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CURRENT SITUATION AND EVOLUTION OF PHOTOVOLTAIC IN SPAIN

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1. INTRODUCTION

Germany and Spain, world leaders in photovoltaics. Also in 2019, the solar technology industry will continue to grow globally. The solar industry association BSW-Solar and the European photovoltaic industry association EPIA have estimated that the international market will reach 3.6 gigawatts (GW) in 2018, when it was 5.6 GW. These 14 are 50% more than the previous year. Germany and Spain are world leaders in the use of innovative and pollution-free solar energy technologies. Many new solar installations were installed in 2018, with around 1.35 GW in Germany and 2.6 GW in Spain. The great commercial success lies in the solar energy remuneration laws, similar in Germany and Spain. However, with the reforms established in the new RD, Spain can stop this development, at least during 2019 and 2020, since each one has a maximum power of 500 MW, and according to the data available in 2019, it does not seem possible. exceed 200 MW, and the remaining 500 MW will be added in 2020. The German Bundestag decided in June to keep the structure of the Energy Injection Law "EEG" unchanged, which regulates the remuneration of electrical energy obtained from renewable sources. However, in response to the unexpected success of the PV market, the compensation amount will be reduced more quickly in the future. Rewards for new PV installations are currently reduced by 5% per year. In 2019 and 2020 there will be a reduction of 8% per year for installations of up to 100 kW and 10% per year for installations of more than 100 kW. Tariffs for all installations will be reduced by 9% per year from 2021. In Germany, operators will be paid for a fixed installation year of 20 years. There is no limit to the number of sponsored installs. “Solar energy legislation needs to be revised regularly in order to respond to market developments,” says Gerhard Stryi-Hipp, Managing Director of BSW-Solar 15 in response to the amended remuneration regulation. "Our 17-year experience with solar energy development programs shows that consistency is most important, as abrupt changes are detrimental to the market and industry and can undermine successes." The Federal Association of Solar Energy Industries believes that excessive restrictions on the solar market will seriously harm the Spanish solar industry. More and more countries recognize the enormous potential of solar energy to protect the climate, establish autonomous home energy supply networks and stabilize energy prices in the long term. The positive impact of photovoltaic power generation on regional development and job creation during the production, distribution and assembly of photovoltaic installations is also crucial. Building solar energy supplies in the Mediterranean basin countries is high on the EU agenda. PV is also an important element in achieving the EU's 2030 target of meeting 20% of energy demand through renewables. Currently many countries in southern Europe follow the German and Spanish example: In Italy the year 2018 has ended in such a way that it has practically quadrupled, and in France it has doubled compared to the previous year. In Greece, a remuneration law has entered into force under which solar installations of more than 1 GW are expected to be created in the coming years. Solar energy is considered as a market with a great future throughout the world. Currently, the US and Japan occupy the third and fourth positions in the world market, and in 2018 they carried out approximately photovoltaic installations for a total power of 340 MW and 230 MW, respectively. However, also in these markets a considerable increase in demand is expected in the coming years.

“It is extremely important that European governments continue their efforts to consolidate solar markets in the next four to five years,” says Gerhard Stryi-Hipp, “because by then it is estimated that a considerable reduction in costs is expected and the competitiveness of solar energy in many regions. The countries that now carve out their markets will be ahead and will be able to take full advantage of all the advantages of solar energy.”

2. CURRENT SITUATION OF THE SPANISH PHOTOVOLTAIC SECTOR

2.1 Change of regulations

In May 2007, the Spanish government published the new RD 661/2007, which established the legal and economic regime for the activity of electricity production under the special regime.

This new RD, which replaced Royal Decree 436/2004, was part of the commitment of the energy policy to promote the use of clean, indigenous, and efficient energies in Spain. At this time, the government decided to bet in favour of these energy technologies, which is why the new regulation seeks stability over time that allows businessmen to program in the medium and long term, as well as sufficient profitability and reasonable that, together with stability, make investment and dedication to this activity attractive.

Likewise, the Royal Decree was a boost to be able to achieve the objectives of the Renewable Energy Plan 2005-2010, as well as the objectives set by Spain at community level. With the development of these technologies, energy renewable energy in Spain would cover 12% of energy consumption in 2010 and the emission of 27 million tons of CO2 would be avoided in that year. Similarly, with the achievement of the targets set for cogeneration was avoided in the year 2010 the emission of 6.3 million tons of CO2.

The regulations determined the right to receive a special remuneration for energy produced to facilities included in the special regime, that is, with a 12 power less than 50 MW, and also those that having a power greater than 50 MW, whether cogeneration or using renewable energy or waste.

It was in 2010 when the rates and premiums established in the proposal were revised from in accordance with the achievement of the objectives set in the Energy Plan Renewables 2005-2010 and in the Energy Saving and Efficiency Strategy, and in accordance with the new objectives that were included in the following Plan of Renewable Energies for the period 2011-2020.

In the case of photovoltaic solar installations, RD661/2007 established a limit for the collection of the photovoltaic rate when it will reach 371 MW, limit to from which the General Secretariat of Energy could modify upwards the limit of power, since if it was not necessary to wait for the rates to be revised in 2020 and raw materials, according to the new objectives of the new Renewable Energy Plan for the 2011-2020 period.

These objectives were widely exceeded, having planned when has just counted the year 2008 (the power counts made by the CNE, take many months to stabilize), that the total accumulated power is 3,200 to 3,400 MW.

In order to control this situation, the Government issued the new Royal Decree RD1578/2008, which establishes in its article 5, that in each call are established some power quotas by typology, base, and additional powers.

2.2 Increase in remuneration

In RD 661, the sale option to the distributor increased the remuneration of the photovoltaic energy with a power greater than 100 kW, and the remuneration of the photovoltaic solar plants with a power lower than that mentioned.

Thus, the increases in the regulated rate with respect to that contemplated in the Real Decree 436/2004 were for photovoltaic plants greater than 100 kW, 82 percent, although the reality was that of almost all the installations, even if their power was greater than 100 kW, its processing was carried out as if it were a set of installations less than or equal to 100 kW, in order to access the maximum remuneration provided for in RD 661.

Rates, premiums and upper and lower limits, as well as other supplements, will be updated by the RD with the CPI minus 0.25 until 2012 or minus 0.50 from then.

In the New Royal Decree, the values of the regulated tariff corresponding to the facilities of subgroup b.1.1 that are registered in the pre-assignment register associated with the first call will be the following:

-Type l (ceiling):

-Subtype l.1 (<20kw) 34,00 c€/kWh

-Subtype l.2 (>20kW y <1MW) 32,00 c€/kWh

-Type ll (floor): 32,00 c€/kWh.

2.3 Industrial potential of photovoltaic generation in Spain

Spain, due to its location and climate, is one of the European countries where the solar resource is more abundant. Additionally, it has the advantage of being distributed by the territory in a relatively homogeneous way, producing few variations in solar irradiation at distances less than 100 km. This feature allows the installed power to be distributed around the large consumer agglomerations, instead of adapting said distribution to the geographical characteristics of the territory. This ability, if harnessed adequately, it would reduce the need for transport infrastructure and distribution. It is important to highlight the importance of this characteristic considering the public resistance to the development of new transport and distribution infrastructure in Spain, one of the main responsible for the quality problems of supply presented by our system.

Additionally, photovoltaic solar installations do not require specific characteristics specific geographic locations to be productive. In this, solar photovoltaics differs from other renewable sources such as wind power, in which the selection of sites must consider the characteristics of the wind and on numerous occasions it forces locate generation in areas of low demand. The sites economically exploitable will also limit the development of wind energy.

In other renewable technologies such as biomass and hydraulics, the availability of resource is also a limiting factor, compared to the unlimited resource of the photovoltaic energy.

