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## **Spanish retail energy market**

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The retail energy market very interesting because it gives the knowledge of how the country is dealing with the energy and how the energy is extracted from the different sources. The main objective of this master thesis is to give a general explanation of the energy market in Spain and his history, and analyze the current market with two different examples. The methodology used is based on the different webpages of the Spanish companies and the Spanish Electrical Net webpage, together with more interesting bibliography. The result of this thesis is an analysis of different companies and their tariffs, and the application of these tariffs to an example of a house, in order to compare every tariff, and to see which of them are cheaper and better.

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**Keywords** Spanish, Market, Energy, Electricity, Tariff, Peak ,Off-Peak,

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## Preface

This master thesis has been done in order to finish my Erasmus stay in Helsinki.

I would like to thank Sanna Syri for the attention that she paid on me, and for the opportunity of investigating the retail energy market in Spain, because after this thesis, I understand more the energy field, and I feel that I want to keep learning about it in order to find a work related with the energy market.

Espoo 23.05.2018

A handwritten signature in black ink, appearing to read 'Gonzalo Pedrosa Gil', with a horizontal line drawn through the middle of the text.

Gonzalo Pedrosa Gil

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## Abbreviations

In this part, all the abbreviations are listed in alphabetic order. The abbreviation is written with the Spanish acronym, and after the acronyms, there are the explanation of the acronym in English.

|         |   |
|---------|---|
| BOE     | Spanish Official Bulletin                     |
| CCHSBCN | Hispanic-Sueca Market Chamber of Barcelona    |
| CNMC    | National Commission of Markets and Competence |
| PVPC    | Voluntary Price for the Small Consumer        |
| REE     | Electrical Spanish Net                        |
| TUR     | Last Resource Tariff                          |
| EDP     | Portugal Energies                             |
| CC      | Shopping Mall                                 |

# 1 Introduction

The background of this master thesis is the study of the Spanish retail energy market, in order to analyze and describe different electrical supplier companies, the quantity of energy that they use, and the different electricity prices of them.

This topic is interesting, because the Spanish energy market was an oligopoly in the past, just five companies were allowed to generate, distribute, transport and sell energy all over the country; but during the years, the laws have changed in order to separate these four activities and have allowed the liberalization of the market.

For that reason, nowadays in Spain there are many companies that are allowed to sell energy in the country, and each company has some particularities that makes every company unique and different from the others.

In the first part of this master thesis, the energy market in Spain is being analyzed from before 1987 until the present days, in order to give a global view of how the energy market works nowadays, and also how it used to work, and how the laws changed the situation in order to arrive to the open market that now exists.

To see and to compare different electrical companies, two examples are going to be examined, a particular house, in order to see how the electrical market works for a small consumer, and a mall, to see how the electrical market works for a big consumer.

This master thesis has been done by consulting the different companies webpages, the webpage of the Spanish Electrical Market, some newspapers based on economy and energy, and some thesis dedicated to energy and marketing as well.

## 2 Theory and description of previous knowledge

The Spanish energy market is a very important market in Spain, due to the fact that it represents the second place in consumption of energy sources, considering the first place the petroleum market.

There are five main companies in this sector: Iberdrola, Unión Fenosa (currently Gas Natural Fenosa), Endesa, EDP-Energias de Portugal and E.ON (currently is Viesgo).

This market was considered an oligopoly, but during the last 20 years, this situation has been changing.

In 1987, with the 1538/1987 decree [1], the Stable Legal Framework was established, in order to provide a stable framework referred to the income system of the companies that supply electrical energy and to determinate the electrical tariff in conditions of minimum cost. According to [1], the framework also had the objective of guaranteeing stability in the tariff, recovering the investments, achieving a properly planning of the sector activities, reducing the uncertainty and pushing the efficiency.

The electrical market structure in this Stable Legal Framework included four activities: generation, transport, distribution and marketing, all of them regulated.

The remuneration to the generation companies, the companies which are in charge of the energy production, was assigned by the Ministry of Industry to the producers through the Standard Costs, which included costs such as investment or fuel. This costs were important, because with them, the companies were able to obtain some benefits of their work.

With respect to the transport, this framework established the nationalization of the transport nets, the high voltage nets which transmitted the electricity. Before this point, there were many companies carrying the energy in each region, but the connections between them were deficient. Due to this fact and in order to improve the efficiency, in 1985, a company was created to be in charge of the transport in the whole country, This company is the Electrical Spanish Net (*REE*), and became the first world company that was dedicated exclusively to the transport of the electricity and to be the system operator. Nowadays, this company is still in charge of this task.

The distribution activity were managed by private companies that were in charge of the medium and low voltage nets.

The marketing activity, whose main objective is to sell the energy to the consumers, was based in an only tariff (same tariff depending of the consumption) called Integral Tariff.

Before the Integral Tariff, the price of the energy was established through a negotiation between the companies and the Ministry of Industry and Energy, using the real costs of the companies, fact that generated a significant instability. With the Legal Framework, this situation changed, and the tariff was calculated by some granted costs divided by the predicted demand of the year.

The included costs were the Standard Costs, fixed by the Ministry for a year, and these costs were updated with some formulas. These costs included fuel, investment, operation and maintenance of the production facilities costs, the cost of the working capital, distribution cost and structure cost. According to [1].

