From energy consumer to energy prosumer:
a sustainable project for Barcelona

Gemma Puigbó I Camps, Joan Sierra Sánchez, Luis Monzón Holguin and Meritxell Ibáñez Torres

Advisor: María Gundín Castro

Project Code: GME01

Academic Year: 2021 - 2022
ABSTRACT

In a changing environment such as the current one, in which society is increasingly aware of the environment, while the fossil fuel energy market weakens, it is necessary to move towards an ecological transition in which solar energy plays a fundamental role.

For this reason, in this study, not only a quantitative but also a qualitative analysis of the energy market and the installation of solar panels in Barcelona will be carried out - taking into account all its aspects: costs, public and private funding, taxation and subsidies, geographical location, among others - to be able to finally conclude that carrying out this type of project in Barcelona has notable advantages over carrying it out in other places.

**Key words:** sustainability, solar panels, energy market, solar energy, Barcelona, renewable energy, fiscal incentives, funding, environment, social awareness.
# TABLE OF CONTENTS

1. **INTRODUCTION**  

2. **ANALYSIS OF THE STATE OF THE ENERGY MARKET**  
   2.1. Beneficial trend changes for Spain  
   2.2. Main sources of energy in Barcelona  

3. **THE INSTALLATION OF SOLAR PANELS**  
   3.1. A cost analysis for the city of Barcelona  
   3.2. A benefit analysis for the city of Barcelona  

4. **TAX INCENTIVES AND SUBSIDIES FOR THE INSTALLATION OF SOLAR PANELS**  
   4.1. Fiscal incentives to the installation at a local level: the case of Barcelona  

5. **FUNDING FOR THE INVESTMENT OF THE INSTALLATION**  
   5.1. Public funding  
   5.2. Private funding  
   5.3. The ethical banking and sustainable projects  

6. **QUALITATIVE STUDY OF THE PROJECT**  
   6.1. SWOT analysis  
   6.2. Social Awareness  

7. **CONCLUSIONS**  

8. **BIBLIOGRAPHIC REFERENCES**
1. INTRODUCTION

Europe’s current energy crisis represents a critical problem for the society and the economy of the continent. The scarcity and the location\(^1\) of available fossil fuels plays an important role in geopolitical conflicts in which Europe finds itself. Following this idea, as the diplomatic relationship between Europe and a big supplier of fossil fuels - such as Russia - deteriorates\(^2\), energy security policies raise as a priority within the members of the European Union in order to turn their countries from dependent to self-reliant. When Europe adheres to common objectives such as the Paris Agreement, in which it is stated that carbon neutrality must be reached by 2050\(^3\), countries join forces to tackle climate change by searching for solutions. These solutions are based on the development of renewable, clean and inexhaustible energy that may someday become a substitute product for fossil fuels\(^4\). The goal of our project is to explore the renewable energy sector, specifically the solar energy sector in Barcelona, in order to find conclusions on its current state and market prospects.

The procedures for this project will be grounded on finding, recollecting and interconnecting information extracted from previous academic papers and formal documents in order to constitute an objective analysis of the solar energy sector in Barcelona. Firstly, a qualitative study will be carried out on the costs and benefits between renewable and non-renewable energy. This comparison will be strengthened by a SWOT\(^5\) analysis. Later on, the focus will be on the exploration of the legal aspects as well as subsidies for the installation of solar panels granted not only by the local administration but also by national institutions within the European continent. Additionally, the incentives from some governments will be contrasted in order to highlight how important they are in the race to embrace eco-friendly approaches. Another section will be dedicated to the economic analysis of the level of access to credit and external funding of agents involved in the installation of solar panels. The benefits coming from the installation of solar panels will also be discussed in the aim of arguing the potential economic value from the development of this sector in the city. Eventually, some conclusions

---


\(^5\) SWOT stands for: strengths, weaknesses, opportunities, and threats. This business analysis framework will be used to evaluate the solar panel sector’s competitive position in Barcelona.
will be stated and certainly will help the reader to acquire a more accurate perspective on the energetic, sustainable transition in Barcelona.

In terms of academic basis, this essay will essentially rely on official reports from recognized and prestigious institutions in the academic field, such as the United Nations Organisation (UN), the World Bank, the International Monetary Fund, among others. The current legislation will be consulted for all matters of a legal nature on which the analysis will be based. Given the current controversy of the topic discussed, the press will additionally be referred to in the goal of incorporating crucial, contemporaneous information on political, social and economic issues.

2. ANALYSIS OF THE STATE OF THE ENERGY MARKET

As of today, a large part of global emissions originate from the generation and consumption of energy in the cities\(^6\), mainly from non-renewable sources such as coal, oil and natural gas. Global cities play a very important role in this field as they are the main consumers accounting for 78% of the demand\(^7\). This consumption includes all types of activities, from economic and industrial activity, through modes of transport to household consumption.

