

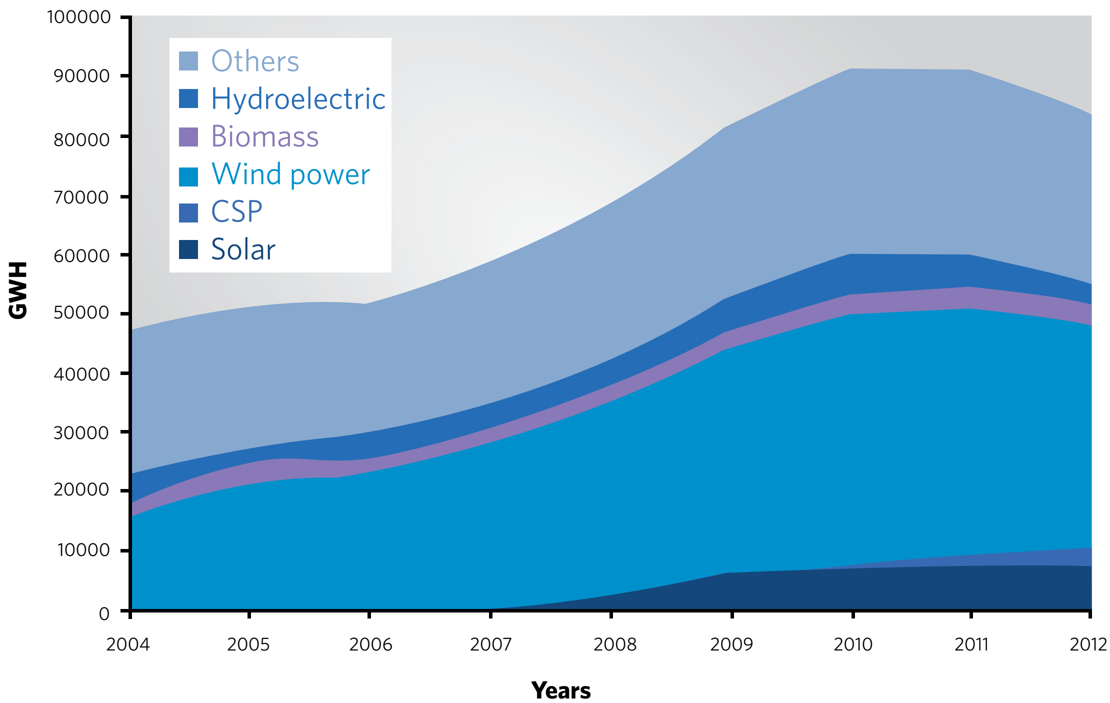

FIGURE A3. RES-E GENERATION (GWh)

Source: Authors' elaboration from CNE (2012).
**Provisional data from January to mid-December.*