There were also more costs that could not be treated as the Standard Costs due to their nature. This cost were called Extra Charge, and were formed by Uranium stock cost, costs of the second part of the nuclear fuel cycle, costs of the extra peninsular system, costs of the carbon help, costs of the investigation and development electronic and the contingent costs.

As a result of this costs, the calculation of the tariff was the sum of all of them, having in account the incomes that lowered the costs, divided by the expected demand.

Before 1997, the electrical market worked as a state interventionism, in which the incomes were divided into a fix part of the investment costs, and other variable part over the input costs used and maintenance. In that situation, the Spanish State was the responsible of controlling the energy price. With those conditions, there were a few companies that shared all the energy market. Endesa had a 50 % of market share, followed by Iberdrola.

This situation changed in 1997.

In 1997, the European Directive 96/92/CE was applied to Spain with the 54/1997 Law, so the liberalization of the market started. With this directive, the electrical market was divided into the following principal activities in the following way:

Regulated activities:

- Transport: The transport was considered a natural monopoly due to the creation of the company called REE.
- Distribution: The distribution is a regulated activity but it is performed by private companies.

Non regulated activities:

- Generation: The generation is the production of electrical energy.
- Marketing: The marketing is the selling and buying of electricity.

The non-regulated activities were the ones that became liberalized, and therefore, they were not subjected to the state regulation, but there existed a certain control, in order to get the necessary licenses to operate in the market.

In the case of the generation, there are two types of producers: producers in ordinary regime, which are the ones that generate electricity through the use of renewable energies and cogeneration if the power is lower than 50 MW; and producers in ordinary regimen, which are the rest of them.

In the case of the distribution, even though was a regulated activity, was carried out by private companies, and the consumers had to pay some costs that are recognized by the State. Currently, 97 % of the distribution is controlled by Endesa, Iberdrola, EDP-HC and E.ON. [2]

In the case of marketing, two types of companies are distinguished: the free-market marketing companies, and the last resource (“*TUR*”) companies, that are the ones named by the Ministry of Energy to offer the *TUR* at the fixed prices. The five companies mentioned in the distribution are the ones that also control most of the marketing. This five companies are the only companies designated for the Ministry of Justice to offer the *TUR*.

The 29<sup>th</sup> of March 2014, the 216/2014 Royal Decree-law (Source: [3]) was published, and that decree changed the electrical tariff *TUR* into *PVPC* (Voluntary price for the small consumer). This decree [*according to the BOE*] changed the way to calculate the final price of the electricity. The fixed term remained the same as the *TUR*, but the variable term, which was established quarterly in an auction, from that moment, it changed in order to establish it in the wholesaler market.

Also the billing way depends if the consumer has intelligent meter or not. For the consumers that actually have that intelligent meters, the price of the energy is calculated depending on the price of the wholesaler market in each hour. This is possible due to the fact that having intelligent meters allows the company to know the real consumption in each moment. For the consumers that actually do not have intelligent meters, the energy will not be counted each hour (because is not possible), but they will be charged by doing the average for each billing period. For that reason, the price will be predefined and will be the same regardless on the time that is consumed.

This Decree, also define three tariffs in this regulated market:

- PVPC: Is the maxim price that the companies can charge the consumers. Everyone can apply for this tariff if the contracted power is lower than 10kW, but the price is function on the electricity market.
- Yearly fix price: This tariff allows the consumers to know what they are going to pay for the energy during the year. This tariff eliminates the variability of the energy prices, and the consumption price (variable term) remains constant. In that case, every marketing company offers a fixed price that remains constant during a year and will be applied since the moment of the contracting, and also the prices will be published in the webpage of CNMC\*(National Commission of Markets and Competence). This tariff may be subject to some permanence in case the consumers wants to change the marketing company; but according to the Royal Decree 216/2014 [3], those fines cannot exceed 5 % of the estimated energy remained to supply.
- Bono Social: The consumers that can apply for this tariff are the ones that have less than 3 kW of contracted power, the pensioners older than 60years, the numerous families, and those families that have every member unemployed.

\*This organism is the responsible of promoting and defending the good operation of the markets and the companies.

### 3 Analysis of the current energy market in Spain

The electrical energy is the most valuable energy, due to the fact that this energy is used by every single person day workaday.

This energy can be obtained by different sources that can be divided into two main groups: renewable sources and non-renewable sources.

The renewable sources of energy are the ones that remain endless, or can be replaced in a short period of time. Examples of renewable sources are hydric energy, wind energy, solar energy, geothermal energy, maritime energy, and biomass.

The non-renewable sources of energy are the ones that can disappear in a period of time because the materials may run out. Examples of non-renewable sources are: Carbon, petroleum, natural gas and uranium,

The electrical companies use these sources of energy and transform them into useful energy to the final consumers.

The total energy necessary for the whole country is obtained with these sources, but if the generation of the energy through the sources is not enough to cover the energy demand, the energy has to be gathered from other countries.

