



an NTT DATA Company

Distributed Generation Concept and Case Study





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1 | CURRENT EUROPEAN ENERGY FRAMEWORK

The **energy sector is one of the most important sectors for the European economy**, since it provides employment for almost 2.2 million people, distributed between 90,000 companies throughout Europe. It is also a sector with great strategic value.



2,2M of employees generated by the **energy industry**

Energy prices affect the competitiveness of all economic sectors and on average represent 6% of annual household spending. With 74% reliance on imports, **the EU continues to be exposed to volatility in fossil fuel prices**, which are set at a worldwide level.



74% of EU energy dependence

Currently, **the energy sector is going through a profound transformation** driven by the **energy needs set out by the EU**, by the **new trends in the sector** and by the **development of different technologies** that give greater power to final consumers who are more educated about energy use. This transformation will significantly change the way energy companies relate to their customers from now on.



Renewable energy



Regulation



New Customer Role

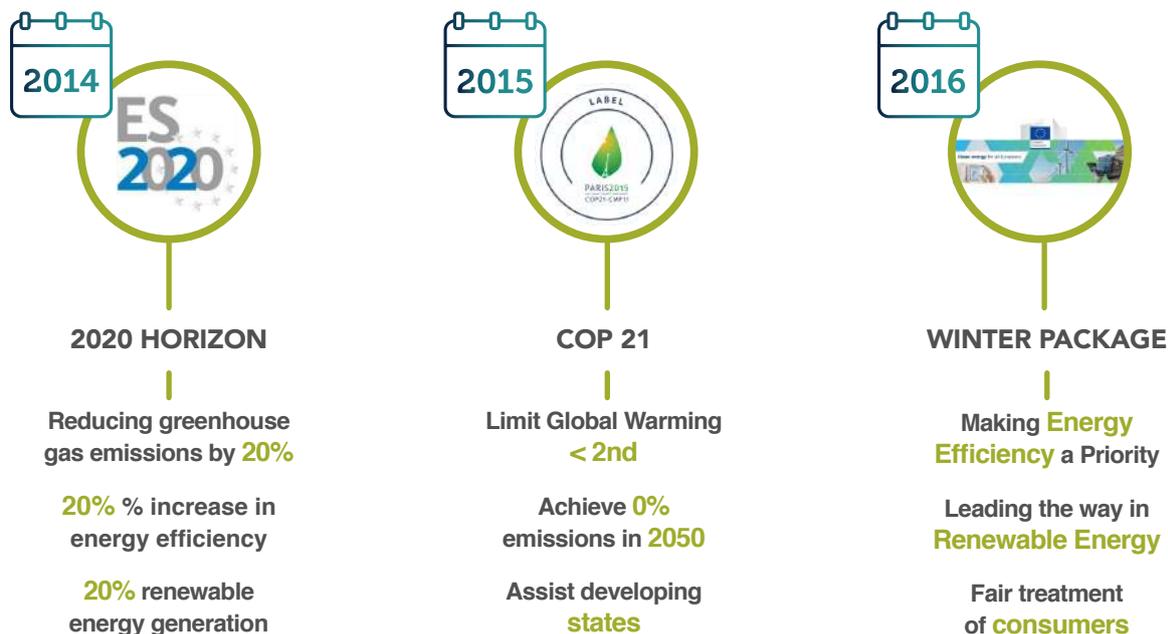


Digital transformation

The **EU has set out a route map** for European countries along the lines of **the development of renewable energies**, both to increase the efficiency of the electrical power system and to reduce the polluting emissions generated as a result of electricity production by means of non-renewable technologies, developing towards what are known as **distributed generation** and **energy self-consumption**.

This disruptive change in the sector will **generate new business models** through which the utilities can relate to their customers. These have now become **“prosumers”**, who have acquired an active role by becoming small producers who benefit from self-consumption and have the possibility of injecting their surplus energy into the grid.