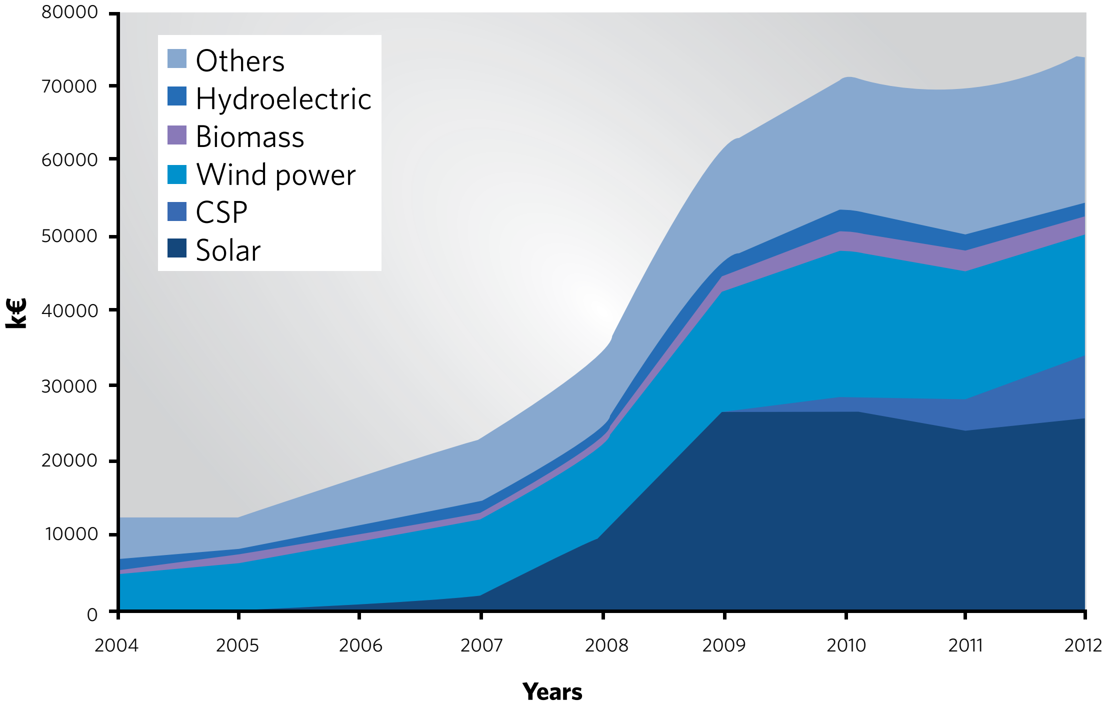

FIGURE A4. NET SUPPORT COSTS (THOUSAND €)

Source: Authors' elaboration from CNE (2012).
**Provisional data from January to mid-December.*

TABLE A6 SOLAR PV CAPACITY INSTALLED IN SPAIN, ANNUAL DATA

YEAR	CUMULATIVE MW
1999	1
2000	1.9
2001	2.5
2002	4.7
2003	5.3
2004	24
2005	49
2006	148
2007	705
2008	3,463
2009	3,540
2010	3,836
2011	4,244
2012 (e)	4,347

Source: Authors' elaboration from National Energy Commission (CNE), (2012).

TABLE A7 SOLAR PV CAPACITY INSTALLED AND IN OPERATION IN SPAIN, MONTHLY DATA (ACCUMULATED)

YEAR	2007		2008		2009		2010		2011		2012	
MONTH	MW	Δ *monthly*	MW	Δ *monthly*	MW	Δ *monthly*	MW	Δ *monthly*	MW	Δ *monthly*	MW	Δ *monthly*
January	165	-	765	10.9%	3,438	1.2%	3,437	1.1%	3,869	0.7%	4,274	0.6%
February	189	14.5%	836	9.3%	3,443	0.1%	3,471	1.0%	3,907	1.0%	4,282	0.2%
March	212	12.2%	910	8.8%	3,430	-0.4%	3,504	1.0%	3,944	0.9%	4,303	0.5%
April	238	12.3%	1,033	13.6%	3,404	-0.8%	3,544	1.1%	3,985	1.0%	4,318	0.3%
May	261	9.7%	1,196	15.8%	3,395	-0.3%	3,591	1.3%	4,009	0.6%	4,333	0.3%
June	326	24.9%	1,441	20.5%	3,397	0.1%	3,641	1.4%	4,049	1.0%	4,355	0.5%
July	381	16.9%	1,946	35.1%	3,381	-0.5%	3,725	2.3%	4,081	0.8%	4,377	0.5%
August	419	10.0%	2,471	27.0%	3,386	0.1%	3,752	0.7%	4,130	1.2%	4,399	0.5%
September	457	9.1%	3,105	25.6%	3,389	0.1%	3,761	0.2%	4,147	0.4%	4,401	0.0%
October	521	14.0%	3,327	7.1%	3,396	0.2%	3,774	0.3%	4,161	0.3%	4,410	0.2%
November	588	12.9%	3,375	1.5%	3,390	-0.2%	3,806	0.8%	4,208	1.1%	-	-
December	690	17.3%	3,398	0.7%	3,398	0.2%	3,841	0.9%	4,250	1.0%	-	-

Source: Authors' elaboration from CNE (2012).