In [Figure 1], obtained from the 2017 report of the Electrical Spanish System, is visible the electrical demand of energy in Spain and where does it come from.

| ELECTRICAL<br>YEARLY<br>BALANCE | Penninsular System |            | Non-Penninsular System |            | Total National |            |
|---------------------------------|--------------------|------------|------------------------|------------|----------------|------------|
|                                 | GWh                | % 17/16    | GWh                    | % 17/16    | GWh            | % 17/16    |
|                                 |                    |            |                        |            |                |            |
| Hydraulic                       | 20.210             | -48,4      | 3                      | -15,3      | 20.213         | -48,4      |
| Nuclear                         | 54.825             | -2,3       | -                      | -          | 54.825         | -2,3       |
| Coal                            | 43.345             | 23,2       | 2.610                  | 13,3       | 45.955         | 22,6       |
| Fuel/gas                        | -                  | -          | 7.028                  | 3,9        | 7.028          | 3,9        |
| Combined cycle                  | 35.459             | 38,0       | 3.441                  | -3,7       | 38.901         | 32,9       |
| Hydro Eolic                     | -                  | -          | 21                     | 15,0       | 21             | 15,0       |
| Eolic                           | 46.550             | -1,6       | 392                    | -1,5       | 46.942         | -1,6       |
| Photovoltaic solar              | 7.945              | 4,8        | 405                    | 1,7        | 8.350          | 4,7        |
| Thermal solar                   | 5.375              | 6,0        | -                      | -          | 5.375          | 6,0        |
| Other renewables                | 3.610              | 5,8        | 10                     | -3,3       | 3.621          | 5,7        |
| Cogeneration                    | 28.055             | 8,4        | 35                     | 2,3        | 28.090         | 8,4        |
| Waste                           | 3.164              | 1,4        | 303                    | 11,6       | 3.467          | 2,2        |
| <b>Generation</b>               | <b>248.538</b>     | <b>0,0</b> | <b>14.249</b>          | <b>3,4</b> | <b>262.788</b> | <b>0,2</b> |
| Pumping consumption             | -3.503             | -27,3      | -                      | -          | -3.503         | -27,3      |
| Link Mainland-Balears           | -1.173             | -6,2       | 1.173                  | -6,2       | 0              | -          |
| International exchanges         | 9.220              | 20,3       | -                      | -          | 9.220          | 20,3       |
| <b>Demand (b.c.)</b>            | <b>253.082</b>     | <b>1,2</b> | <b>15.422</b>          | <b>2,6</b> | <b>268.505</b> | <b>1,3</b> |

Figure 1: Electrical Yearly Balance of Spain. Source: [4]. Translated by Gonzalo Pedrosa



According to this data, the renewables represent a total amount of energy of 87.989 Gwh, that means a 33,5 % of the total energy production in Spain.

To distribute this energy, an important transport net is needed. This net is represented in Figures [2], [3] and [4]; according to the report of the Electrical Spanish System:

### ELECTRICAL ENERGY TRANSPORT NET INSTALLATIONS

|                         | 400 kV        |               | ≤ 220 kV     |               | TOTAL         |
|-------------------------|---------------|---------------|--------------|---------------|---------------|
|                         | Penninsular   | Penninsular   | Balears      | Canary Island |               |
| <b>Total lines (km)</b> | <b>21.729</b> | <b>19.040</b> | <b>1.808</b> | <b>1.422</b>  | <b>43.998</b> |
| Air lines (km)          | 21.612        | 18.265        | 1.089        | 1.146         | 42.112        |
| Submarine wire (km)     | 29            | 236           | 540          | 30            | 835           |
| Underground wire (km)   | 88            | 539           | 179          | 245           | 1.051         |

Figure 2: Electrical energy transport net installations of Spain. Source: [5]. Translated by Gonzalo Pedrosa