Besides that, currently most cities can play a very important role in reducing the consumption of this energy to promote more efficient and beneficial options not only for the environment, but also for the well-being of citizens. The Spanish decentralised government system serves as an example of the importance for its different regions to thoroughly create, implement and control their energy policies, as well as it becomes essential to efficiently coordinate the centre with these regions so as to achieve the national energy targets.

Spain, as a member of the European Union, is currently developing its energy policy in compliance with the European Union’s 2030 Climate Target Plan\(^8\), which is a guide for its member states to increase their energy efficiency and consumption rate of renewable energy.

---


From energy consumer to energy prosumer: a sustainable project for Barcelona - GME01

That is, Spain is now focusing on cutting greenhouse gas emissions and incrementing the share of renewable energy, while reducing consumption. More specifically, and according to the Integrated National Energy and Climate Plan 2021-2030 (INECP), the country should be able to achieve the following targets by 2030:

Table 1. 2030 targets of the energy sector in Spain and its comparison with recent data.

<table>
<thead>
<tr>
<th></th>
<th>2020 Comparison</th>
<th>2030 Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gas emissions compared to 1990</td>
<td>17.9% (1990-2017)</td>
<td>- 23%</td>
</tr>
<tr>
<td>Energy efficiency (+39.5%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Primary energy consumption (Mtoe)</td>
<td>122.6</td>
<td>98.5</td>
</tr>
<tr>
<td>- Final energy consumption (Mtoe)</td>
<td>87.23</td>
<td>73.6</td>
</tr>
<tr>
<td>End-use energy from renewable sources (share)</td>
<td>20%</td>
<td>42%</td>
</tr>
<tr>
<td>Renewable energy in electricity generation (share)</td>
<td>43%</td>
<td>74%</td>
</tr>
</tbody>
</table>

Source: Own elaboration based on data obtained from the INECP 2021-2030

Despite meeting the European target of covering at least 20% of the demand with renewable energy in 2020, and managing to surpass the average 19% emission reduction of Europe, by reducing them almost 27% between 2005 and 2019, the country has a long trajectory to become a responsible energy generator and consumer, as can be seen in Table 1. Mainly due to road transport, electricity and households, it is one of the five EU states which

---


have not been able to effectively decrease emissions in comparison to 1990\textsuperscript{12}, even though it has experienced a greenhouse gas (GHG) emissions reduction during the last years, especially during the COVID-19 outbreak, which caused a temporary drop\textsuperscript{13}.

For instance, Chart 1\textsuperscript{14} illustrates a decreasing tendency of carbon dioxide emissions in Spain, as well as the mentioned 2019 pandemic drop: the country experienced reduction rates of 2.4\% between 2017-2018 and 7\% between 2018-2019, followed by a substantial reduction of 18.7\% between 2019-2020. Despite this positive evolution, Spain still was 2.7\% above 1990 CO2 levels in 2020, and 82\% above 1970 CO2 levels.

Chart 1: Annual carbon dioxide emissions in Spain (2005-2020)

![Chart image]

Source: Own elaboration based on data obtained from Statista

2.1. Beneficial trend changes for Spain

Notwithstanding, the current situation presents an opportunity for Spain to optimally invest in the energy transition it has needed for a long time. Being able to positively manage the substantial impact of the pandemic, as well as the funds derived from it (i.e., Next Generation EU fund), would not only make it possible for it to reach the European climate change targets, but it would also help decrease its long lasting dependency on foreign


sources, for which its energy sector is historically known. Its imports, which still accounted for 67.89% of its energy in 2020\textsuperscript{15}, could drop to 61% in 2030 if given the correct implementation of the exhaustive, yet realistic, measures proposed in the Integrated National Energy and Climate Plan.

The rigorous policy plans bring us back to the key element of enhancing the state coordination with regional authorities. In addition, to reach the potential results, it becomes essential to create a detailed regulatory framework, and for all involved authorities to efficiently manage public financing and private investment incentives.

The planned investment focuses on renewable electric and thermal energy sources, in particular, solar and wind energy, which accounted for approximately a third of the Spanish energy generation in 2021\textsuperscript{16}, specifically, a 10% and a 23%, respectively, as can be seen in Chart 2. Moreover, the Spanish government considers renewable hydrogen as crucial and has recently approved a hydrogen roadmap, which it considers key to achieve climate neutrality by 2050 at the latest.

\textbf{Chart 2: Generation structure by technology (GWh), 2021}

\begin{center}
\begin{tikzpicture}
  \pie{Non-renewable waste; 22.38; 1%, Renewable waste; 87.8; 0%, Nuclear; 54.04; 2.3%, Coal; 49.86; 2.3%, Fuels + Gas; 0; 0%, Diesel engines; 25.17; 1.1%, Steam turbine; 11.08; 0.4%, Gas turbine; 4.24; 0.1%, Combined cycle; 4.44; 0.17%, Hydrogen; 3; 0%}
\end{tikzpicture}
\end{center}

Source: Own elaboration based on data obtained from REData


In addition, the plan has the objective of boosting the decentralised generation of renewable energy and own consumption, as well as it plans to increase citizen participation in demand management and local energy communities\textsuperscript{17}.