TABLE A8 PV INSTALLED CAPACITY AND ELECTRICITY GENERATED PER REGION

YEAR	REGION	ELECTRICITY GENERATED (GWH)	INSTALLED CAPACITY (MW)
2005	Andalusia	2	2
	Aragon	0	0
	Asturias	0	0
	Balearic Islands	1	1
	Canary Islands	0	0
	Cantabria	0	0
	Castilla La Mancha	2	3
	Castilla and Leon	4	5
	Catalonia	3	3
	Ceuta and Melilla	0	0
	Valencia	4	7
	Extremadura	0	1
	Galicia	1	1
	La Rioja	0	1
	Madrid	5	5
	Murcia	1	3
	Navarre	15	12
	Basque Country	2	2
	TOTAL 2005	40	47

YEAR	REGION	ELECTRICITY GENERATED (GWH)	INSTALLED CAPACITY (MW)
2006	Andalusia	6	10
	Aragon	1	2
	Asturias	0	0
	Balearic Islands	1	1
	Canary Islands	3	5
	Cantabria	0	0
	Castilla La Mancha	9	18
	Castilla and Leon	14	20
	Catalonia	7	10
	Ceuta and Melilla	0	0
	Valencia	14	21
	Extremadura	1	3
	Galicia	2	1
	La Rioja	1	2
	Madrid	8	8
	Murcia	6	10
	Navarre	28	31
	Basque Country	3	4
	TOTAL 2006	105	146
2007	Andalusia	45	62
	Aragon	6	8
	Asturias	0	0
	Balearic Islands	2	1
	Canary Islands	19	23
	Cantabria	1	1
	Castilla La Mancha	91	163
	Castilla and Leon	66	87
	Catalonia	28	37
	Ceuta and Melilla	0	0
	Valencia	58	85
	Extremadura	31	62
	Galicia	3	3
	La Rioja	5	8
	Madrid	14	13
	Murcia	32	70
	Navarre	78	60
	Basque Country	5	7
	TOTAL 2007	484	690
2008	Andalusia	358	600
	Aragon	62	118
	Asturias	0	0
	Balearic Islands	28	51
	Canary Islands	63	94
	Cantabria	1	2
	Castilla La Mancha	692	811
	Castilla and Leon	260	336
	Catalonia	120	173
	Ceuta and Melilla	0	0
	Valencia	180	241
	Extremadura	323	416
	Galicia	6	9
	La Rioja	30	81
	Madrid	24	24
	Murcia	228	299
	Navarre	140	125
	Basque Country	11	17
	TOTAL 2008	2,528	3,398

YEAR	REGION	ELECTRICITY GENERATED (GWH)	INSTALLED CAPACITY (MW)
2009	Andalusia	1,176	656
	Aragon	203	112
	Asturias	1	1
	Balearic Islands	81	53
	Canary Islands	163	96
	Cantabria	2	2
	Castilla La Mancha	1,517	814
	Castilla and Leon	573	330
	Catalonia	281	164
	Ceuta and Melilla	0	0
	Valencia	361	222
	Extremadura	798	404
	Galicia	13	9
	La Rioja	76	78
	Madrid	37	26
	Murcia	525	290
	Navarre	248	125
	Basque Country	20	17
	TOTAL 2009	6,074	3,398
2010	Andalusia	1,212	729
	Aragon	230	135
	Asturias	1	1
	Balearic Islands	88	59
	Canary Islands	195	126
	Cantabria	2	2
	Castilla La Mancha	1,524	853
	Castilla and Leon	619	388
	Catalonia	298	192
	Ceuta and Melilla	0	0
	Valencia	382	264
	Extremadura	835	467
	Galicia	13	10
	La Rioja	122	80
	Madrid	42	36
	Murcia	573	340
	Navarre	247	135
	Basque Country	21	19
	TOTAL 2010	6,404	3,836
2011	Andalusia	1,402	790
	Aragon	268	142
	Asturias	1	1
	Balearic Islands	101	63
	Canary Islands	230	138
	Cantabria	2	2
	Castilla La Mancha	1,660	879
	Castilla and Leon	757	453
	Catalonia	357	230
	Ceuta and Melilla	0	0
	Valencia	442	302
	Extremadura	1,012	531
	Galicia	15	12
	La Rioja	136	85
	Madrid	60	48
	Murcia	656	401
	Navarre	288	148
	Basque Country	25	22
	TOTAL 2011	7,412	4,247