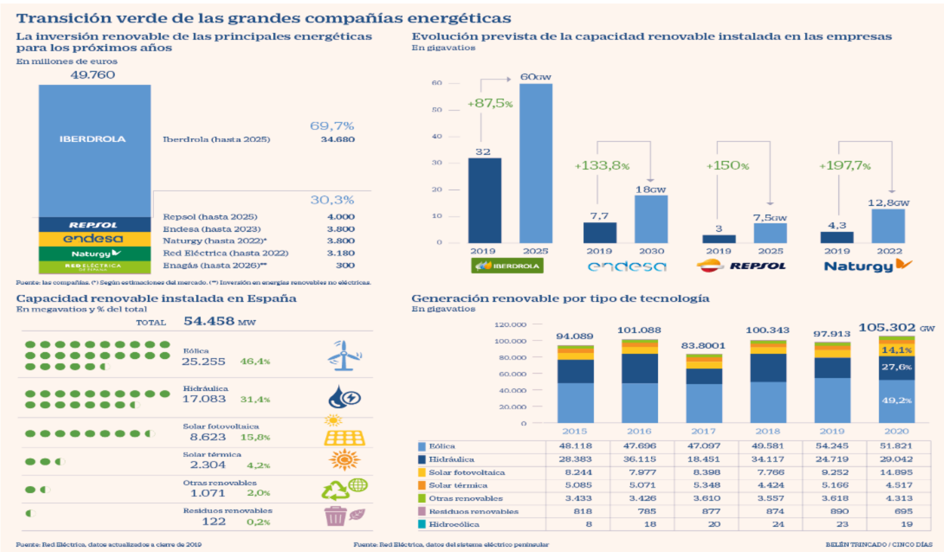
The solar resource does not present these limitations, being only limited by the available territory. In a hypothetical scenario in which forms of extensive enough energy storage, solar installations could satisfy the total national demand for the year 2018 occupying less than 1.5% of the territory. In practice, photovoltaic solar energy presents possibilities for virtually unlimited development.

2.4 Social support

Photovoltaic solar energy is clean energy with little visual impact, which creates wealth and develops disadvantaged rural environments. This has caused a wide base of social, political and trade union support that has facilitated and encouraged the development of the industry.

Various surveys carried out on the use of photovoltaic energy seem demonstrate that, as social concern about climate change grows, the Spanish consumer presents an increasingly favourable attitude towards the use of renewable technologies compared to conventional generation alternatives, and the photovoltaic solar energy compared to other renewable alternatives.

So, according to the Eurobarometer's on the population's attitude towards energy published in January 2016 and April 2017, 70% of Spanish consumers are "very concerned" about climate change and 23% are "concerned". This same study states that 90% of Spaniards (compared to 84% of Europeans) think that renewable energies should have a minimum base share in the energy mix generation and that 72% reject nuclear technology as an alternative. in sayings barometers shows strong support for the development of solar energy. The main results of the Eurobarometer's are shown in the following image.



2.5 How much do people know about?

In order to find out what knowledge people have about photovoltaic solar energy and to see what aspects need to be improved in order to raise awareness, it was decided to carry out a survey with a series of basic questions and the conclusions will be analysed below.

After having asked different age groups, the first conclusion we can draw is that almost all those surveyed have knowledge, albeit basic, about photovoltaic solar energy, and that of the 85.7% who claim to know about it, 40.5% consider that they would like to know more about the subject. Looking further we can see that 97.6% of those surveyed agree that the use of this type of renewable energy would help the environment. Furthermore, 90.5% agree that the use of renewable energies such as solar photovoltaic energy would help to reduce global warming.

Although not all users agree that it is a type of energy production that can help the environment, what they do agree on, however, is that there is a great deal of misinformation on the subject among the population. 64.3% say that the only way they know of obtaining solar energy are solar panels, and even so, 59.5% could not say what the life of a solar panel is in terms of a possible investment.

What we can say for sure is that the majority of users consider solar energy to be an expensive means of obtaining energy and that the government of their country does not provide sufficient aid to make this means a viable option for all users, and the vast majority share that they do not have this means installed because the investment is very large, and they must study their situation carefully.

Even so, if there were more aid and the price were more affordable so that it could be amortised in fewer years, 69% say they would like to have solar panels in their homes and 81% say that if they had panels, they believe they would reduce electricity consumption in their homes.

After all, the conclusion we can draw is that we need to work hard to raise public awareness and make all the necessary information available to the public so that they are able to analyse the benefits of having these installations for private use.

Nombre	How old are you?	What studies do you ha	Would you say that you	Do you know any differ	If you have answered 'y	Do you think that the us	Do you know what the I	Do you think this syster
1	18-25	University Degree	No	No		Yes	No	Yes
2	<35	Engineer's Degree	Yes	No		No	No	Yes
3	18-25	Certificate of Higher Ed	Yes	Yes	Thermo-solar	Yes	Yes	Yes
4	25-35	University Degree	No	No		Yes	Maybe	Yes
5	<35	Engineer's Degree	Less than I would like	Yes	Solar Roof tiles	Yes	Yes	Yes
6	<35	University Degree	Yes	No		No	Yes	Yes
7	<35	University Degree	Less than I would like	No		Yes	No	Yes
8	25-35	Engineer's Degree	Yes	Yes	Concentrated Solar Po	Yes	Yes	Yes
9	<35	Engineer's Degree	Less than I would like	No		Yes	Maybe	Yes
10	>18	University Degree	Less than I would like	No		Yes	Yes	Yes
11	<35	University Degree	Yes	Yes	Photovoltaic Windows	Yes	Yes	Yes
12	>18	University Degree	Less than I would like	No		Yes	No	Yes
13	<35	University Degree	Yes	No		Yes	Yes	Yes
14	18-25	Engineer's Degree	Yes	Yes	Solar collector	Yes	No	Yes
15	25-35	University Degree	Less than I would like	No		Yes	No	Yes
16	<35	University Degree	Less than I would like	No		Yes	No	Yes
17	18-25	Certificate of Higher Ed	Less than I would like	Yes	Molinos de viento	Yes	Yes	Yes
18	25-35	Engineer's Degree	No	No		Yes	Maybe	Yes
19	18-25	Engineer's Degree	Yes	Yes	ThermosolR	Yes	Yes	Yes
20	18-25	Engineer's Degree	Less than I would like	Yes	Electromagnetic radiati	Yes	Yes	Yes
21	18-25	Certificate of Higher Ed	Yes	No		Yes	Maybe	Yes
22	18-25	Certificate of Higher Ed	Less than I would like	No		Yes	Maybe	Yes
23	18-25	Engineer's Degree	Yes	Yes	thermal pannels	Yes	Yes	Yes
24	18-25	Engineer's Degree	Yes	Yes	Hay unas ventanas que	Yes	Maybe	Yes
25	18-25	University Degree	Less than I would like	No		Yes	No	Yes
26	18-25	Engineer's Degree	Yes	Yes	solar colector	No	Yes	Yes
27	18-25	Engineer's Degree	Yes	Yes	Thermal Solar Energy	Yes	No	Yes
28	18-25	Certificate of Higher Ed	No	No		Yes	No	Yes
29	18-25	University Degree	Less than I would like	No		Yes	Yes	Yes
30	18-25	Certificate of Higher Ed	No	No		Yes	No	Yes
31	18-25	University Degree	Yes	No		Yes	Yes	Yes
32	18-25	General Certificate of S	Less than I would like	Yes	Planta solar térmica	Yes	Yes	Yes
33	18-25	Certificate of Higher Ed	Yes	Yes	Eolic energy, biomass	No	Yes	No
34	18-25	Engineer's Degree	Yes	Yes	Colector solar y termos	Yes	No	Yes
35	18-25	Certificate of Higher Ed	Less than I would like	No		Yes	No	Yes
36	18-25	University Degree	Yes	No		Yes	No	Yes
37	18-25	Engineer's Degree	Yes	No		Yes	No	Yes
38	18-25	Certificate of Higher Ed	Less than I would like	No		Yes	Yes	Yes
39	18-25	Certificate of Higher Ed	Less than I would like	No		Yes	No	Yes
40	18-25	Certificate of Higher Ed	No	No		Yes	No	Yes
41	18-25	University Degree	Less than I would like	No		Yes	No	Yes
42	18-25	University Degree	Yes	No		Yes	No	Yes