The transformation towards a clean electrical power network that benefits all Europeans is being strongly driven by the EU through its participation in different agreements:



The latest proposal published by the European Commission is the **Winter Package**, which defines the route map for Europe in the **area of energy efficiency** and sets out binding **targets** along three main lines of action:



1. Putting energy efficiency first throughout the electrical power system in order to successfully take surplus production capacity out of the market, especially that for fossil fuels, through:

- Achieving **active demand management** that enables energy consumption to be optimised.
- **Reducing costs** to consumers and **dependence** on imports.
- Investing in **energy efficient** infrastructure.

“The cheapest and cleanest energy source is energy that does not need to be produced or used”.

2. Achieving global leadership in renewable energies. Europe continues to be the world leader in wind energy but has lost its leadership in solar energy. One of the pillars on which the EU bases its attempt to recover the leadership is its commitment to reduce emissions of **CO₂** by **40% by 2030** through:

- Driving the development of transmission and distribution networks that integrate energy self-consumption and distributed generation.



Global renewable energy investment forecast

€ 6,8 trillion
(2014-2035)

“Today’s package will boost the clean energy transition by modernising our economy”

Maros Sefcovic (Vice-President for Energy Union)

3. Providing a fair deal for consumers. Consumers must be seen as the fundamental pillar in the entire electrical power system, as a result of:



Quality information



Active role in the energy market



Greater cost control

The new objectives and regulatory changes, and the **evolution** from conventional, centralised production to **interconnected, smart and decentralised markets** will enable:

- **Consumers** to generate, store, share, consume and/or sell **their own energy** on the market.
- The **active control and management** of both the consumption and production of energy by prosumers as a result of **new smart technologies**.
- The active participation of households and companies in the energy system, which will give rise to **new business models** through which **companies will be able to offer** a wider range of **higher quality services**.

Thus, **innovation and digitisation will be promoted** and European companies will be helped to **successfully increase their energy efficiency** and base their systems on low-carbon technologies.

“Our proposals provide a strong market pull for new technologies, set the right conditions for investors, empower consumers, make energy markets work better and help us meet our climate targets”

Miguel Arias Cañete (Commissioner for Climate Action and Energy)



2 | ENERGY CONTEXT: SPAIN

As a country, Spain is highly dependent in terms of energy since it uses imported fossil fuels to meet most of its energy demand (86.1%). However, it has huge potential for generating energy through renewable fuels, principally through wind energy and solar energy.

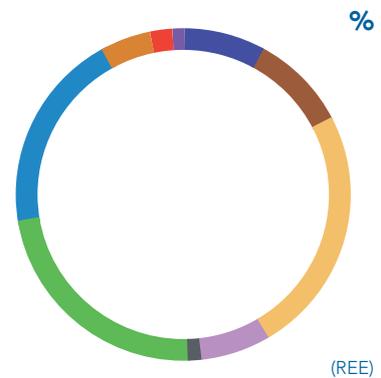
The installed capacity for electricity generation is distributed through a transmission network of over 43,000 km, and there is a degree of parity between installed conventional energies (49.5%) and renewables (50.5%).

INSTALLED CAPACITY AT 31 DECEMBER 2016

100,088 MW

● Nuclear 7,6	● Wind 22,8
● Coal 9,5	● Hydro 20,3
● Combined cycle 24,9	● Solar Photovoltaic 20,3
● Cogeneration 6,8	● Solar thermal 2,3
● Waste 0,7	● Other renewables 0,7

(1) Includes net pumping power (3,329 MW).



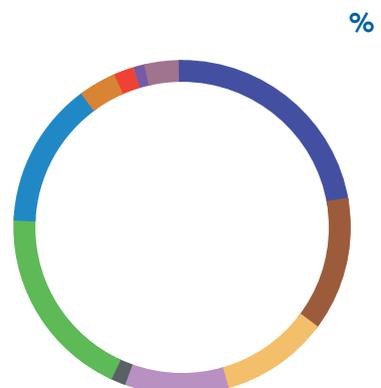
(REE)

Spanish electricity demand in 2016 amounted to 250 TWh, which was met through conventional sources (58.9%) and renewable generation (41.1%), showing great dependence on carbon and nuclear energy.