YEAR	REGION	ELECTRICITY GENERATED (GWH)	INSTALLED CAPACITY (MW)
2012	Andalusia	1,240	806
	Aragon	231	145
	Asturias	1	1
	Balearic Islands	89	70
	Canary Islands	194	143
	Cantabria	2	2
	Castilla La Mancha	1,467	891
	Castilla and Leon	700	466
	Catalonia	335	239
	Valencia	429	314
	Extremadura	930	535
	Galicia	14	12
	La Rioja	118	85
	Madrid	64	61
	Murcia	650	418
	Navarre	265	158
	Basque Country	24	23
	TOTAL 2012	6,753	4,369

Source: Authors' elaboration from CNE (2012).

TABLE A9 CUMULATIVE NUMBER OF SOLAR PV INSTALLATIONS IN SPAIN

YEAR	NUMBER INSTALLATIONS
1990	0
1991	0
1992	0
1993	0
1994	0
1995	0
1996	0
1997	0
1998	12
1999	16
2000	45
2001	196
2002	795
2003	1,581
2004	3,266
2005	5,391
2006	9,875
2007	20,284
2008	51,310
2009	52,090
2010	55,007
2011	57,963
2012	59,013

Source: Authors' elaboration from CNE (2012).

TABLE A10 EVOLUTION OF PRODUCTION, EXPORTS AND IMPORTS OF SOLAR TECHNOLOGIES IN SPAIN (BILLION €)

	1995	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Production	-	72.3	90.8	123.8	129.5	213.9	264.9	258.3	531.7	645.3	560.4
Exports	8.3	58.9	94.1	137.7	175.6	227.8	214.6	205.7	138.7	248.6	541.0
Imports	13.2	33.9	50.0	54.7	48.4	50.5	159.7	750.7	2283.7	5434.5	827.4

Source: Authors' elaboration from EUROSTAT (2011). PRODCOM database of the European Statistics Office (EUROSTAT).

TABLE A11 RETAIL ELECTRICITY PRICES

YEAR	€CENTS KWH
2000	8.54
2001	8.4
2002	8.44
2003	8.57
2004	8.72
2005	8.88
2006	9.4
2007	10.04
2008	11.24
2009	12.94
2010	14.17
2011	15.97

Source: Authors' elaboration from National Statistical Office (INE) (n.d.).

TABLE A12 AMOUNT OF ANNUAL TARIFF DEFICIT (M€)

YEAR	€ million
2002	1,910
2003	177
2004	177
2005	4,007
2006	3,026
2007	1,528
2008	4,641
2009	4,300
2010	5,554
2011	3,899
2012	-

Source: Authors' elaboration from National Statistical Office (INE) (n.d.).

TABLE A13 AMOUNT OF ACCUMULATED TARIFF DEFICIT (M€)

YEAR	€ million
2003	2,087
2004	2,264
2005	6,271
2006	9,297
2007	10,825
2008	15,466
2009	19,766
2010	25,320
2011	29,219

Source: Authors' elaboration from National Statistical Office (INE) (n.d.).

GSI Global Subsidies Initiative

iisd International Institute for Sustainable Development / Institut international du développement durable

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