Do you think solar ener	Does your government	If you will use solar par	Do you know people wi	Would you like to have
Yes	Not enough	No	Family	Yes
Yes	No	Yes	Neighbours	Yes
No	Yes	No	Friends	Yes
Yes	Yes	Yes	Neighbours	Yes
No	Not enough	Yes	Friends	Yes
No	Not enough	Yes	Neighbours	It doesn't matter
No	Not enough	Yes	No	It doesn't matter
No	Not enough	Yes	Friends	Yes
Yes	Not enough	Yes	Friends	Yes
Yes	Yes	Yes	Friends	Yes
Yes	Not enough	Yes	Friends	Yes
Yes	No	Yes	No	It doesn't matter
No	Yes	No	Friends	Yes
Yes	Not enough	Yes	Friends	Yes
Yes	Not enough	Yes	No	It doesn't matter
Yes	Not enough	Yes	Neighbours	No
Yes	Not enough	Yes	No	Yes
No	Yes	Yes	Friends	Yes
No	Not enough	Yes	Friends	It doesn't matter
Yes	Yes	Yes	Neighbours	Yes
No	Not enough	Yes	Neighbours	It doesn't matter
No	Yes	Yes	Neighbours	Yes
No	Not enough	No	No	It doesn't matter
No	Yes	Yes	Family	Yes
Yes	Not enough	Yes	Friends	Yes
No	Yes	No	Family	Yes
Yes	Yes	Yes	Friends	Yes
Yes	Not enough	Yes	No	Yes
Yes	Not enough	Yes	Friends	Yes
No	Yes	Yes	Friends	Yes
Yes	No	Yes	Family	No
No	Not enough	Yes	Neighbours	Yes
No	Yes	Yes	Neighbours	Yes
Yes	No	No	Friends	Yes
No	Yes	No	Family	Yes
No	Not enough	Yes	No	Yes
No	Yes	Yes	Friends	No
Yes	No	Yes	Neighbours	It doesn't matter
Yes	Not enough	Yes	Friends	No
Yes	Not enough	No	No	Yes
Yes	Not enough	Yes	No	No
Yes	No	Yes	Friends	Yes

3. COMPARISON WITH REMUNERATION MODELS IN THE WORLD

This chapter has made a summary of the state of the photovoltaic industry current in the world, to be able to see the installed powers and the growth planned, the tariffs used according to the different power segments and places of use, and some possible restrictions used by the different state regulations. As a consequence of the growth in 2018 of the Spanish market, in more than 2,600MW, the world market has grown in the order of 5,600 MW, which with respect to approximately 2,900 in 2017, represents an enormous growth of 100%, situation that gave rise in part to the shortage of modules, as well as their high price. On the other hand, the limit established in Spain by the Government, of 500 MW in the next two years, it will be noticed worldwide, but it will cause an excess of stock that will quickly lower prices by 20% to 50%, bringing closer the objectives of the countries to be able to reach the "Grid Parity". It is possible that the market world in 2019, is somewhat lower than in 2008, but grows again as of 2020.

Within the information of the different countries, the report of the scenarios of EPIA until 2023, seems the most significant, and is reproduced graphically within its two studied scenarios, the first called Moderate scenario, which as already has been said raises development without relevant public support mechanisms, and a second, that of Support Policies, which contemplates the application of said mechanisms.

3.1 Germany Market Information

The total installed capacity in 2020 was 14 GW, and in 2021 about 16 GW.

During 2017, this market was slightly less than 50% of the world market, with feed-in rates that are decreasing, but although in 2021 its leadership has been widely surpassed by Spain, in 2019 it is expected to regain said leadership, with annual growth of around 20%, giving forecasts for 2022 according to EPIA of between 17 and 17,5 GW, and between 18 and 19 GW for 2023.

The new regulation establishes a decrease in rates, with respect to the previous one, which was a decrease of 5% per year for installations on roofs, and 6.5% per year for installations on the ground. In these changes, for 100 kW installations, the decrease is: 10% in 2021, 10% in 2022, 9% as of 2023. For ground installations: 10% in 2021, 10% in 2022, 9% from 2023.

There is a scaling, which does not vary when growth is within a band, but if the growth of the photovoltaic market (new installations) in a year is stronger or weaker, then the reduction in the following years it varies, with an increase or decrease of one percentage point, respectively.

Based on market growth in 2021 (1,100 MW of new installations), the upper part of the band indicates a growth of 15% annual growth, and when said growth exceeds this value, the sliding scale must correct the regressivity of the rate (before 2023).

New category of remuneration for rooftop installations> 1,000 kW

- Remuneration in 2019: 33.00 c€/kWh

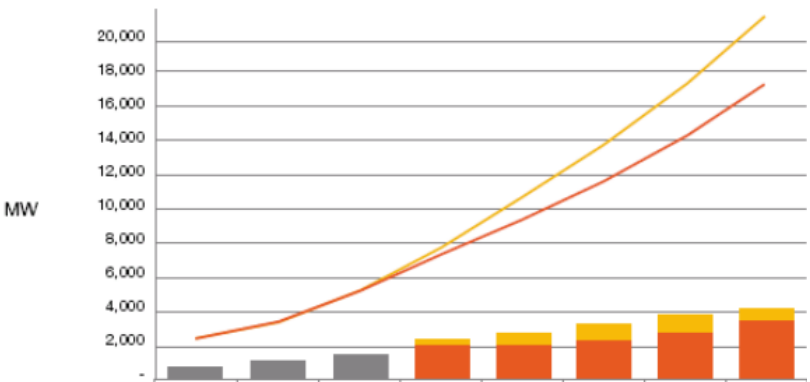
- Decrease rate of the same as installations >100 kW: 10% in 2021, 9% from 2023 "Bonus for Facade installation" cancelled

- The previous tariffs added a supplementary premium of 5 cts/kWh for installations integrated in the facade that has been cancelled.

Discount for photovoltaic energy for own consumption (only for installations of 100 kW)

- All installations >100 kW, must be capable of being remotely controlled by the network operator (for old installations, there will be a concession period until 01.01.2023

- Grid operators will be able to regulate the production of photovoltaic systems in the grid, only after the grid capacity has been sufficiently optimized and expanded.



		2006	2007	2008	2009E	2010E	2011E	2012E	2013E
Annual market (MW)	Moderate scenario	850	1,100	1,500	2,000	2,000	2,300	2,600	3,000
	Policy-Driven scenario				2,500	2,800	3,200	3,600	4,000
Projected cumulative PV power installed (MW)	Moderate scenario	2,708	3,808	5,308	7,308	9,308	11,608	14,208	17,208
	Policy-Driven scenario				7,808	10,608	13,808	17,408	21,408

3.2 USA Market Information

In the USA, there has been market growth, mainly in New Jersey and California, with support programs that will continue in the coming years, with total installed capacity in 2021 of around 15 GW, and more than 17 MW in 2022.

PV demand in the US has been boosted by the 30% federal tax credit, which expires in 2024, although extensions have been put in place.

Although there is no national feed-in tariff law, a number of state and municipal governments have offered incentives for PV installations. Seventeen states have committed to finance the installation of more than 10 GW of solar PV over the next 15 years, including California, New Jersey, Arizona, Maryland, and Pennsylvania.

Solar PV electricity prices in 2022 assume a cost of 8.3 $/W over the 25-year lifetime with an annual solar irradiation: 2000 kWh/m2.

High-cost market selling price - With a retail electricity price of $0.18/kWh, and unsubsidized electricity prices of $0.24/kWh.

3.3 France Market Information

The total installed capacity up to 2018 was almost 50 GW, but a major evolution was foreseen in the coming years.

France could emerge as the largest market for BIPV (Build Integrate PV), due to its favourable tariff system, as the government plans to increase installed PV capacity to 113 GW by 2028, and establish a tariff schedule that favours BIPV systems. With a tariff of 0.57

€/kWh for BIPV across France.

In general, a basic tariff of 0.32 €/kWh is offered on the mainland and 0.42 €/kWh in the overseas territories, for 20 years (with review).

Small systems receive from the market, a tax credit for individuals of 50% of the acquisition costs in income tax, which sometimes represents 50% of the investment in the solar module.

For the IRR calculation of the solar project, with a 20-year incentive programme, with an annual solar irradiation of 1450 kW/m2, it gives 16.3% in 2023 and 17.6% in 2024.

3.4 Italy Market Information

Italy could double the capacity of its solar photovoltaic plant in the next three years. years'', said Giuseppe Farinato

There are currently around 21 GW of PV plants in operation. It is estimated that 40 GW could be reached in the next three years. Between mid-2019 and 2020, operators submitted applications to build new PV plants with an aggregate capacity of more than 10 GW.

With the so-called "super bonus" for building renovation projects another reason for the likely boom, growth is expected to slow down after 2025. By 2030, installed PV in Italy could be around 50-55 GW in total, including the current GW in operation. The 110% tax exemption is offered for building renovations and energy requalification projects, which may also include the installation of a rooftop PV system and is an income tax rebate.