COVERAGE OF ELECTRICITY DEMAND 2016

● Nuclear 7,6	● Wind 22,8
● Coal 9,5	● Hydro 20,3
● Combined cycle 24,9	● Solar Photovoltaic 20,3
● Cogeneration 6,8	● Solar thermal 2,3
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● Net imports resulting from international energy exchanges	

(1) Excludes pumping.

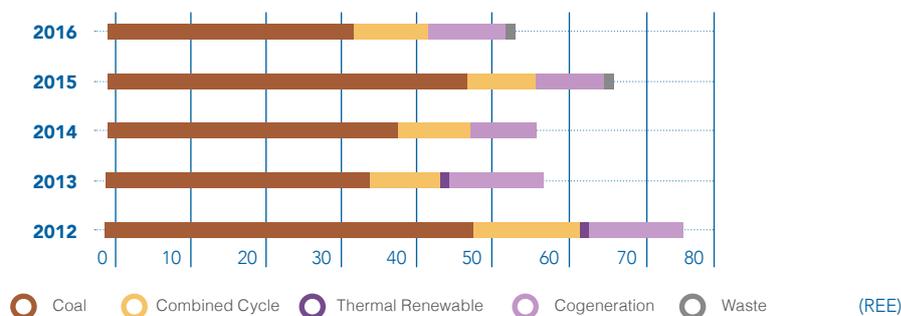


(REE)

On average, electricity generation entails total emissions into the atmosphere of 55 million tonnes of CO₂, the source that contributes the most to these emissions being carbon (60%).

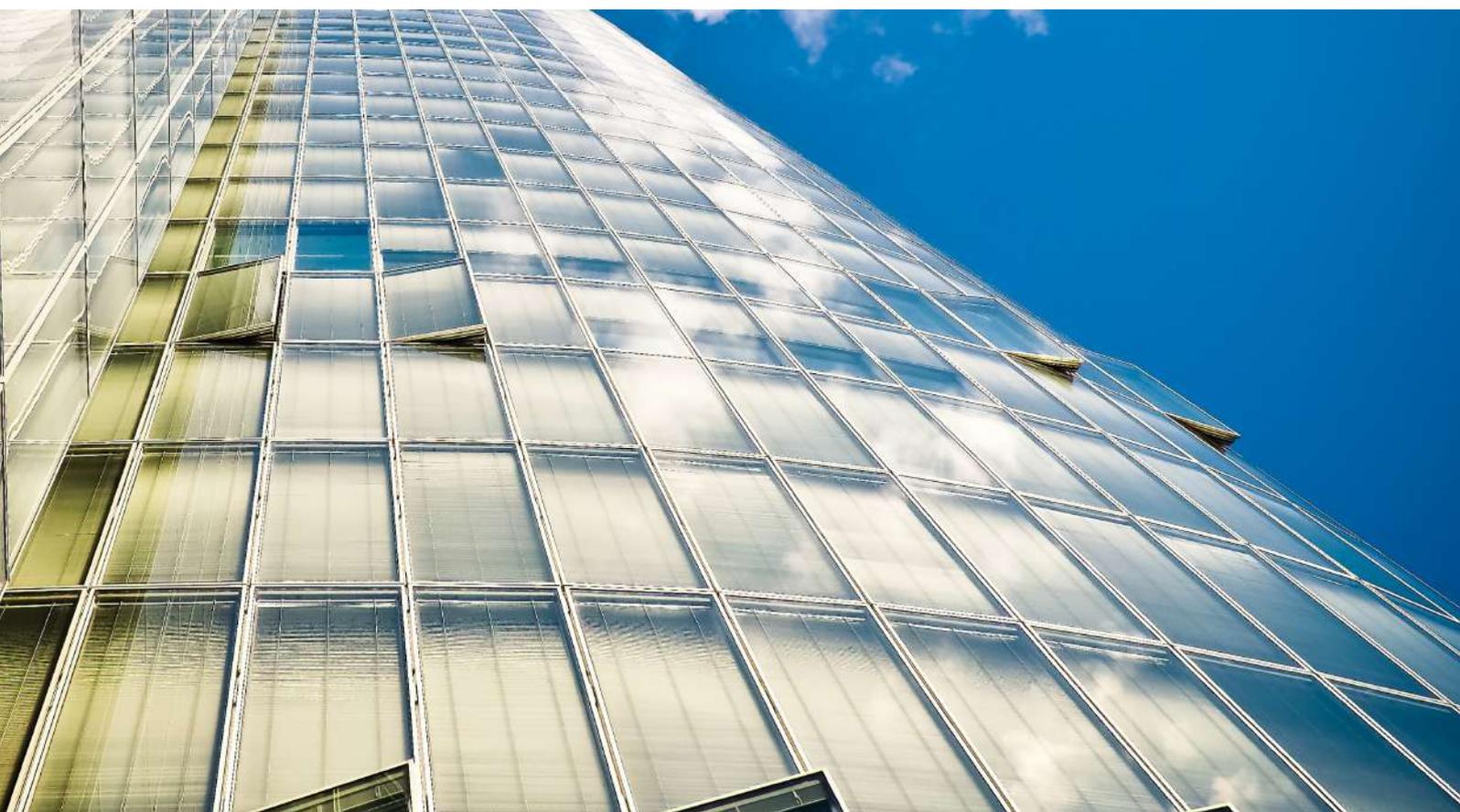
EVOLUTION OF CO₂ EMISSIONS ASSOCIATED WITH ELECTRICITY GENERATION IN THE IBERIAN PENINSULAR