Regarding the case of Barcelona, it has experienced a slow reduction in final energy consumption during the last 20 years, with a negative growth rate of close to 2% per year.\textsuperscript{18} This trend is due to both the technological improvement of electronic devices and the decrease in private vehicle travel, and a greater renewal of the city's vehicle fleet as of the restrictions due to the low emissions areas.

In recent years, the total amount of energy consumed in the city is around 16,000 GWh, although it should be taken into account that energy producers have to generate more energy than energy demanded to compensate for the loss of energy of transportation. Because of this, many efforts have also been made to improve the efficiency of the electricity sector from 33.6% to 40.7% from 1999 to 2019\textsuperscript{19}.

\subsection*{2.2. Main sources of energy in Barcelona}

In this part of the analysis, we are going to study what are the main sources of energy used in Barcelona. When it comes to the sustainability of energy sources, it is important to note that there is much work to be done, as according to the municipality's records only 9% of the energy consumed today comes from renewable sources.

At the time of evaluating sources of greenhouse emissions in the city, in 2018, electricity was the third principal factor of these emissions. As illustrated in Chart 3, it accounted for roughly 20% of them, right behind natural gas and automation, respectively.


\textsuperscript{18} Municipality of Barcelona. (2018). Balanç d'energia i emissions de gasos amb efecte d'hivernacle de Barcelona.

\textsuperscript{19} Municipality of Barcelona. (2018). Balanç d'energia i emissions de gasos amb efecte d'hivernacle de Barcelona.
From energy consumer to energy prosumer: a sustainable project for Barcelona

Chart 3: Sources of Greenhouse Emissions (2018)

Source: Energy balance of Barcelona’s Municipality

The main sources of emissions in Barcelona are: transport, households and commercial, as detailed in Chart 4. The data from Chart 3 and Chart 4 suggest that efforts have to be made in order to decrease the greenhouse emissions in the city, especially by depending mostly on renewable energy to later on carry new projects such as electrifying the vehicle fleet using more sustainable sources, switching natural gas systems in the households and enterprises to electric systems or incentives to cutting down energy consumption to reduce energy used for unnecessary purposes.

Chart 4: Greenhouse emissions by sector (2018)

Source: Energy balance of Barcelona’s Municipality

According to the data published by C40 Cities, a global city network confronting the climate crisis, Barcelona had one of the lowest per capita emissions in Europe in 2018. Despite

---

21 C40 Cities. (2018). Data provided by the cities publicly and recompiled by the organisation and mentioned in (18).
being more sustainable than many European cities, the city is committed to halve the greenhouse gas emissions by 2030 with respect to 1992. For instance, according to the municipality’s agenda, they are committed to foster measures to increase the sustainability of the city by rehabilitating old buildings; to multiply by 5 the generation of solar electricity; and to totally reduce energy poverty, so as to become carbon neutral by 2050. However, many measures will have to be created for such objectives to be achieved, and the importance for policymakers to analyse the successful plans being carried out by similar cities so as to act fast and efficiently only increases with time.

3. THE INSTALLATION OF SOLAR PANELS

One of the most ambitious measures is the production of solar energy on a large scale in cities, being installed on most rooftops where the technical characteristics are favorable and may supply 30% of the annual city’s demand, according to some studies carried out in many Asian, European and North American cities.

In this section, a market analysis is conducted so as to estimate the costs and benefits of installing solar panels, regarding both monetary and non-monetary aspects (i.e., CO2 levels, bureaucracy, etc.).

3.1. A cost analysis for the city of Barcelona

Given the promising plans around the potential of solar energy, it is important to conduct an analysis of the costs involved in its generation. In this section, the focus will mainly lie on studying the approximate initial investment concerning photovoltaic installations, which has decreased during the last years, due to technology innovation, tax reductions and other policy tools, yet is expected to suffer a raise throughout 2022 due to the following factors: a demand increase; material shortages due to the supply chain crisis; higher transportation costs; unexpected delays because of covid restrictions; as well as the inflation and the higher interest rates and increasing discount rates.

---

Such calculation can be a burden given that there are no fixed installation costs, but everything depends on many factors, such as the city of residence, the type of building or house, the square metres of the property, its orientation, its roof, the chosen solar panels, the hired potency, the need for a crane, the hired workforce, etc. That is, an initial problem concerning the installation of solar panels could be the lack of precise information: each household has to ask for a personalised study so as to know the costs and benefits its installation will generate.

That being said, it is possible to study the average costs of such installations in Barcelona, always keeping in mind that such estimates could suffer large variations depending on the household, the energy company and the panel selection.