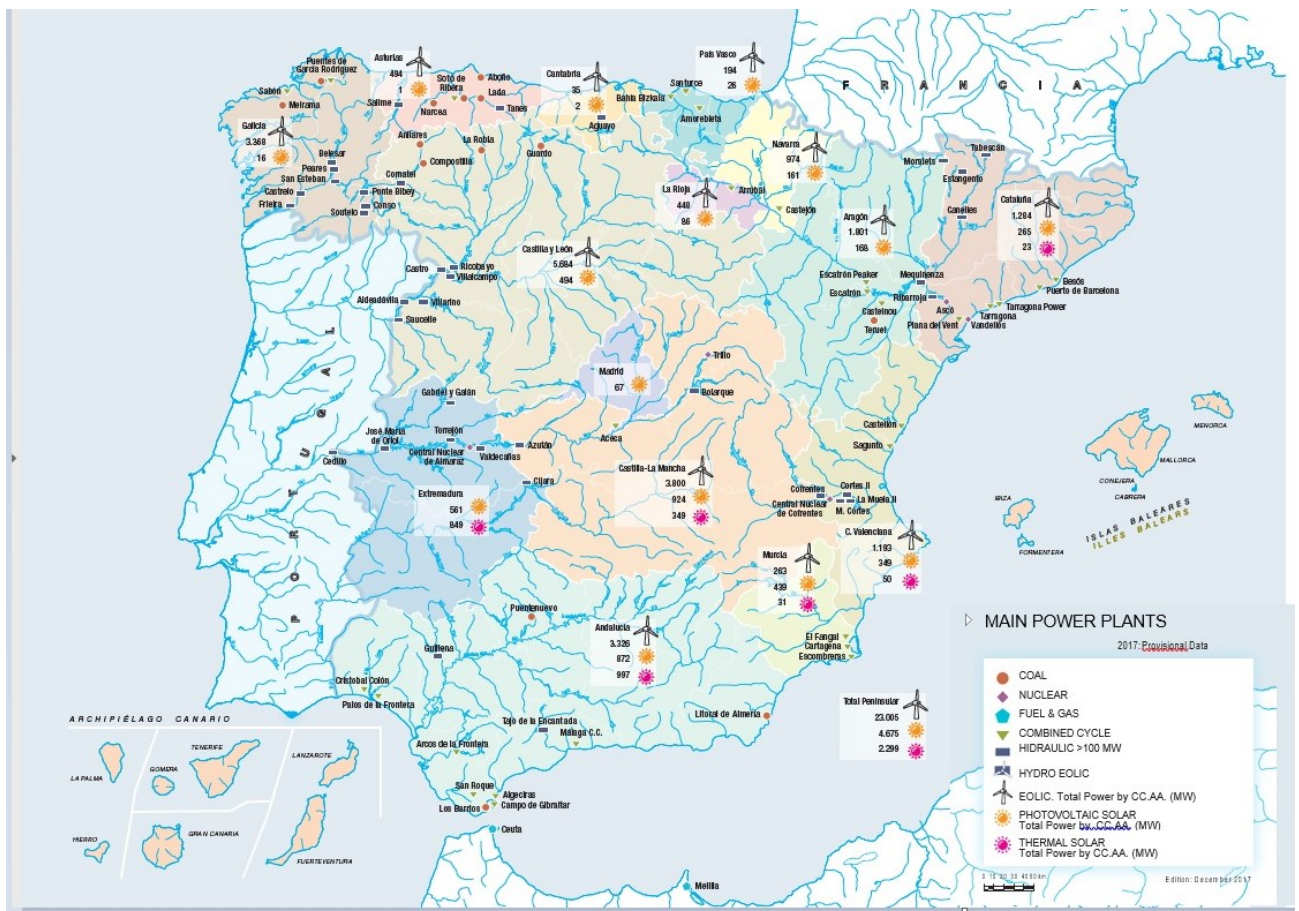


Figure 3. Principal Power Plans in the Spanish Mainland. Source: [6]. Translated by Gonzalo Pedrosa.



Figure 4: Principal Power Plans in the Balears. Source: [6]. Translated by Gonzalo Pedrosa

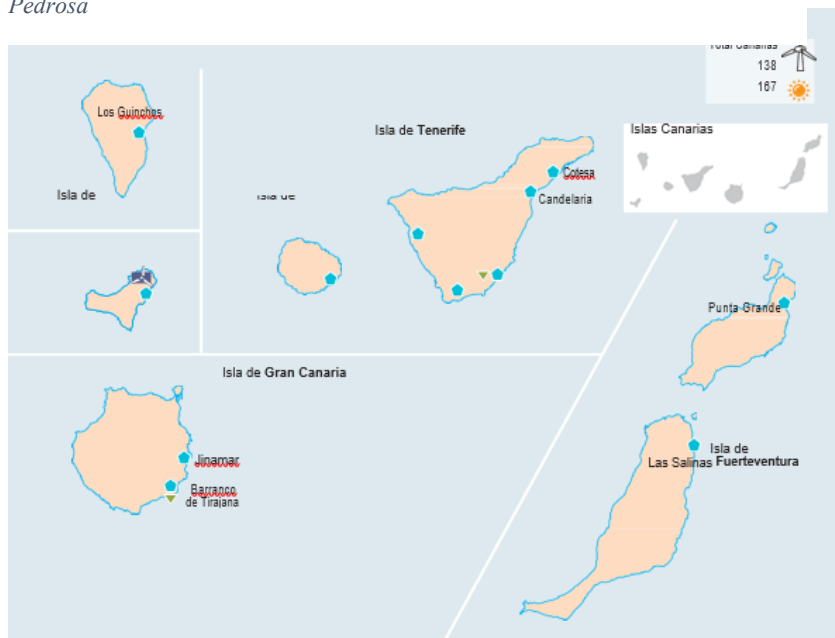


Figure 5: Principal Power Plans in the Canary Islands. Source: [6]. Translated by Gonzalo Pedrosa

As it is shown in the figures below, there are different nets whether the mainland or the different islands. Due to this fact, there are many companies that supplies energy to the mainland, the different islands, or both.

The energy companies can be divided into two groups: Distribution and marketing companies. The distribution companies are in charge of supplying the energy into the final consumers, and the marketing companies are in charge of selling the energy to the consumers.

In the past, the companies were in charge of both distribution and marketing issues, and the market was a close market without options to choose any company of electricity. But with the Law 54/1997 a process of liberalization started, in order to give the consumers the option to choose.

This process was based on separating the distribution and marketing processes, just to let new companies introduce themselves into the energy market. Due to that fact, the big companies of distribution, started to increase their distribution activities and reduce the marketing function, and this companies started to distribute energy for other marketing companies. This process started on 2003, where the Spanish population got the right to choose the company that they would like to work with, and ended in 2009.

Nowadays there are five distribution companies: Endesa distribution, Iberdrola distribution, Gas Natural Fenosa distribution, E.O.N. distribution and Hidrocantábrico distribution, and there are more than 300 retailing or marketing companies.