Tariffs range from 0.40 €/kWh for 1 - 3 kW, 0.38 €/kWh for the 3 - 20 kW range and 0.36

€/kWh for non-integrated installations >20 kW. Additional incentives of 0.04 - 0.05 €/kWh

are offered for building-integrated projects.

For the IRR calculation of the solar project, with a 20-year incentive programme, with an annual solar irradiation of 1650 kW/m2, it gives 12.1% in 2022 and 13.3% in 2023.

3.5 China Market Information

The installed PV capacities in China in 2007 and 2008 were very small, and small growth is expected in the coming years.

China has focused more on increasing solar hot water applications.

The government had set a target of 1.8 GW of installed solar PV capacity by 2010.

However, the Chinese government has changed its mentality in this regard and the production of energy through solar panels has reached record levels, reaching almost 110 GW installed in 2021. In this way, China is leading the way in this type of green energy.

For Chinese PV, tariffs depend on the region and are calculated on a cost base plus reasonable margin.

In 2019, solar PV electricity prices are for a cost of 8.3 $/W, with an installation lifetime of 25 years and an annual solar irradiation of 1,450 kWh/m2.

With a retail electricity price of $0.07/kWh, and unsubsidised electricity prices of

$0.33/kWh.

3.6 Remuneration policies in the world

Having seen the different countries with the expected evolution of their industry, and the existing remunerations, the different existing incentives for photovoltaic energy have been analysed.

Four main remuneration and incentive programmes have been identified:

- Feed in Tariff
- Green Certificates with Fee System
- Investment support and tax incentives
- Tendering with Quota System

Feed in Tariff

Basis

Contract with a fixed price for a specified period of time with operational conditions for producers. It can be combined with a premium payment on the price of energy in the spot market. The premium price represents the cost or value of the energy generated.

Modalities

Remuneration can be per total kWh produced, including self-consumption (Gross FiT) or per net kWh (Net Metering). 137

Tariffs may vary according to the size of the installation, technology, etc., and their value may decrease over time.

Main countries of application Germany, Austria, Czech Republic, Spain, France, Holland, Italy, Portugal, Switzerland, Turkey, California, Canada (Ontario), China, South Korea, India, Australia...

Green Certificates with Fee System

Basis

The government obliges producers, distributors or consumers to maintain a certain share of renewable energy in the energy mix.

The price is fixed between the different actors involved in the programme. Modalities

The quota system is often referred to as the "Quota Obligation" or RPS (in the US).

The main mechanism used to articulate this system is that of Green Certificates. ("Green Certificates")

Main countries of application Belgium, Poland, UK, Romania, Japan, USA, ...

Investment support and tax incentives

Basis

A set of measures aimed at facilitating access to credit and reducing the tax burden, with the objective of favouring and promoting the installation of PV systems.

The cost of capital is perceived as the main barrier to the development of the PV industry.

It is often combined with other incentive schemes. Modalities

There are different measures: Investment support: Subsidies, soft loans, etc. Tax incentives: Tax credit, accelerated depreciation, tax reduction, etc.

Main countries of application Virtually all countries, with the exclusion of Switzerland and Hawaii among others.

Tendering with Quota System

Basis

A system whereby the government puts certain projects to produce electricity out to public auction.

Each producer submits a project, and the winner of the auction is subsequently paid for it.

Modalities

This is the second mechanism used to articulate the quota system.

Previous experience with this mechanism in other countries has not been successful, due to high transaction costs and long waiting times.

Main countries of application, only France for large projects. The United Kingdom and Ireland have abandoned this system as inefficient.

These tendering programmes have had little success in the area of photovoltaics. Due to their complex procedures, only France still maintains them, but only for its large power plants.

4. PHOTOVOLTAIC GENERATION IN THE SPANISH ENERGY DEMAND COVERAGE

4.1. Demand and energy coverage

Over the last few years, the global demand for primary energy in the world has been growing steadily and is expected to continue to increase in the coming years. According to various studies, an annual growth rate of 1.6% is expected in the worst-case scenario until 2050, reaching 22.1 billion tonnes of oil equivalent. Even with these figures, unless the world undergoes a radical change in energy policy, fossil fuels, such as oil and coal, will continue to meet the majority of this global demand, accounting for 80% of the share of primary energy demand until 2050.

Even with the growth being experienced in renewable energy production, coal's share of total primary energy demand is projected to increase from 24% to 34% by 2050, overtaking oil as the main energy source.

Because of this increase in fossil fuel use, the expected growth in energy demand will also imply increases in CO2 emissions, which could grow at a rate of 1.7% until 2050.

However, there is a silver lining to all this data: electricity demand is expected to increase by 20% by 2030, thereby increasing the share of electricity in overall energy demand to 19%.

Similarly, in the last two years, oil experienced a drop in demand of 8%, coal 7% and natural gas 3%. It should be remembered that, although these data are positive, they cannot be interpreted as an example, as the falls have coincided with a global halt in activity caused by the coronavirus crisis.

4.2. Energy dependency

Today, most developed countries cover a very large part of their energy needs through the use of fossil fuels. Europe is forced to import fossil fuels from other regions due to the non- existence or depletion of oil and gas deposits in the region.

This is one of the serious problems for the European Union's economy, as it conditions and harms it greatly by not being able to turn this energy expenditure into wealth creation.

In the most industrialised countries, this energy dependence has been increasing significantly in recent years. In the future, with the expected growth in demand, combined with the increasing concentration of reserves and production in politically important regions of the world, it will be possible to reduce energy dependence in the most industrialised countries will result in increased dependence and associated risk if action is not taken soon. According to current studies, and unless there is some improvement, European energy dependence is expected to reach 65% by 2030.

This dependence will be particularly high for oil, reaching 93%, and for natural gas, reaching 84%. Even ignoring the possible impact of unforeseen supply disruptions, the mere payment for imported energy could amount to as much as 170 billion euros by 2030.

In the current scenario, and having commented on the above, it is not surprising that one of the main axes of the European Union's energy policy is economic independence, with the promotion of renewable energies being one of its main components.

In Spain, the situation is even more critical, as 81.4% of the total primary energy consumed in 2019 is imported, rising to 83% in 2021. This means, apart from the obvious cost of paying for energy imports, Spain has had to incur additional costs to diversify supply sources and ensure the existence of an adequate level of strategic reserves.

In this section and looking at the situation we are currently living in, when we talk about energy dependence it is inevitable that our minds do not turn to the war between Russia and Ukraine. This conflict, in addition to all the social consequences it will have both for the countries involved and for the rest of Europe, will have multiple economic consequences, from tariffs and exclusions for Russian companies, to a lack of energy supply, since much of the natural gas imported by the EU is supplied by Russia, and with the current situation, supply cuts to certain countries opposed to the Russian regime have already begun, or an exponential and disproportionate growth towards the rest of the EU countries, reaching record levels.

4.3. Public opposition to transmission, generation, and distribution facilities

One of the main conditioning factors of the European Union's energy needs is the social resistance to the construction of new production facilities. While this resistance is evident in cases such as nuclear power generation, the impact is also negative for many of the generation, transmission and distribution facilities required to meet growing demand.

Today, and leaving aside the case of nuclear generation, electricity companies encounter an almost insurmountable resistance to the development of conventional generation projects, especially for coal-fired plants. This resistance does not diminish when projects include advanced technologies such as integrated gasification or supercritical power plants and may even increase if CO_2 separation and storage are considered.

Some of the renewable technologies also encounter barriers that, although less relevant than in the case of traditional technologies, also hinder their deployment.

In the case of transmission and distribution infrastructure development, the experience is similar; public resistance delays or prevents the commissioning of facilities needed to maintain supply quality levels, and when it does, it is generally at a higher cost.

Solar photovoltaic energy, due to its greater social acceptance and ease of integration at the point of consumption, can be one of the key tools to meet demand, overcoming the public resistance that other alternatives face.

4.4. The coverage of electricity demand in Spain

The need to promote the development of photovoltaic solar energy involves considering its role in covering global energy needs. In order to assess what this role should be, we initially start with scenarios of the evolution of the Spanish peninsular electricity demand and alternatives for its coverage, evaluating the impact on aspects such as costs, renewable participation in primary energy consumption and CO_2 emissions. In practice, it will be energy policy, including support for photovoltaic generation, which will determine what the future situation will be, and thus provide information on the impact of the different alternatives available.