A method to calculate the average cost of solar panels would be conducting an “euro per watt” calculation: to check the amount of generated and consumed watts (W) so as to estimate the amount of money needed.

First of all, in Spain, households paid around 1.3€/watt in 2020 for a solar panel installation. However, Barcelona citizens can benefit from Spanish and Catalan subsidies which can make this price go down. For instance, residents could reduce the price between 0.3€ and 4.55€ per watt, depending on the installed power, the beneficiary and the used technology, if managing to benefit from the grants of the catalan Program of incentives linked to self-consumption and storage, with renewable energy sources and implementation of renewable thermal systems in the residential sector.

Secondly, different types of solar panels exist (e.g., polycrystalline, monocrystalline, PERC, thin-film, etc.), each of which has different characteristics, such as the efficiency rates or their maximum power. Not going into further detail, choosing a standard efficiency solar panel of 250-300W, the approximate cost would be around 357,5€ per solar panel before applying the local subsidy, and an average of 275€ afterwards, if applying the minimum reduction of the mentioned catalan subsidy (i.e., -0.3€/W).

---


Thirdly, the amount of solar panels needed has to be established, which can be done by comparing the quantity of power generated by a single solar panel with the average power consumption of the citizens, which amounts to an average of 3.272K/year\textsuperscript{26}. In this case, a solar panel of 250-300W has been selected, which means it will generate this power for each sunny hour. According to the Instituto Geográfico Nacional, Barcelona has around 2,200 hours of annual insolation, that is, an average of approximately 6h/day\textsuperscript{27} if simplifying the solar differences between seasons and adverse climate conditions. Then, the mentioned solar panel would generate an average of 1,650W/day, which equals 602.25kWh/year. That being said, a total of 6 solar panels of 250-300W would be needed to fulfil the needs of the average citizen, which would amount to a total of around 2,145€ without a subsidy and 1,650€ after applying the -0.3€/W subsidy selected for this calculation example.

However, one can quickly realise just by skimming at corporate websites of the energy sector (e.g., Otovo\textsuperscript{28}, SotySolar\textsuperscript{29}, HolaLuz\textsuperscript{30}, IKEA in collaboration with Contigo Energía\textsuperscript{31}, etc.) that organisations which conduct such installations tend to offer quite higher prices, typically around 5,000€ if it is for an average residential use, although costs can go up fast.

The reason for this difference lies on the fact that an important part of the installation costs come from the following elements: the workforce, which normally costs around 20€-30€/h; components, like installation rails, a solar inverter, solar batteries or wiring, among others, which cost an average of around 50€/panel, 1,500€, 1,500€, 1€/m, respectively; as well as the previously mentioned differences in location, orientation, type of roof, etc., which can increase both the workforce and components costs, or even arise the need for extra solar panels.


Apart from the installation costs, the future owners of solar panels must also consider several less significant costs which they will incur during the installation process and once it ends, such as: the costs to manage the application for grants, as well as the administrative processes, which might include a building licence or administrative authorizations and legal requirements; and the maintenance costs, which highly vary depending on the type of maintenance hired by each household, its regularity and the different offers of the chosen company, among others.

However, all the energy companies studied throughout the making of this project already include the paperwork management in its installation costs, mainly due to the non-monetary cost that they represent for potential owners of solar panels, who know little about administrative requirements and would rather pay a little more to ensure this management is taken care of by the installation company. In addition, these companies are prepared to highly adapt to the maintenance needs of the different customers, for which the main costs that potential buyers of solar panels face are the initial lack of knowledge, in non-monetary terms, and the initial investment, in monetary terms.

3.2. A benefit analysis for the city of Barcelona

In this section, both the monetary and environmental benefits derived from the installation of solar panels in one’s residence will be studied, with the objective of comparing them to the costs of the previous section, 3.1. A cost analysis for the city of Barcelona, and being able to establish whether such installations are a profitable investment or not.

According to most solar panel specialists (e.g., Smart Spain\textsuperscript{32}, SotySolar\textsuperscript{33}, EnergySage\textsuperscript{34}, HolaLuz\textsuperscript{35}, etc.) the standard lifespan of solar panels is about 25 to 30 years, establishing an average amortisation period of 7 years. This equals an average of 18-23 years of free energy, although, as it is typical when it comes to these types of installations, the amount of years can vary due to factors affecting the amortisation, such as: the installation size, the solar irradiation, the orientation of the solar panels, the quality of the installation.

\textsuperscript{32} Smart Spain. (2020, October 2) ¿Cuánto se tardan en amortizar las placas solares? Retrieved June 14, 2022, from: https://smartspain.es/cuanto-tardan-amortizar-placas-solares/


From energy consumer to energy prosumer: a sustainable project for Barcelona - GME01

That is, despite the high initial investment required and the following maintenance costs, the installation can be considered a low-risk investment which provides long-term returns for many years and has the capacity of yielding returns which go from 10% to more than 30%, as stated by the previously mentioned experts.