As a consumer, you have the right to choose whether stay in the regulated market or change into the free market.

The regulated market is managed by the government and was implemented on 2009, in order to protect the consumers from the excessive prices of the energy. The price for the energy changes every hour and day to day, also is fixed by the government and the tariff of that was called *TUR*, but as it is said before, this tariff changed in 2014 and became the *PVPC*. The only requirement is that the contracted power has to be less than 10 kW.

The free market is managed by the sales companies, and the companies fix the prices. The advantage of choosing this market is that the price of the energy is already known beforehand.

In the next table there are a summary of the free and regulated market main issues.

| <b>Regulated market</b>   | <b>Free market</b>  |
|---|---|
| The price of the tariff is fixed by the government                        | The price of the tariff is put by the marketing companies |
| Extra services such as maintenance cannot be contracted                   | Extra services such as maintenance cannot be contracted   |
| There are no discounts  | The companies can offer discounts                         |
| The user can only contract with the reference commercialization companies | The user can contract with every electrical company       |
| The electrical power has to be lower than 10 kW                           | There is no limit of electrical power hired               |

*Table 1: Differences of regulated market and free market*

With all this information, in this thesis some marketing companies are being analyzed and with the information extracted from each company, an analysis of the retail Spanish

energy are being explained, and applied into two cases, one for a particular customer, and the other for a shopping mall.

## 4 Electricity consumption of a house

For the calculation and analysis of the different tariffs and electrical companies, it is important to calculate the consumption of a standard house. This calculation is not an exact calculation, because it depends on the power of the electrical appliances, the power of each light bulb, the heating power...

Due to this fact, the calculation is just an estimation of the consumption of a standard house.

The house that is being under study is a house located in the center of Valencia, and has 200 m<sup>2</sup> separated into three bedrooms, two dining rooms, two bathrooms, and a kitchen. In this case, a webpage has been used in order to do the calculations, based on the 6 people house mentioned before.

According to [7]: Consumption of a house with 6 people, 200 m<sup>2</sup>, with great isolation, with central heating, electrical hot water, electrical kitchen, and with 6,9 kWh of electric power, 3 televisions, 1 washing machine, 6 computers, 1 dishwasher, 1 fridge and 1 freezer.

Consumption: 10339 kWh/year, which means 861,583 kWh/month.

According to Fotocasa webpage [8], this electricity is used for:

| Used for                    | Consumption | Total consumption/month |
|-----------------------------|-------------|-------------------------|
| <b>Household applicants</b> | 60%         | 517,11 kWh              |
| <b>Electricity</b>          | 15%         | 129,28 kWh              |
| <b>Heating</b>              | 10%         | 86,16 kWh               |
| <b>Boiler</b>               | 5%          | 43,08 kWh               |
| <b>Others</b>               | 10%         | 86,16 kWh               |

Table 2. Standard consumption of a 6 people house. Source: [8].

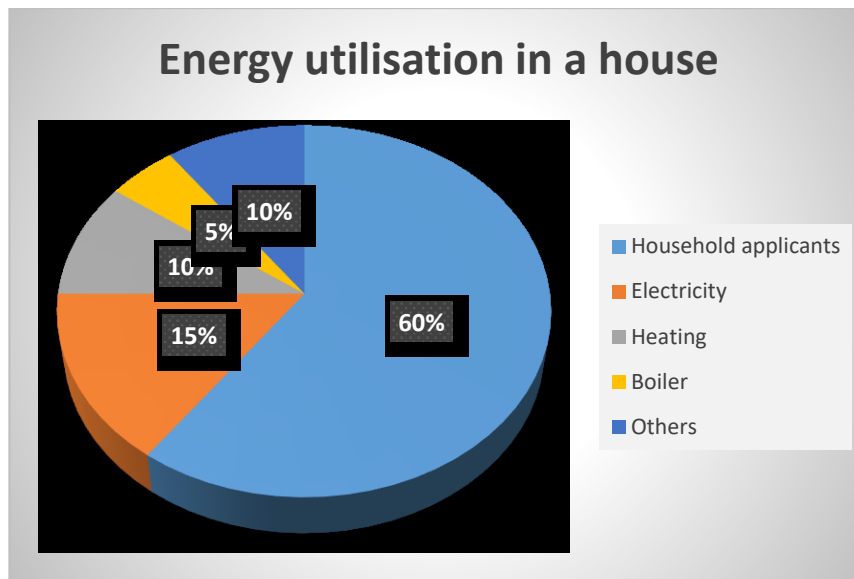


Figure 4. Chart of standard consumption of a 6 people house

The consumption can be also calculated by hand, knowing the consumption of the different electrical devices. Consulting two different sources, two tables have been made in order to calculate the consumption of a house, with the objective of contrasting our data. This sources are CEMAER [9] and ELECTROCALC [10].