Mill. tCO₂



In spite of having been one of the benchmark countries both at the European level and worldwide with regard to renewable energies, in recent years Spain has been developing more slowly than other European countries, which currently lead on *interaction between the prosumer and the electrical grid* (net balance and/or sales of energy to the grid), *the development of renewable energies*, and evolution towards an energy environment that is based on *distributed generation* in the urban context.

Thanks to the measures *being driven by the EU*, considerable development is foreseen in terms of *renewable energies* geared towards *distribution* and towards *energy self-consumption*.



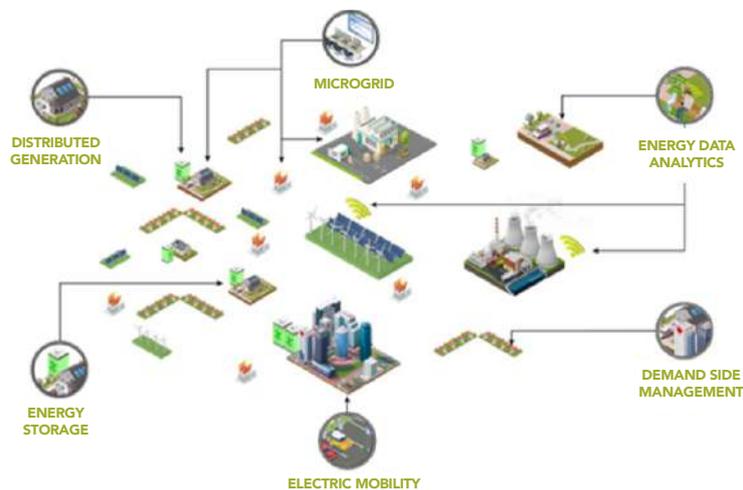
3 | DISTRIBUTED GENERATION

Distributed generation is changing the way in which energy is produced, reducing the use of conventional energies and strengthening the development and use of renewable energies. The main philosophy is based on citizens sharing the renewable energy they produce, transforming the electrical power system into a distributed system in which energy is generated by small renewable energy installations distributed throughout a whole city.