In addition, the annual return of such installations is only increasing with time, due to both the continuous historical fluctuations in the price of electricity in Spain36, and the sudden rises it suffers due to external factors, such as the recent Russian invasion of Ukraine. That is, the savings achieved increase with time, given that the investment stays still while the electricity price rises and, even though the percentage of savings varies per each household, in accordance with the power capacity of its installation, the monetary impact of the installation stays positive37.

A third benefit of owning solar panels lies in the resale price increase of the residential property. As the social awareness of the dangers of climate change38 increases, people are more willing to pay more to contribute to the fight against it, which means that buyers are more prone to paying more for self-sufficient houses which decrease their negative impact on the environment. Specifically, industry experts (e.g. SotySolar39, Social Energy40, SolarMente41, among others) establish that the value of a house with solar panels increases around 3-5% of its initial price, as long as the sellers are the owners of the installation.

Besides, owners of solar panels which generate more energy than needed can also benefit from selling the photovoltaic surplus to energy marketers or from compensating it through the electricity bill. In the case of residential installations, it is advisable to focus on the second option, given the possible capacity of households to generate enough energy to compensate the bought one, in contrast to having to assume all the costs, as well as fiscal and tax obligations, to sell the surplus.

The compensation method consists of pouring the surplus obtained through the solar panels into the energy network, in exchange of having the electricity bill reduced by the marketer at the end of the month. However, it is important to be aware of the fact that this discount is applied to the variable part of the bill, the consumption, without taking into account the fixed costs, like taxes or the fixed part of the power, among others. Another relevant aspect of the compensation option is that the energy consumed by the household is always given a higher value than the energy it pours into the network, and that it tends to be valued around 0.05€/kW, although each marketer offers different valuations. Finally, consumers should keep in mind the fact that the received discount will never be higher than the price of the consumed energy, so that it is possible to have a bill which equals zero, but not less.

In brief, installing solar panels leads to many different types of monetary benefits, including tax incentives, which will be developed in the following section, 4.1. Fiscal incentives to the installation at a local level: the case of Barcelona. However, not only the householders are benefiting from the installations, but also the environment, given their capacity to decrease the amount of greenhouse emissions derived from energy use in buildings. Concretely, a household decreases its carbon footprint immediately after installing the solar panels, yet it needs around three years to compensate for the carbon debt produced during the first years of operating a solar energy system (i.e., around 50g of CO2 per kWh). Afterwards, the solar system can be considered carbon neutral during the rest of its lifespan\textsuperscript{42}.

4. TAX INCENTIVES AND SUBSIDIES FOR THE INSTALLATION OF SOLAR PANELS

Although we have studied the energy market and the benefits and costs of the installation of solar panels, it is important to analyse the incentives to this kind of investment. Both subsidies and tax reductions represent potential tools to increase the willingness of consumers to invest in renewable energy sources. It is particularly relevant to design approaches that will increase the likelihood of households taking the decision to install solar panels. For example, in Germany, the owners of approximately half (46%) of the renewable energy installations in 2012 were individuals and local cooperatives\textsuperscript{43}. This is the reason why it is particularly interesting to directly promote policies aimed at these agents.


4.1. Fiscal incentives to the installation at a local level: the case of Barcelona

Currently, the city council of Barcelona, in the aspiration of fostering the solar panel installations within the city, applies fiscal benefits to those who decide to invest in this form of eco-friendly way to produce energy. This policies are specifically translated into: a reduction of 50% in the tax on private property - *Impuesto sobre bienes inmuebles, IBI* - during a 3 years period which runs immediately after the the equipment is installed, a reduction of 95% on the tax for the installation and a 50% reduction on the tax quota for those passive individuals that use solar energy in the exercise of their business activities.\(^4\)

The Catalan government also supports this goal, but this time with subsidies financed with European funds, the so-called NextGeneration, and granted to the citizens through the Catalan Energy Institut (ICAEN). This monetary injection aimed at individuals is considered to stimulate the installation of solar energy equipment and electrical storage systems. The final goal is to ensure energy efficiency together with energetic self-production and self-consumption. To be precise, this specific plan is to channel around 35 million EUR in the form of subsidies to the installation of solar and photovoltaic panels which will produce domestic hot water and electricity, respectively. The program also contemplates subsidies to businesses

which could finance from 15% to 65% of the final price of the equipment plus the installation depending on the type of required technology and the magnitude of the firm.  