| Electric device                  | Number of devices | Hours of consumption | Days/ month | Consumption (CEMAER) | Total consumption (CEMAER) |
|----------------------------------|-------------------|----------------------|-------------|----------------------|----------------------------|
| Lights                           | 20                | 6                    | 30          | 0,04                 | 144                        |
| Oven                             | 1                 | 1                    | 30          | 1,04                 | 31,2                       |
| Microwave                        | 1                 | 1                    | 30          | 0,64                 | 19,2                       |
| Dishwasher                       | 1                 | 1                    | 30          |                      | 0                          |
| Washing machine                  | 1                 | 1                    | 30          | 0,882                | 26,46                      |
| Fridge                           | 1                 | 24                   | 30          | 0,098                | 70,56                      |
| Freezer                          | 1                 | 24                   | 30          | 0,09                 | 64,8                       |
| Boiler                           | 1                 | 2                    | 30          | 2,4                  | 144                        |
| Heating                          | 1                 | 5                    | 30          | 1,013                | 151,95                     |
| Computers                        | 1                 | 24                   | 30          | 0,3                  | 216                        |
| Laptop                           | 6                 | 5                    | 30          |                      | 0                          |
| Television                       | 3                 | 6                    | 30          | 0,07                 | 37,8                       |
| Cookpot                          | 1                 | 2                    | 30          |                      | 0                          |
| <b>TOTAL</b>                     |                   |                      |             |                      | <b>905,97</b>              |
| <b>Others (10% of the total)</b> |                   |                      |             |                      | <b>100,66</b>              |
| <b>TOTAL</b>                     |                   |                      |             |                      | <b>1006,63 kWh</b>         |

Table 3. Monthly consumption calculated with CEMAER. Source: [9].

| Electric device                  | Number of devices | Hours of consumption | Days/ month | Consumption ELECTROCALC | TOTAL                   |
|----------------------------------|-------------------|----------------------|-------------|-------------------------|-------------------------|
|                                  |                   |                      |             |                         | Consumption ELECTROCALC |
| Lights                           | 20                | 6                    | 30          | 0,04                    | 144                     |
| Oven                             | 1                 | 1                    | 30          | 0,95                    | 28,5                    |
| Microwave                        | 1                 | 1                    | 30          | 0,64                    | 19,2                    |
| Dishwasher                       | 1                 | 1                    | 30          | 0,98                    | 29,4                    |
| Washing machine                  | 1                 | 1                    | 30          | 0,95                    | 28,5                    |
| Fridge                           | 1                 | 24                   | 30          | 0,102                   | 73,44                   |
| Freezer                          | 1                 | 24                   | 30          | 0,11                    | 79,2                    |
| Boiler                           | 1                 | 2                    | 30          | 1,5                     | 90                      |
| Heating                          | 1                 | 5                    | 30          | 1,35                    | 202,5                   |
| Computers                        | 1                 | 24                   | 30          | 0,26                    | 187,2                   |
| Laptop                           | 6                 | 5                    | 30          | 0,035                   | 31,5                    |
| Television                       | 3                 | 6                    | 30          | 0,1                     | 54                      |
| Vitroc ceramic                   | 1                 | 2                    | 30          | 1,2                     | 72                      |
| <b>TOTAL</b>                     |                   |                      |             |                         | 1039,44                 |
| <b>Others (10% of the total)</b> |                   |                      |             |                         | 115,49                  |
| <b>TOTAL</b>                     |                   |                      |             |                         | <b>1154,93 kWh</b>      |

Table 4. Monthly consumption calculated with ELECTROCALC. Source: [10].

#### 4.1 Hourly consumption

Once we have calculated the total electricity consumption of a house, the next step is to define the hourly consumption, due to the fact that this information defines the importance to have a discriminate tariff and what tariff is the best in each case.

To extract this information, two sources have been consulted.

The first source comes directly from the Spanish Electricity Grid webpage (Also known as REE), and shows the total daily energy consumption in Spain divided by sectors.

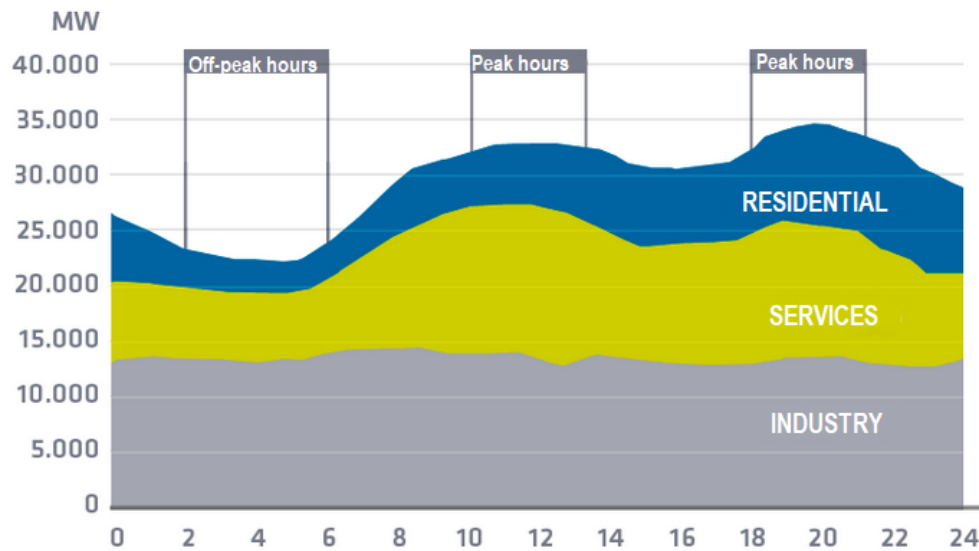


Figure 5. Hourly consumption of the energy in Spain per day. Source: [11]. Translated by Gonzalo Pedrosa

From this table, the information that can be extracted is that the off-peak hours are from 2:00 to 6:00, and there are two peak hours, corresponding from 10:00 to 13:00 and from 18:00 to 22:00. But this table is not enough to determine one model of our case, because with this table, is not possible to extract the percentages of energy utilized in each hour. With the objective of expanding the information, the second source is a report from REE [12], in which this information is expanded for the houses, in summer and winter.