The period 2018-2030 has been considered, which is sufficiently long to allow for a gradual evolution of the current coverage structure and coincides with the planning period envisaged by the Government.

5. GAS EMISSIONS AND POLLUTION

It is now generally accepted that the increase in the concentration of greenhouse gases in the atmosphere is one of the main causes of climate change and that this change can have a high economic impact.

CO_2 is estimated to be the main greenhouse gas (60%-85% of the total impact), with fossil fuels being the main contributor.

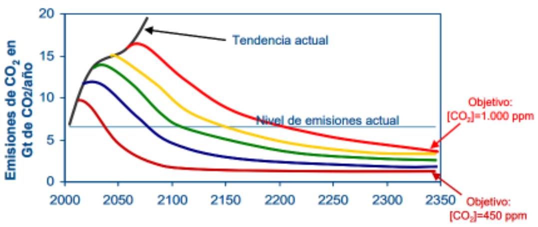
The current concentration of CO_2 in the atmosphere is around 380 parts per million (ppm), with studies suggesting that the range of 450-550 ppm should not be exceeded if major economic effects are to be avoided.

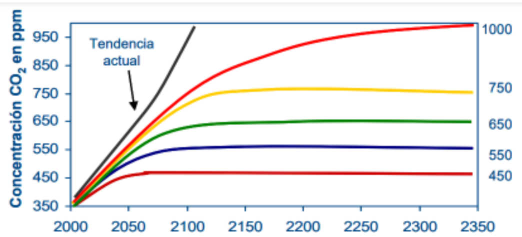
If emission control policies are not adopted and current trends continue, CO_2 concentrations in the atmosphere could rise to 1,260 ppm by the year 2100.

Stabilisation of greenhouse gas concentrations at admissible levels will require not only a simple reduction in the growth of emissions, but also a significant reduction in absolute emissions.

The current growth trend in global CO_2 emissions and its effect on atmospheric CO_2 concentration (black curve) depends on the programmes in place.

The other curves shown represent emission reduction scenarios of increasing ambition and the resulting atmospheric CO2 concentration level in ppm.





At the European Council meeting in March 2007, the leaders of the member governments decided to place the Union at the forefront of the fight against climate change, setting a firm target for 2020 of 20% reductions in emissions compared to 1990, which could be increased to 30% depending on the actions of other countries. In addition, a target has been set to increase the share of renewable energies from the current 7% to 20% by 2020 and the level of biofuels in transport to 10%.

5.1. CO2 emissions in Spain

The Kyoto Protocol implied for Spain that average greenhouse gas emissions could not exceed the 1990 base year by more than 15%.

All the countries of the European Union, including Spain, had assumed this commitment to reduce greenhouse gas emissions. This commitment was accepted by different laws of the European Commission directives and ratified in Spain by the administration in Royal Decree 5/2004 and modified by Law 1/2005 to be developed and modified in multiple Royal Decrees a posteriori.

At the end of 2008, Spain was 42.7% above the target set by the Kyoto Protocol, 28% above the level of greenhouse gas emissions needed to meet its commitments, which was 15% above the base year of emissions. While this was a dismal figure, it was a clear improvement considering that in 2006 it was 50.6% above the Kyoto Protocol's target.

In 2008, 413.5 million tonnes of CO2 equivalent were emitted compared to a target of 332 million tonnes of CO2 equivalent by 2012 and 256 tonnes by 2020. In 2007, the figure was

441.4 million tonnes. In other words, Spain had the challenge of reducing its emissions by around 160 million tonnes equivalent over a period of twelve years, regardless of the evolution of energy demand.

The electricity sector is, after the transport sector, the largest contributor to greenhouse gas emissions in Spain, with 21.4% of total emissions in 2020.

In addition, this is the sector in which, due to the existence of alternative technologies, the reduction of emissions is easiest due to the easy use and installation of different renewable energy sources such as the installation of solar panels. This reduction capacity is reflected in the allocation of emission allowances to electricity production facilities, which in Spain for the period 2008-2012 was set at 56 million tonnes, compared to emissions of 122 million tonnes in 2005. In 2020, Spain is estimated to have emissions of 271.5 million tonnes equivalent, a reduction of more than 13% compared to 2019.

5.2. Reduction of carbon emissions

With the increased use of fossil fuels (oil, natural gas and coal) to generate electricity, run engines, heat homes and provide heat for industrial processes, large amounts of greenhouse gases are released into the atmosphere.

Considering developing countries' economies, population growth and unchanged energy policies would lead to almost a doubling of emissions by 2050 and stabilising the concentration of carbon dioxide (CO2) in the atmosphere at 550 ppm (currently 385 ppm) requires halving current emissions, the solution appears to be threefold.

The first corresponds to making major efforts in energy conservation, i.e., improving energy efficiency and rationalising energy use.

The second is in the commercial development of the CO2 capture process.

The third refers to evolving the mix of primary energies used to meet demand to reduce CO2 emitters, which is driving the increased use of renewable energy in the electricity sector.

It also shows that the use of renewable energy would reduce CO2 emissions by 0.977, 0.644, and 0.394 tonnes/MWh for technologies that use coal, natural gas with gas turbine, and natural gas in combined cycle respectively. Current CO2 emissions from the use of fossil fuels for electricity generation are also estimated according to a projection of energy consumption.

Many activities that currently produce greenhouse gas emissions are essential to the global economy and are a fundamental part of modern life. If emissions from these activities continue to increase, the planet will be warmer in the near future. Gaining knowledge about greenhouse gases, CO2 capture and the impact of human activities on the earth's climate has become relevant in recent years as renewable energy projects have the potential to reduce the amount of greenhouse gas emissions released into the atmosphere. By using renewable sources such as water, sun, biomass or wind to produce energy, it generally has the effect of reducing the amount of fossil fuels.

The reduction of greenhouse gas emissions resulting from renewable energy projects is known as Carbon Emission Reductions, which represent an added value for renewable energy generation projects compared to conventional (fossil fuel) energy generation.

5.3. Photovoltaics in the control of greenhouse gas emissions

A photovoltaic installation does not emit gases, it does not pollute and is therefore not allocated emission allowances. If a photovoltaic installation is allocated greenhouse gas emission allowances, it does not pollute and is therefore not allocated allowances.

PV installation, the holder would be able to sell all allocated allowances and earn an additional return.

According to the data included in the Renewable Energy Plan, each kWh produced with coal (hard coal + national anthracite) causes 977 g of CO2 emissions, and if it is produced with natural gas in combined cycles, 394 g of CO2 per kWh generated.

National electricity production includes technologies with low greenhouse gas emissions (renewables, nuclear, large hydro, etc.) so that the kWh produced in Spain causes average emissions of approximately 400 g of CO2, depending on the energy mix at any given time.

A photovoltaic installation with a fixed structure produces on average 1200 kWh/kWp (1200 hp) in Spain, which means that an installation of 100 kWp of panels can save on average per year:

100 kWp *1200 kWh/kWp * 400 g CO2/kWh = 48,000,000 g CO2 ~ 50 tonnes of CO2 If the duty is set at 20 €/tonne of CO2, the CO2 emission savings from this

100 kW photovoltaic installation in economic terms of emission rights would be: 50 Tm CO2*20 euros/Tm CO2 = 1,000 euros per year.

As indicated above, the photovoltaic installation does not pollute and therefore has no emission allowances allocated to it. The European Emissions Trading Directive does not include any of the installations generating electricity from renewable energy sources among the electricity generation activities to which allowances are allocated. This is consistent with the Directive itself, which allocates allowances to industrial sites that are going to pollute and whose pollution is to be limited.

Thus, the owner of the PV installation is left out of the economic compensation he could have for producing without pollution, however, the moral satisfaction that he is saving 400g of CO_2 per kWh he produces and therefore the satisfaction that he is contributing to some extent to controlling greenhouse emissions and complying with the Kyoto protocol should be highlighted.

Only companies that have been assigned a certain emission level and replace part of their polluting electricity generation with PV will obtain economic benefits from emissions trading. For example, a coal-fired power plant that installs PV to power part of its ancillary services would gain economic benefits from the emission savings provided by the PV installation.

But the effect of PV on Kyoto compliance exists independently of the importance of its role in emissions trading.