Nevertheless, fiscal policies on the benefit of solar energy can be found around Europe. In the Netherlands, for example, although the law dictates the provision and the use of energy have to be subject to tax rates, the generation of self-consumed renewable electricity is exempt. This rule becomes clearer when it comes to local firms who possess their own photovoltaic installations. Furthermore, the *Energie-investeringsaftrek* (EIA), which stands for “energy investment allowance”, allows accounting benefits in the form of deductions at the amortisation periods for business when they purchase assets listed on the Energy list (Energielijst). Assets such as solar panels for electricity generation or solar collector systems for heating can be found at Energielijst. Thus, investments in cutting off CO2 emissions or more energy-efficient technologies may very well be eligible for the EIA.

5. FUNDING FOR THE INVESTMENT OF THE INSTALLATION

Another relevant factor to analyse is the accessibility to the credit for households and companies. The relevancy of this section has to do with the funding of renewable energy projects bearing in mind the high costs it may represent for a family or a firm to acquire and install such equipment. In this chapter, then, the feasibility for solar panels and photovoltaic installations to be founded will be discussed whether the funds come from the public or private sector.

---


5.1. Public funding

There exists a program launched by the Barcelona City Council called Sustainable Energy Mechanism\(^\text{48}\) (MES Barcelona) which intends to strengthen the investment in solar panelling within the city in order to accelerate the transition to a more sustainable place for its inhabitants. To do so, the City Council selects a limited number of solar panel installers who will finance the approved project and will recover the investment through the generated electricity by the photovoltaic panels. Once the initial investment has been recovered, the owners of the building will have the property of the installed equipment. The goal is to finance projects that will boost the production of green electricity in the available spaces located at the top of the buildings in the city. These rooftops will then be used to install photovoltaic panels for industrial constructions, offices or residential buildings. Part of the monetary resources will additionally be given to more ambitious installation projects that will provide electricity to more energy intensive demandants, such as hospitals or hotels.

5.2. Private funding

When it comes to the private sector, we can differentiate three main paths to access bank credits: green loans, mortgage ampliation and consumption credits\(^\text{49}\). In the banking sector, green marketing stands for the development of new financial products, such as credits for cleaner technology, applied to environmental purposes, which includes: energy efficiency, waste management approaches, among others. They appeared in the market as a response to satisfy the consumer’s demand for eco-friendly products, as fruit of their late change in preferences\(^\text{50}\). It is possible to currently find several banks operating in Spain offering green loans and the main feature is translated into lower interest rates compared to conventional loans on consumption. Thus, the major benefit for consumers for green credits is the low interest rates payments which directly acts as a hook for initiating sustainable projects. Mortgage credits amplifications also may be a finance solution, but this will be subject to the bank’s availability.


In order to provide a practical example, we must first briefly define what both TIN and TAE are. The acronym TIN stands for *Tipo de Interés Nominal* (Nominal Interest Rate) and it is the fixed interest rate which determines the monetary cost of the borrowed money. TAE, at its turn, stands for *Tasa Anual Equivalente* (Equivalent Annual Rate) and it is calculated based on a normalised formula that not only includes the TIN but also the payment frequency, the amortisation costs and other operational costs. Thus, TAE tends to be higher than TIN but offers a better overview insight about the cost of the loan. Green loans have an average cost of 4.45% TIN and 4.80% TAE, approximately 3.5 percentage points compared to those conventional credits aimed at private consumption. The following figure may help to have a more visual overview of this fact:

<table>
<thead>
<tr>
<th>Table 2: Green loan versus credit to private consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount</td>
</tr>
<tr>
<td>Maturity</td>
</tr>
<tr>
<td>Interest Rate</td>
</tr>
<tr>
<td>Instalment</td>
</tr>
<tr>
<td>Surplus generated from interest rate</td>
</tr>
<tr>
<td>Total to pay</td>
</tr>
</tbody>
</table>

Source: Information on this table entirely extracted from the financial portal HelpMyCash.com

As it can be seen from the table above, a green loan represents, considering the given conditions, a decrease in the costs for the credit equivalent to approximately 2,000€. The reasons for lower interest rates can be linked to the incentives coming from the regulator. The European Central Bank decided to lower the minimum capital required by 25%, that is to say, this new rule allows banks to multiply by 0.75 the own funds requirements for credit risk. The

---


result is a relaxation in the solvency regulation for those banks offering green loans in order to foster its promotion and selling\textsuperscript{54}. Nonetheless, among the main conditions for this loan to be granted is related to its purpose. Green loans are characterised for being used to: hybrid or electric car purchases (85.7\% of the total number of banks offer this credit for this purpose); projects to improve energy efficiency and self-generation (57.1\%); and, the acquisition of energy-efficient electrical appliances (28.6\%).