Among the many advantages that distributed generation has, we could highlight the following:

- It increases the use of renewable energies and reduces emissions of CO₂.
- Losses through the electricity grid are reduced as generation centres are brought closer to points of consumption.
- It improves the quality and reliability of the electrical power system since there are generation sources distributed throughout the territory, thus increasing the reliability of the system faults when occur.
- Reduction in the economic costs of the system as a result of its increased efficiency, since it is based on a distributed rather than a centralised system.
- It enables optimisation of demand for electricity and improvements in the service, both in areas that are distant from the grid and in areas where the grid is overly saturated.

This evolution of the electrical power system produces a series of key opportunities and new business models which are applicable across the whole energy value chain, and which challenge the traditional model by means of an energy development that is geared towards the evolution of renewable technologies (Cleantech). The future outlook produces a change in thinking in which energy ceases to be simply a commodity and becomes a generator of services and business.



Consumer

Their role changes from merely wanting to be supplied with energy and they become active agents (prosumers) in the market to help meet energy demand.

As prosumers they will have the right to generate, store, consume and sell self-generated electricity in the organised market.



Utilities

They are no longer merely providers of a “commodity” and become service providers. They must adapt to new market conditions that involve a totally disruptive change in operating philosophy since now they will need to be integrated and act jointly with their customers.

They start managing a multipass network in which power and information flow in multiple directions.

The system changes from a centralised system to a distributed system requiring a very thorough control and real-time balance.



TSO

Storage devices become necessary to enable the integration of renewable energies. The electric car used as a storage battery equips the system with a pool of storage batteries scattered throughout the country.

E-mobility also brings the new concept of “dynamic batteries”: a new agent system that allows energy to be used somewhere other than where the recharging took place. The electric car acts as a DSO.



Electric car

The focus will be put on the development of smart networks based on sensing and network monitoring. Operating and maintenance processes will be upgraded to ensure the security and stability of the system, taking into consideration the impact involved in the introduction of prosumers and electric vehicles in the energy pool.

They will manage the energy pool that feeds into the SmartGrid and goes from comprising a small number of production plants to include a large number of micro-plants that generate energy for both home use and to meet the needs of grid, relying on energy management and demand supply systems.

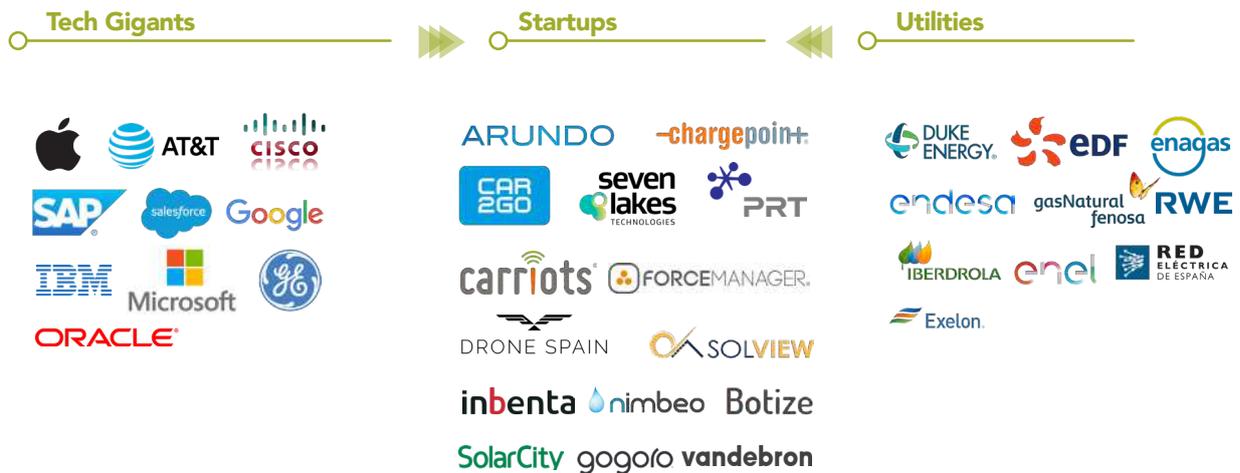
This whole evolution of the electrical power system requires powerful technological support in order to reliably manage the grid with all of its new players. This support runs from the management of consumption, the quantity of energy produced by the consumers and the subsequent bi-directional communication of this information with the grid thanks to the Internet of Things (IoT) and smart meters, to the interactive, unified control of all the renewable microplants and static and dynamic storage elements that are being developed with what are known as virtual power plants (VPPs).