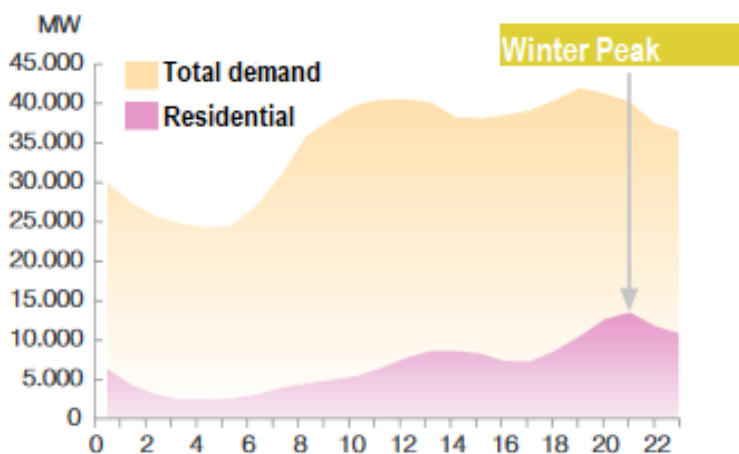


Figure 6. Hourly consumption of the energy in a house per day in Winter. Source: [12] Translated by Gonzalo Pedrosa



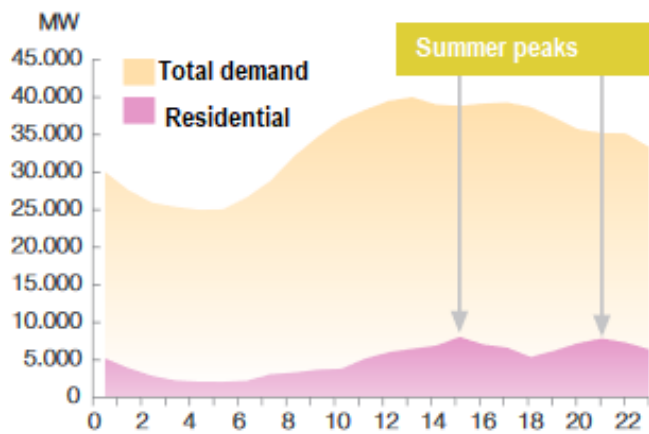


Figure 7. Hourly consumption of the energy in a house per day in Summer. Source: [12]. Translated by Gonzalo Pedrosa

As is visible, the peak hours depends on the summer or winter.

|              | Winter<br>consumption<br>(MW) | Percentage<br>of the<br>energy per<br>period (%) | Summer<br>consumption<br>(MW) | Percentage<br>of the<br>energy per<br>period (%) |
|--------------|-------------------------------|--|-------------------------------|--|
| 1:00         | 5000                          | 2,98   | 5000                          | 3,84   |
| 2:00         | 3750                          | 2,24   | 3750                          | 2,88   |
| 3:00         | 3000                          | 1,79   | 2500                          | 1,92   |
| 4:00         | 2700                          | 1,61   | 2500                          | 1,92   |
| 5:00         | 2700                          | 1,61   | 2500                          | 1,92   |
| 6:00         | 3000                          | 1,79   | 2500                          | 1,92   |
| 7:00         | 4500                          | 2,68   | 3750                          | 2,88   |
| 8:00         | 5000                          | 2,98   | 3900                          | 2,99   |
| 9:00         | 5000                          | 2,98   | 4000                          | 3,07   |
| 10:00        | 5000                          | 2,98   | 4200                          | 3,23   |
| 11:00        | 6250                          | 3,72   | 5000                          | 3,84   |
| 12:00        | 7500                          | 4,47   | 5500                          | 4,22   |
| 13:00        | 8750                          | 5,21   | 6250                          | 4,80   |
| 14:00        | 8750                          | 5,21   | 7500                          | 5,76   |
| 15:00        | 8750                          | 5,21   | 7500                          | 5,76   |
| 16:00        | 7500                          | 4,47   | 7500                          | 5,76   |
| 17:00        | 7500                          | 4,47   | 7300                          | 5,61   |
| 18:00        | 8750                          | 5,22   | 5000                          | 3,84   |
| 19:00        | 10000                         | 5,96   | 6250                          | 4,80   |
| 20:00        | 12500                         | 7,46   | 7500                          | 5,76   |
| 21:00        | 13000                         | 7,75   | 7750                          | 5,95   |
| 22:00        | 12500                         | 7,46   | 7500                          | 5,76   |
| 23:00        | 11250                         | 6,71   | 7500                          | 5,76   |
| 0:00         | 5000                          | 2,98   | 7500                          | 5,76   |
| <b>TOTAL</b> | <b>167650</b>                 |  | <b>152650</b>                 |  |

Table 5. Percentages of energy consumption of a house in summer and winter.