5.3. The ethical banking and sustainable projects

Whereas several conventional banks are currently offering green financial products, a new banking sector coined “ethical banking” is becoming stronger as years pass by. It is relevant to highlight how these new banks promote modern ways of doing finances by directly channelling funds to sustainable projects. Triodos Bank, for instance, calculates the mortgages with variable interest rate based on the dwelling’s electricity efficiency\textsuperscript{55}. Eventually, this may act as an incentive for installing photovoltaic panels to those searching for a mortgage.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Certificación energética & TIN Primera 18 meses & Diferencial a partir del mes 19 Euribor + TAI/Variable\footnote{TAI/Variable}\textsuperscript{51} \\
\hline
A+ (**) & 2,25 \% & 1,90 \% 2,79 \% \\
A (**+) & & 1,96 \% 2,84 \% \\
B & & 2,00 \% 2,88 \% \\
C & & 2,03 \% 2,90 \% \\
D & & 2,06 \% 2,93 \% \\
E & & 2,09 \% 2,96 \% \\
F & & 2,13 \% 2,99 \% \\
G & & 2,16 \% 3,02 \% \\
\hline
\end{tabular}
\caption{Mixed mortgage and energetic certification}
\label{table:mixed_mortgage}
\end{table}

Source: Triodos Bank

It is particularly important to notice how the installation of solar panels has evolved. Thanks to the following figure we can graphically see how solar energy production has changed between 2000 and 2019.


There is a clear positive growth of the national supply that has been progressively increasing within these years. It is a common property for new technologies to behave in a similar way when introduced to the markets. The Bass model explains this effect by using a differential equation with zero-initial level condition. It captures the evolution of demand and states three different levels: a lethargic introduction, a brisk market expansion, a saturation stage and a declining market share. We can certainly apply this model to solar energy generation and forecast major production in the years to come. This is another reason why it is especially relevant to analyse this sector which could ensure energy security and sustainability.

Chart 7: An example of illustration of the Bass Model’s pattern


---

6. QUALITATIVE STUDY OF THE PROJECT

6.1. SWOT analysis

To make a qualitative analysis of the solar energy sector, we believe it is convenient to carry out a SWOT analysis (which refers to the acronym Strengths, Weaknesses, Opportunities and Threats, respectively). With it, we will be able to analyse in a global way how the solar energy sector is doing, what opportunities and strengths we can take advantage of and what threats and weaknesses we will have to face.

As we already know, the sections on weaknesses and strengths refer to the internal sphere - we will take the solar energy market as a point of reference here - and the sections on opportunities and threats refer to the external sphere, and we will take the situation here as a reference to the current economy and the markets in general as well as other vicissitudes that may affect this analysis, focused particularly on Spain (and, obviously, on Barcelona), but also on Europe, given that it is the planning centre for the Sustainable Development Goals (SDGs) and in which the transition to renewable energy plays a fundamental role.

<table>
<thead>
<tr>
<th>STRENGTHS</th>
<th>WEAKNESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Spain, due to its location and climate, can be a strong supplier of solar energy.</td>
<td>- Lack of knowledge and mistrust on the part of citizens in the field of installing solar panels.</td>
</tr>
<tr>
<td>- Subsidies and aid to encourage the installation of these solar panels are increasing.</td>
<td>- The energy isolation of Spain - called &quot;energy island&quot; - makes it difficult to send renewable energy to the rest of Europe.</td>
</tr>
<tr>
<td>- The use of solar energy allows the customer to control their own energy use and manage it according to their preferences through intelligent technologies.</td>
<td>- The installation of solar panels requires a higher initial investment compared to the conventional electrical installation (very intensive in capital factor).</td>
</tr>
<tr>
<td>- The price of solar energy is stable since it requires a single installation - and its respective maintenance - which increases certainty and reduces volatility.</td>
<td>- Currently, there is a lack of skilled labour to deal with the installation of these solar panels if the demand were to increase.</td>
</tr>
<tr>
<td>- Security and reliability: solar panels enjoy a wide security of their installation.</td>
<td>- We can still say that the level of R&amp;D in the solar energy sector is low.</td>
</tr>
<tr>
<td>- Investment in solar panels (specifically in Spain) represents great profitability and long-term benefit.</td>
<td>- There may be areas where the heat source is insufficient and it is not profitable to make the investment since a mixed installation with electrical energy will be needed.</td>
</tr>
<tr>
<td>- The surplus energy not consumed by the individual is compulsorily purchased by the State, so there is no energy wastage.</td>
<td></td>
</tr>
</tbody>
</table>

Table 4: SWOT analysis
- The mandatory installation of solar panels in new buildings implies an expectation of market growth in the short term.
- In turn, it encourages the use of the electric vehicle, since it can also be charged with energy from solar panels.

**OPPORTUNITIES**

- Energy dependence on fossil fuels compared to other countries is increasing (loss of autonomy and source of geopolitical conflicts).
- Increased citizen awareness of the environment and its preservation.
- The demand for renewable energy is growing and is expected to continue to do so to the detriment of non-renewable energies.
- Rise in world prices of primary materials (for example, oil), which causes the search for alternative energies.
- The market for fossil fuels has a very high volatility in its price, which increases the uncertainty of consumers, contrary to the market for solar energy.
- The current inflation encourages investment from those people who want to avoid higher prices in the future on their solar installations as well as their energy consumption.