The quantification of this effect can be made assuming that in the coming years, as proposed by ASIF, around 500 MW per year are installed in the remainder of this decade, with a growth rate of around 20%; this growth rate would lead us to have a photovoltaic park of around 5,000 MW in operation in 2020. This park would save around 2 million tonnes of CO_2 per year.

If we do not succeed in the measures, we are taking to control emissions, some experts estimate that Spain, by 2020, could exceed the 15% target by 100 million tonnes of CO_2.

This indicates that the contribution of photovoltaics, in order to avoid this possible excess of emissions above the EU targets associated with the Kyoto Protocol, would be 2/100*100 ~ 2 %.

Spain can carry out photovoltaic projects in the states that have assumed the Protocol (Western and Eastern European countries in transition to a market economy) and could therefore obtain recognition of the emission reductions involved, quantified in Emission Reduction Units, but the host country, where the installation is carried out, must agree to the emission savings being accounted for in another country.

This mechanism will not be widely applied for PV projects, firstly because the interest of investors in developing PV plants in developed countries will be limited, secondly because the host country may not agree to export the CO_2 savings benefits when the host country has commitments to fulfil, and thirdly because the economic benefit per emission reduction unit does not justify the investment in itself, as the PV project is an investment with a very low emission reduction unit/invested capital ratio.

5.4. Clean Development Mechanism

In countries outside the Protocol, generally developing countries, with no specific reduction commitments to fulfil, Spain's implementation of renewable energy projects will mean, compared to other options, a saving in emissions in those countries, and it will therefore be able to acquire and count the reductions achieved in those countries with these projects as its own reductions.

In fact, the realisation of a power plant with photovoltaic technology can save emissions compared to other possible solutions or, for whatever reason, achieve a reduction in emissions compared to those that would have occurred if the project had not been realised. For these reasons, the photovoltaic project would be eligible for Certified Emission Reductions.

The project host country will benefit from the technology transfer and will not object to the export of Certified Emission Reductions when it does not have to meet emission reduction commitments.

Thus, when a Spanish company carries out a photovoltaic project in the third world within the CDM mechanism, it will be able to obtain an additional return on that investment by obtaining the Certified Emission Reductions corresponding to that investment installation, which will be used to offset the company's emissions in Spain or to trade the corresponding emission allowances.

However, investment projects in clean technology in third countries, especially those associated with the CDM, will play an important role for Spain; 7% of the reduction in the period 2018-2022 is expected to come from these mechanisms given the presence of Spanish companies in Latin America. Photovoltaic projects can be part of this contribution.

It can be summarised that the certified emission reductions in PV will not justify the investment but will be a further incentive to realise PV installations in the third world.

6. GENERATION IN SPAIN UNTIL 2030

In this chapter, a series of scenarios will be presented, the purpose of which is to propose different generation alternatives for the Spanish peninsular system over this horizon, based on the current situation, taking into account the possible energy needs of the coming years and their extrapolation in the long term in order to make progress in the definition of these scenarios.

Among all the alternatives proposed, more emphasis will be placed on the development of renewable energies in general, but special interest will be placed on photovoltaic solar energy, analysing whether it is feasible to admit the amounts of power and energy specified in each of the cases.

One factor that must be taken into account is that investments in electricity generation are very high and have very long payback periods, so when making decisions on this issue, it must be borne in mind that the decisions taken today and in the coming years will largely condition the characteristics of the generation fleet available in the future, and undoubtedly in 2030.

6.1. Possible situations

We will take into account the following situations:

- One in which the equipment in the MITyC planning is taken into account to the maximum extent possible in the Network Planning, with minimal additional equipment. This would be the Base Case representative of a situation in which the ESF is not considered to be able to provide a significant percentage of the energy needs and therefore there is no strong economic, regulatory, or promotional support, and the PV industry simply follows the vicissitudes of the international market, representing a wait-and-see situation.

This scenario is dominated by market forces where the SFE clearly does not manage to reach a sufficient volume to compete on price with other forms of generation, requiring aid which, in the Spanish case, is mostly in the form of production premiums and thanks to which it manages to achieve the objectives set by the administrations.

- Another possible scenario is the one that takes into account nuclear expansion, considering that the current generation fleet remains in operation for 60 years and increases by 6,500MW in the period considered.

- There are 4 scenarios of maximum penetration of renewable energies, with different levels in terms of the consideration of photovoltaic solar energy, in order to check whether this penetration is possible, experiencing constant annual growth of 300, 500 and 800MW, for the first three cases, and exponential growth with annual growth of 20% with respect to the previous year.

With regard to the medium-term outlook 2030, the progress recorded by the ESF can already be seen.

In these cases, gas, coal and CO2 prices are taken into account.

Precio del gas (€/MWh pcs)	12
Precio del carbón ($/tec)	70
Precio del CO_2	30

Source: UNESA

At the end of the day, this is only an assumption and this and the other factors that we will consider below will only serve to demonstrate that photovoltaic energy can have a great influence, in terms of quantity, and that the possible technical restrictions placed by Distributors and Transporters will be responded to in the medium and long term. We will also take into account the corresponding technological innovations that may arise over the years, as is being done with other renewable energy sources such as wind energy.

Therefore, six possible new base power facilities have been considered to meet the electricity demand and peak power indicated above.

The different cases mentioned:

Casos	**Equipos**
Caso Base	Equipo fijo + Centrales de punta que sean necesarias
Caso Nuclear	Equipo fijo + 6.500 MW de nueva Nuclear
Caso 1 Escenario mínimo de penetración de Energías Renovables	Equipo fijo con un total de 7 GW de Fotovoltaica para el 2020, y 10 GW para el 2030 (continuan todas las Nucleares en el total del periodo)
Caso 2 Escenario bajo de penetración de Energías Renovables	Equipo fijo con un total de 9 GW de Fotovoltaica para el 2020, y 14 GW para el 2030 (prorroga de 10 años para todas las Nucleares)
Caso 3 Escenario medio de penetración de Energías Renovables	Equipo fijo con un total de 13 GW de Fotovoltaica para el 2020, y 21 GW para el 2030 (prorroga de 20 años para todas las Nucleares)
Caso 4 Escenario maximo de penetración de Energías Renovables Fotovoltaica 20	Equipo fijo con un total de 22 GW de Fotovoltaica para el 2020, y 44 GW para el 2030 (no existen prorrogas en el cierre previsto de las Nucleares)

In the first two cases, the share of renewables remains at 35% of production during the 2020-2030 decade, being variable for the Maximum Renewables Penetration cases rising to 64% in 2030, being variable in the Maximum Renewables Penetration years rising to 64% in 2030, depending on the penetration of all renewables, and with the particular case of the gradual penetration of photovoltaics.

Casos:	Máximo Aprovechamiento Equipo 2011	Expansión Nuclear	Caso 1 Escenario mínimo de penetración de Energías Renovables	Caso 2 Escenario bajo de penetración de Energías Renovables	Caso 3 Escenario medio de penetración de Energías Renovables	Caso 4 Escenario maximo de penetración de Energías Renovables Fotovoltaica 20
Nuclear	7.496	13.801	7.496	-	7.044	-
Carbón	562	562	562	562	562	562
CCGT	28.384	28.384	28.384	28.384	28.384	28.384
Centrales de Punta	25.202	18.412	158	124	89	214
Hidroeléctrica y Bombeo	18.110	18.110	21.360	21.360	21.360	21.360
Regimén Especial	51.964	51.964	83.414	87.444	94.414	117.813
Cogeneración y trat. Residuos	9.100	9.100	9.100	9.100	9.100	9.100
Eólica	35.000	35.000	58.750	58.750	58.750	58.750
Fotovoltaica	2.300	2.300	10.000	14.030	21.000	44.399
Resto Renovables	5.564	5.564	5.564	5.564	5.564	5.564
Total Equipo Fijo	131.718	131.233	141.374	137.874	151.853	168.333

Therefore, the key to a robust and sustainable electricity system lies in its diversification, both in terms of primary energy sources, including geographical diversification in terms of origins and technology, and in terms of sites, as well as a sufficiently meshed and interconnected transmission and distribution grid.

6.2. Demand and peak demand growth

The first thing to bear in mind is the demand hypothesis to be taken into consideration, both in terms of energy and peak power. According to the data provided by UNESA, the different evolutions of renewable energies have been studied and it can be observed that:

- Regulated hydropower + pumping increased from 300MW in 2018 to 400MW in 2019.