In addition, with artificial intelligence and advanced analytics techniques, this management of the grid can be made efficient as well as reliable, enabling all the players in the new system to have useful information available which enables them to optimise the energy ecosystem as a whole.

4 | NEW ENTREPRENEURSHIP ECOSYSTEM IN THE ENERGY SECTOR

With the change that the energy sector is going through currently, it is no longer only the utility companies that play an active role. A role is also being introduced for start-ups and “technology giants”, creating an ecosystem of alliances which is accelerating the adaptation of the sector to the new scenario.

On the one hand, a large number of start-ups are breaking into the digital market in the utilities sector, focusing their strategy on disruptive innovation. On the other hand, there are the big tech companies investing in the value differential that these start-ups contribute to the market, since they have the potential to develop solutions with reduced time to market and more limited capital investment than the tech giants themselves.



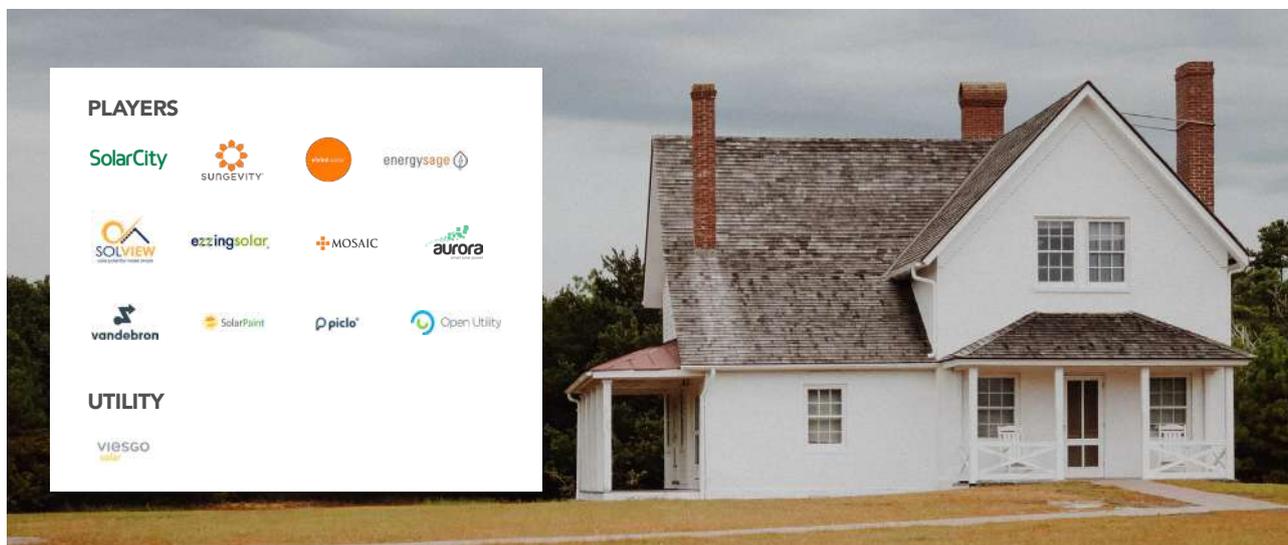
Following a study conducted by Everis, which assessed information from more than two million start-ups included in the Everis NEXT repository, it is clear that the main technologies that these new business models are investing in, with capital of more than \$ 144 billion, are:



In addition, the conclusion was that more than 2,000 start-ups focus their investments on distributed generation, with total capital exceeding \$22.9 billion, which comes from more than 1,000 different investors. These start-ups seek to adapt themselves to the evolution of the sector, gearing their activities towards:

- Enabling the final customers to have renewable installations available in their homes with minimal investment.
- Basing platforms on new technologies to help the public utilities improve their handling of customer data, enabling them to meet the demands of the market more reliably and efficiently.
- Developing business models that enable the utilities to increase their levels of renewable energy by using their customers’ installations, without the need for big investments.
- Solutions that transform the current electrical grid into a network that manages the energy flows of both the customers and the utility companies in real time, and facilitates the sharing of energy between all the players.

Among the start-ups with the most advanced solutions and developments and utilities that have started their conversion to the new electrical power system, the following stand out:



Some of the most distinctive business models from among these start-ups are:

SolarCity

recently acquired by Tesla, establishes marketing models with local customers based on leasing contracts of solar panels and roofs in order to sell the surplus to the market.

SOLVIEW

develops smart algorithms that enable calculation of the solar potential of an area (tiled and other roofs, etc.) through image recognition.

vandebron

Develops a distributed generation platform for the purchase and sale of energy on the market, managing both the energy exchange and the associated payments.

5 | CASE STUDY

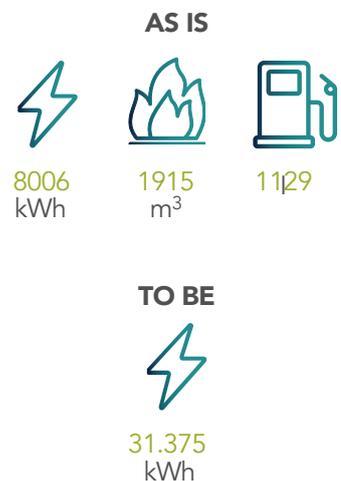
In an attempt to demonstrate both the feasibility and the necessity of evolving towards the energy sector proposed by the European guidelines, a **case study** was carried out on a **real home** in which a **photovoltaic solar installation was dimensioned** to respond to the home's actual energy consumption and the additional need for electricity required by the **inclusion of an electric vehicle**. All this was based on the **regulatory environment of net balance for energy self-consumption**, with no restriction on the injection of surplus energy.

5.1 Details of the home



Location of the house: **Madrid, Spain**
 Available roof area: **80m²**
 Roof orientation: **South**

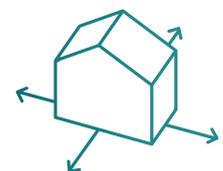
The design home initially met its energy needs from three different sources: electricity, natural gas and transport fuel. **In an attempt to take maximum advantage of the energy production of the photovoltaic installation, all the previous demands came to be met with electricity:** heating and domestic hot water went from being met through natural gas to being met with electricity, and transport began to be carried out with an electric vehicle instead of one with conventional combustion.



5.2 Design of the solar installation

The study was projected forward by 25 years, and **to optimise the design, three different configurations were studied**, accounting for the maximum loss of performance guaranteed by the manufacturer (20%).