**THREATS**

- There is a risk of political interference as oil companies can exert pressure not to carry out this energy transition.
- Traditional forms of business - non-renewable energy - continue to be the main bet of consumers, many of them reluctant to make the change.
- The worldwide shortage of semiconductors and other elements makes it difficult to produce solar panels.
- The current economic slowdown discourages investment and consumption in the energy market.
- The energy market is highly competitive, so any change in regulation, prices or any other aspect substantially modifies the structure of the market.

Source: own elaboration based on external data

---


As we can see in the graph above in relation to what was discussed in the SWOT analysis, Spain has great potential to become one of the main creators of solar energy given its high degree of solar irradiation, which constitutes a great strength in comparison with other European countries.

6.2. Social Awareness

During the last few decades, public opinion, especially in Western countries, became concerned about climate change and the harmful effects, not only on nature, but also for societies. As a result, people are more aware about sustainability in a broad range of areas in their routines as the ways in which people are choosing sustainable commuting options like carpooling, new eco-friendly goods, more electricity-efficient products or e-mobility are becoming common. As evidence, the growth of PV installation is increasing around 27% year-to-year and people are becoming more informed about this type of electricity.61

According to a recent survey (750 observations) on Statista conducted by SOLARWATT\textsuperscript{62}, which is a German company specialised in renewable energy, in Spain, the interest in solar energy is increasing as 35% of people are willing to install solar panels in their homes in the short and medium term, in the same direction as other reports that estimate this quantity in 42\%\textsuperscript{63}. Thus, it is a trend increasing over the recent years. However, almost half of people neither are really convinced about the installation nor are very informed about the process.

On the one hand, among those who want to take the step, the main reasons for installing solar panels are the savings on the electricity bill, the positive effect on the dwelling’s value and the sustainability of the panels. On the other hand, those who are not really informed nor convinced point out the high initial investment cost as a barrier, the reliability of the solar panels and its potential savings, the lack of fiscal benefits or subsidies and the future development of this technology.


Generally, we can extract from the survey that public opinion sees that institutions should do more to encourage the installation of solar equipment in homes.

7. CONCLUSIONS

Through our analysis of the energy market, we have been able to see first-hand how dependent countries still are on fossil fuels: this makes them geopolitically vulnerable, as is becoming clear in the current war between Russia and Ukraine. However, some objectives are being set at all levels - European, national and local - to deal with this situation and reduce, above all, the use of electricity which, although it is not polluting per se, can contribute to reducing the use from other types of energy such as natural gas, which it is. In the case of Barcelona, although it is true that according to the studies used in the analysis it is one of the most sustainable cities, there are still measures to be taken.

We have seen how subsidies and tax benefits are offered by municipal and national institutions. These tools are addressed to both firms and consumers in order to promote the installation of solar panels. Other examples have additionally been mentioned, such as the case of Netherlands, in order to provide an overview of the willingness to foster the transition to renewable energy production within the European continent.

In terms of funding, different credit lines both public and private have been analysed so as to describe the accessibility to finance solutions. We proved consumers may very well benefit from lower interest rates by taking green loans.
Installing solar panels has multiple benefits, like the ones we've discussed in the SWOT. It should also be noted, given that the scope of our study is mainly Barcelona, that our city has a comparative advantage over other areas of both Spain and Europe given the high solar irradiation and the predisposition of public authorities to promote this type of project. As for the private sector, it is important to mention the boost to these projects thanks to green loans. In addition, in recent years there has been a notable increase in solar awareness about the protection and preservation of the environment, and this happens, naturally, through the use of renewable energies such as solar.

However, the citizen's will is far from reality since there is much ignorance on the subject. Firstly, the bureaucracy involved in this type of project is long and tedious and, secondly, the incentives for these projects are either unknown or low, so a good strategy to promote this energy transition would be to increase the advertising and incentives. An example of the latter is the already mentioned case of the Netherlands, where citizens who have these photovoltaic installations enjoy tax exemption for installations with self-generation of energy.

The study of the energy market and solar panels is very extensive, so our project has focused on analysing the basic aspects and extrapolating them to the case of Barcelona, in which we have concluded that the installation of solar panels can be beneficial for the city if the project is sufficiently encouraged and publicised, as we believe that social awareness will increase even more over the years. However, we believe that it could be interesting to extend this project to analyse the obstacles to investment - at a bureaucratic and financial level, since we have focused primarily on the benefits - as well as to compare solar energy with other types of renewable energy, such as wind or hydroelectric ones. Moreover, it would be also interesting to study the existing possibility of having the installation without having to assume the initial investment through a leasing or renting system.

---

8. BIBLIOGRAPHIC REFERENCES


https://es.statista.com/estadisticas/493962/dependencia-de-las-importaciones-de-energia-de-espana/.