- Within wind energy, we must differentiate between traditional onshore wind power, which increased from 2000MW in 2013 to 3500MW in 2020 and is expected to increase by 1000MW between now and 2030. On the other hand, offshore wind will reach 500MW per year in 2021.

- Finally, the largest development forecast by UNESA is attributed to photovoltaic solar power, for which an increase of 100MW per year is forecast from 2012 to 2030. Even so, this forecast is lower than the maximum penetration development data foreseen by the administration and therefore only serves as a comparison with the other cases mentioned, with the forecast for photovoltaic being much higher.

In relation to the existing fleet, a useful life of around 40 years has been considered for coal-fired plants, assuming a 15-year life extension for plants undergoing major refurbishment. For fuel oil/gas plants, a useful life of 35 years has been considered, for combined cycle plants 30 years, and for nuclear plants a useful life of 60 years has been estimated.

6.3. Starting generator equipment

Therefore, the different generation alternatives for the 2030 horizon are going to be envisaged from the current perspective, i.e. taking into account the generation technologies and their expected evolution, as well as the energy needs of the coming years and their extrapolation in the long term in order to advance in the definition of some long-term scenarios, which take into account in this particular case the maximum quantities available to be occupied by photovoltaic solar energy, once the long-term economic viability of this type of renewable energy has been demonstrated.

As we have already mentioned, a very important factor to bear in mind is that investments in photovoltaic generation are very high and have very long payback periods, so that the decisions taken today will largely condition the characteristics of the generation park available in the future. We must also bear in mind that the authorisation procedures for this type of installation are becoming increasingly complex and are gradually lengthening, which means that the reaction times for changing a defined course are very long.

For the study of medium-term forecasts, we start from an estimated electricity demand for 2030 and analyse the different possibilities of coverage according to the electricity generation technology to be used, with special emphasis on photovoltaic solar energy. In the event that these measures are not successful, and demand is higher than forecast, this would mean that the quantities of renewable energies to be taken into account could be even greater.

It is worth mentioning that other studies on energy foresight currently being carried out by prestigious organisations and institutions maintain a series of thematic coincidences on different actions to be considered. These include the promotion of energy saving, the important role of nuclear generation, the promotion of renewable energies and the use of clean combustion technologies.

On the other hand, in addition to ensuring that demand is covered at a reasonable cost for reasons of economic competitiveness, it must be compatible with the principles of security of supply from the point of view of the supply of primary energy from third countries, both in terms of quantity and price, and be compatible with the growing requirements of environmental protection, particularly as regards emissions into the atmosphere and, in particular, the fight against climate change.

In conclusion, a brief analysis of peninsular electricity generation from now to 2030 with different equipment scenarios has been discussed, in order to analyse whether or not the different scenarios are possible.

6.4. Characterization of the new equipment

A wide range of technologies are available to determine the technical and economic characteristics of the generating set that could be incorporated in the different equipment options.

There are certain cost items which, depending on how they are treated, can affect the cost per kWh, such as, for example, in the case of nuclear energy, the cost of waste storage.

In the case of natural gas production, the variable costs borne by the facilities are those due to the payment of access, transport and storage tariffs, i.e. the incorporation of the cost of managing natural gas into the Gas System.

As far as the investment cost is concerned, the comparison between technologies with very different capital cost impacts on the product cost can be represented by means of a constant annuity over the entire life of the investment. This procedure does not correspond to the criteria commonly used in accounting, but it allows the costs associated with the investment to be represented by a single parameter with sufficient precision for comparative purposes. The disadvantage of this method is that it does not take into account the need for higher revenues during the first years after start-up to cover financial costs, especially in the case of highly leveraged investments that require higher revenues during those first years to avoid entering into a cost deferral dynamic.

Following these criteria, the investment costs necessary for the different technologies considered are included. The intercalary interest associated with a standard investment profile has been incorporated into this cost, so that the resulting values would correspond to the gross value of the investment at the time of start-up.

				Coste combustible + CO2	Coste Total	
	Inversión €/MWh	Coste del Capital €/MWh b.c.	Coste O&M €/MWh b.c.	Gas Prior €/MWh b.c.	Gas Prior €/MWh b.c.	
IGCC con Captura	1.607.170	15,2	12,9	26,1	54,2	
Turbina de gas	315.000	26,0	20,4	55,8	102,3	utilización: 1000 h/año
CCGT	512.436	6,2	4,5	42,3	53	
Carbón supercrítico sin captura	969.434	9,7	4,0	0	0	Mera referencia sin utilizarse en el análisis
Nuclear	2.083.972	20,6	10,2	5,6	36,4	Incluye Coste de 2ª fase combustible como coste de combustible
Ampliación Hidroeléctrica regulada	630.000	37,26	8,2	0	45,5	
Eólica terrestre	1.100.040	58,4	11,2	0	69,6	TIR: 8%
Eólica off-shore	1.696.000	56,6	16,8	0	73,4	TIR: 8%
Fotovoltaica fija	5.050.000	378,46	1,59	0	380,1	TIR: 8%

Source: UNESA

Based on these investment values and the rest of the operating characteristics of each technology, the table above shows the total costs per MWh for each technology, incorporating the capital costs associated with the investment, maintenance costs and fuel costs. The latter includes the opportunity cost of the associated greenhouse gas emissions.

7. What do we do with the waste?

Photovoltaic panels have a useful life of between 25 and 30 years. Once the technology reaches the end of its useful life, its installations are dismantled, and an attempt is made to return to a zero state in the place where they were installed. It must then be possible to reuse, recycle and minimise the waste produced in the dismantling process, trying to reintegrate it all into the production system using circular economy criteria. Today, there are some problems in photovoltaic technology that need to be faced and solved.

Due to the huge growth in photovoltaic energy installations at the end of 2017, an estimated 402.05 GW of solar energy had been installed worldwide; this figure could reach 4,500 GW by 2050.

But the solar panels that generate this energy will not last forever. The standard lifespan, as mentioned above, is between 25 and 30 years, which means that we will soon have the first waste from pioneering installations in the sector.

With each passing year, more and more glass, silicon and metal photovoltaic modules will be removed, which will soon add up to hundreds of thousands of metric tonnes of different materials. Total waste production from these installations is expected to reach 60-78 million tonnes globally by 2050. In Europe there is currently approximately 35,000 tonnes of waste from solar installations.

This is a lot of waste, both now and in the decarbonisation horizon of the European economy, but through recycling and proper recovery, 2 billion new panels could be produced. In other words, with a proper recycling process for photovoltaic panels, solar energy production would greatly reduce its carbon footprint and greatly improve its life cycle analysis by introducing circular economy elements into its net balance sheet. Recycling options therefore need to be looked at in detail, so that they are up and running on a large scale as soon as possible, well before the year 2050.

7.1. Legislation on solar technology recycling

Since 2012, all producers of solar panels have been obliged to recycle solar panels that are no longer in use. This is regulated by the European Directive on the re-use of electronic and electrical devices 2012/19/EU.

This directive requires the collection of 85 % and recycling of 80 % of the materials used in photovoltaic panels under the directive's content on waste electrical and electronic equipment, which was extended to solar products in 2012, as mentioned above.

7.2. How are photovoltaic panels recycled?

Solar panels can be recycled, but the overall process is not straightforward, as they have many different components in their matrix.

The most expensive component per unit mass of PV panel is silver, followed by copper, silicon, aluminium, glass and polymers. Due to technical advances and new technologies, the use of silver is being considerably reduced in PV panels.

They also contain some hazardous materials that are bonded to the matrix with adhesives and sealing processes that will make it difficult to separate them effectively.

In a PV panel, about 90 % of the glass and semiconductor materials can be reused in new panels or other glass products. Almost 75 % of the separated material is glass, which on the one hand is easy to recycle into new products, but on the other hand has a very low value as a recycled product. The lower the value that can be extracted from a recycled product, the lower the incentive to recycle. This is why other incentives and/or regulations from the governmental sphere are needed.

There are mainly two existing recycling techniques:

1. Thermal recycling.

The standard recycling technique is based on thermal treatment and consists of burning the plastics, adhesives, and sealants to separate the cells from the glass. This is approximately 80 % by weight and components of the panel. Different chemical processes must then be carried out to separate the metal contacts and remove the anti-reflective coating, if any. The silicon wafers can also be reused. This material can be recycled up to four times.