- Panels with optimum tilt angle, with no shadow
- Panels with optimum tilt angle, with shadow
- Panels with the tilt angle of the roof, with no shadow



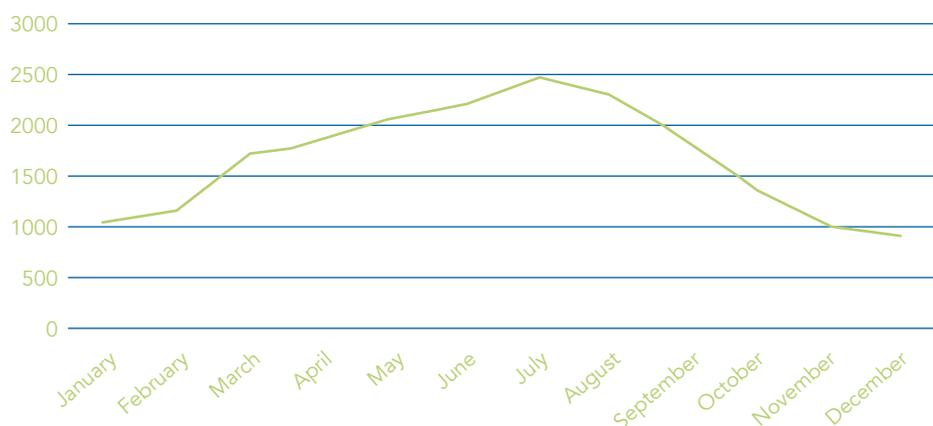
Following analysis of the three configurations it was concluded that, according to all the energy, economic and environmental results obtained and also assessing the urban aesthetics, the **optimum design was that of installing the solar panels on the roof with the same degree of tilt as the roof itself**. Thus, **a design installation was obtained at a cost of no more than € 12,000, consisting of 42 panels installed on the roof of the home**.

5.3 Energy results

As a result of the installation of the solar panels in the home studied, a **total generation** estimated at **451,808 kWh throughout the first 25 years** was obtained. That production would **meet on average 57.6% of the annual demand of the home**, so there is a **need to use energy storage**. This storage can be provided by batteries (storage batteries / electric vehicle) or by the conventional grid in the context of net balance without restrictions on the injection of surplus energy.



Average monthly energy production



The **interaction of energy with the conventional grid, which has evolved into the smart grid environment**, enabled both the entirety of the home's demand to be satisfied and the injection of the surplus energy generated. The highest monthly amount of energy taken from the grid occurred in December (4,864 kWh), while the greatest injection of surplus energy occurred in the month of July (1,332 kWh).

5.4 Environmental results

Thanks to renewable generation in the home and to the electric vehicle transport, a **total emissions saving** in the 25 years of useful life guaranteed by the manufacturer of the installation of **188.55 tonnes** was achieved.



In addition, a study to provide environmental justification for the electric vehicle was carried out, analysing three battery recharging scenarios (a 100% renewable grid, a 0% renewable grid and the current Spanish grid):

Red	Combustion vs e-mobility	
100% Renewable	0,62	0
0% Renewable	0,62	1,21
Spanish Now	0,62	0,38

Kg_{CO₂}/kWh_{final}

As the study confirms, environmental feasibility is directly related to the level of renewability of the energy with which the batteries are recharged: it can actually reach 0 emissions in a 100% renewable environment. The most interesting conclusion obtained was that currently in Spain, an electric vehicle saves around 40% of the emissions of a combustion vehicle.

5.5 Economic results

The economic analysis carried out was divided into two parts, an analysis of the costs and an analysis of the profitability. The results of both were favourable to the objective pursued, of demonstrating both the feasibility and the necessity of developing the current Spanish energy environment towards an environment based on distributed generation with energy self-consumption and energy storage.

Cost analysis		Profitability analysis s de Rentabilidad		
Total savings	Total costs	VAN	TIR	PayBack
2.043 € año	11.793 €	20.307 €	17,57 %	6 años

5.6 Conclusions of the case study

This case study shows the importance of driving the development of the current electrical power system towards an environment based on distributed generation in which energy production is carried out with renewable sources. It demonstrates:

- hat photovoltaic solar technology is a viable source which will enable a large proportion of household energy demand to be met.
- That projects like this can be viable energy-wise, environmentally and economically.
- The importance of investing in new technologies and evolving towards an electrical power system that is based on distributed generation, which enables more efficient use of resources.





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