2. Mechanical recycling.

The second recycling technique used is mechanical. It consists of grinding the entire panel clear of its frame, wires and junction box and then processing it using chemical processes. It is crushed to extract the main materials and then these are separated and sent to separate recycling streams to obtain secondary materials.

The presence or absence of silicon in the PV modules determines whether the first or second recycling option is applied.

8. Conclusions

To talk about the conclusions, we are going to focus on two parts, firstly we are going to talk about the conclusions we have been able to draw with regard to the issue of investment in photovoltaic solar energy. Although certain studies show that Spain can afford a favourable incentive programme, given that we have a very attractive solar radiation profile, the government decided to consider a less favourable scenario for the first years after the crisis. However, in 2020, Spain managed to exceed the target set by the European Union, and, according to the agreement with the Union, Spain should have 20% of its energy demand in renewables, and reached 21.2%, with a 42.94% share of renewable electricity, having increased by more than 5% compared to the previous year. Similarly, the percentage of final energy consumption in transport also increased, from 7.61% to 9.54%.

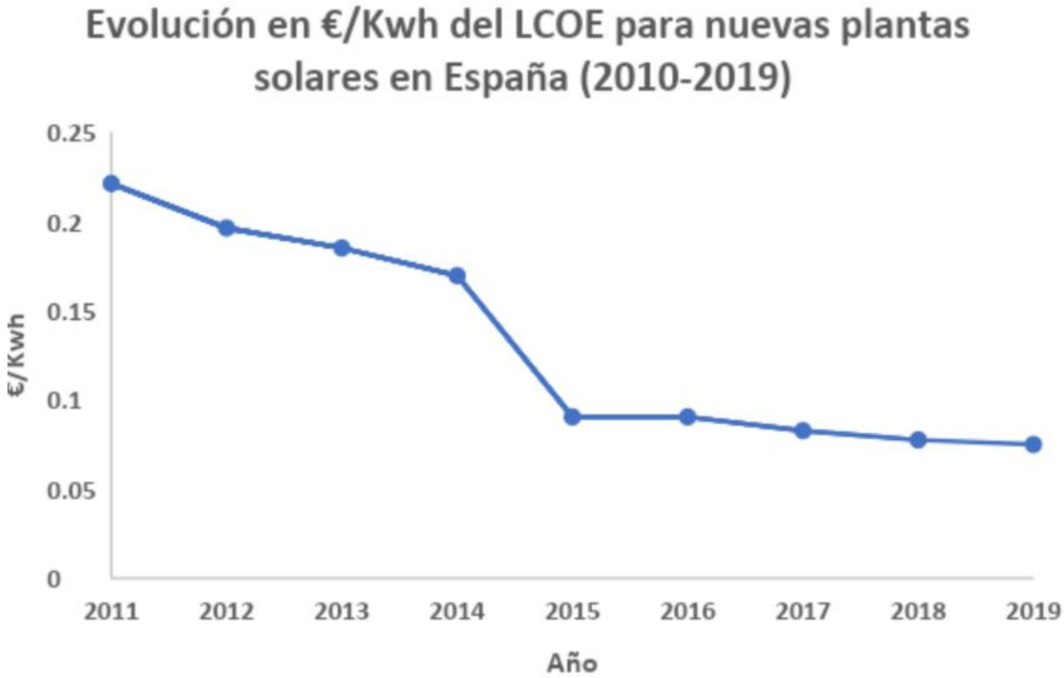
'Spain should build a massive solar array. Could power all of Europe.' According to Elon Musk, with the number of hours of sunshine per year that Spain has, and the high levels of radiation registered on the peninsula, a macro photovoltaic plant could supply electricity to the whole of Europe. Although this is an exaggeration, it has aroused the interest of the Spanish government and the European Commission, and despite the potential of taking advantage of this source of energy, in Spain we are currently nowhere near the levels of electricity generation through solar radiation that we could achieve.

It is true that Spain has one of the best solar resources in Europe due to our temperature and daylight hours. In this sense, we are one of the countries with the greatest natural wealth in the world. We enjoy an average of 300 days of sunshine a year, with an average of 2,500 hours of sunshine. Thanks to this, the capacity of solar panels is much higher than in other European countries. In addition, the price of solar energy, with the new measures and in comparison with the rest of Europe, is very competitive. However, as Minister Pedro Duque says, 'There are many projects, but the procedures are slow and more time is wasted than it should be. A year that we have lost for paperwork in a photovoltaic plant in operation is a year of CO2 that could have been avoided, of wealth that has not been generated and of energy that could be cheaper'. As has already been mentioned, although Spain has made great progress in the generation of electricity, the legal procedures for the installation of large solar plants are still too long and generate almost interminable waiting times.

As a result, the Spanish government has decided, as a measure to encourage the purchase and installation of photovoltaic panels for companies or for private use, to provide citizens with a series of grants and long-term benefits in order to make the purchase and installation of panels cheaper and thus provide us all with a higher percentage of clean energy.

Still on the subject of economics, it is inevitable that the evolution of the normalised cost of solar energy (LCOE) should be addressed. The normalised cost of solar energy represents a net value of the unit cost of electricity over the lifetime of an energy source. It is calculated as the sum of the annualised capital and operating costs, divided by the sum of the annualised electricity production.

As can be seen in the graph below, the normalised cost of solar energy from solar panels installed in Spain has decreased at a considerable rate since 2010. This trend is mainly due to the economy of scale and the innovations that the sector has been implementing over the years, extending the useful life of the panels, reducing their maintenance costs and increasing their electricity production capacity.



Thanks to this extension of the useful life of the panels, as well as new technological improvements to increase their energy generation, it is expected that the normalised cost of solar energy will fall even further and allow solar panels to continue to be an attractive investment thanks to their safety and high performance.

In the same way, in the political year 2021, the Integrated Energy and Climate Plan in Spain was approved, which defines the objectives for the next decade in terms of reducing greenhouse gas emissions, renewable generation and improvements in energy efficiency.

Thus, among these objectives, it is proposed that by 2030 in Spain, renewables will provide 42% of final energy and 74% of electricity. Due to Spain's good climatological and geographical situation, compared to other European countries, one of the main renewable sources that will contribute to the decarbonisation of the energy mix will be solar energy.

Therefore, it has been demonstrated how photovoltaic energy can be competitive in the medium and long term, returning to society the economic contributions that this energy needs to develop, and how it must evolve to become competitive with the rest of the traditional energy sources, and other emerging ones in growth.

At this point, all that remains is to ask ourselves whether the measures proposed by the different bodies are the right ones, and above all whether they are realistic or utopian.

Speaking specifically of the EU, the objectives are well thought out and achievable, as they are technically feasible, but they depend on the political will of the member states, and with these policies the competitiveness of the European economy must be boosted, as we are in a time of uncertainty due to the great economic and social crisis that we are going through in Europe for reasons that are already known. It is important that the decisions taken are strategic, that they consider the medium and long term, and that they guarantee the competitiveness of each of the states, as we do not all have the same resources.

An important factor to take into account is energy dependence, which is why most of the policies carried out in Spain and the EU are aimed at reducing dependence and its associated risks, as it is necessary to counteract the risk posed by certain scenarios of an increase in fossil fuels. On the other hand, and taking into account the social crisis that is occurring in Central Europe, it is now when the development of certain energies that generate important business opportunities must be promoted.

It has therefore been observed what the role of photovoltaic generation is in covering demand in Spain, and how photovoltaic can assume an appreciable percentage of generation, not needing the excessive contribution of 'ordinary' generation, which can be substituted up to reasonable limits, increasing its proportion in the assumptions envisaged up to 2030. However, one of the main conclusions of this project has been that the photovoltaic industry, far from being burdensome for the country, plans to repay in the short term all the subsidised tariffs it has received throughout its development, firstly, through direct and indirect contributions, personnel costs, taxes, installation costs, etc. Secondly, when Grid Parity is achieved and it becomes competitive with respect to domestic tariffs, with the possibility of using the Net-Metering concept, and finally when it becomes competitive with respect to the generation mix. In short, photovoltaics, together with other renewable energy sources, will improve the Spanish energy situation, although this will take a long time, which requires the collaboration of society as a whole.

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