The objective of this table is to calculate the percentage of the energy used in each hour approximately. With this information and the data calculated and obtained, the main task is to calculate the energy consumed by the proposed house, in order to know when is consumed the energy.

To estimate the consumption of the house, some electrical bills of the house that is being under study have been analyzed, in order to extract the real monthly consumption of the house .

As a result of the information obtained from the electrical bills of IBERDROLA (company that the owner of the house has hired to provide the electricity), this table shows the result of the analysis of the electrical consumption since December 2016 until November 2017 (a whole year):

| Month | Dec  | Jan | Feb | Mar     | Apr | May | Jun | Jul | Aug |
|-------|------|-----|-----|---------|-----|-----|-----|-----|-----|
| KWh   | 1058 | 984 | 571 | 433     | 497 | 406 | 439 | 171 | 410 |
| Month | Sept | Oct | Nov | Average |     |     |     |     |     |
| kWh   | 384  | 958 | 644 | 579,58  |     |     |     |     |     |

Table 6. Analysis of Iberdrola Bills of the standard house.

For some companies, there are tariffs than distinguish between summer and winter, according to the time change. For that reason, the information is being treated separately, differentiating summer time and winter time. Summer time goes between the end of March until the end of October, and winter the rest of them, the information is shown in the next table:

| Consideration of the companies | Months included                                       |
|--------------------------------|---|
| Winter                         | November, December, January, February and March       |
| Summer                         | April, May, June, July, August, September and October |

Table 7. Summer and winter according to the electrical companies.

With this distinction, the averages in winter and summer are separately calculated:

*Average consumption per month in summer*

$$= \frac{497 + 406 + 439 + 171 + 410 + 384 + 958}{7} = 466,63 \frac{kWh}{month} [1]$$

$$\text{Average consumption per month in winter} = \frac{644 + 1058 + 984 + 571 + 433}{5}$$

$$= 738 \frac{kWh}{month} [2]$$

In order to have more clearance and to make the case more general, we are combining the information calculated with the information extracted from the electrical bills. With this data, and the information calculated before, the weighted average is calculated for both winter and summer time, considering 70% the real data and 30% the calculated information.

*Weighted Average consumption per month in winter*

$$\begin{aligned}
 &= 0,7 * \text{Real Consumption} + 0,3 * \left( \frac{\sum_0^n \text{Consumption}}{n} \right) \\
 &= 0,7 * 738 + 0,3 * \left( \frac{861,583 + 1006,63 + 1154,93}{3} \right) \\
 &= 848,91 \frac{kWh}{month} [3]
 \end{aligned}$$

For the calculation in summer months, it should be taken in account the fact that the electricity consumption, according to the real bills, is lower than the consumption in winter, so it is normal to think that the calculated consumption would be also lower. To make this equation more real, the calculated consumption is being multiplied by a factor that corresponds to the ratio between the summer and winter consumption.

$$\begin{aligned}
 \text{Average Ratio of the difference between summer and winter} &= \frac{466,63}{738} \\
 &= 0,632 [4]
 \end{aligned}$$

*Weighted Average consumption per month in summer*

$$\begin{aligned}
 &= 0,7 * \text{Real Consumption} + 0,3 * \left( \frac{\sum_0^n \text{Consumption}}{n} \right) \\
 &= 0,7 * 466,63 + 0,3 * 0,632 * \left( \frac{861,583 + 1006,63 + 1154,93}{3} \right) \\
 &= 517,70 \frac{kWh}{month} [5]
 \end{aligned}$$

With the percentages calculated in [Table 5], the hourly consumption per month can be calculated by applying these percentages to the average consumption per month:

|              | Percentages (%) | Winter consumption per month (kWh) | Percentages (%) | Summer consumption per month (kWh) |
|--------------|-----------------|------------------------------------|-----------------|------------------------------------|
| <b>1:00</b>  | 2,98            | 25,30                              | 3,84            | 19,88                              |
| <b>2:00</b>  | 2,24            | 19,02                              | 2,88            | 14,91                              |
| <b>3:00</b>  | 1,79            | 15,20                              | 1,92            | 9,94                               |
| <b>4:00</b>  | 1,61            | 13,67                              | 1,92            | 9,94                               |
| <b>5:00</b>  | 1,61            | 13,67                              | 1,92            | 9,94                               |
| <b>6:00</b>  | 1,79            | 15,20                              | 1,92            | 9,94                               |
| <b>7:00</b>  | 2,68            | 22,75                              | 2,88            | 14,91                              |
| <b>8:00</b>  | 2,98            | 25,30                              | 3,00            | 15,53                              |
| <b>9:00</b>  | 2,98            | 25,30                              | 3,07            | 15,89                              |
| <b>10:00</b> | 2,98            | 25,30                              | 3,23            | 16,72                              |
| <b>11:00</b> | 3,73            | 31,66                              | 3,84            | 19,88                              |
| <b>12:00</b> | 4,47            | 37,95                              | 4,23            | 21,90                              |
| <b>13:00</b> | 5,22            | 44,31                              | 4,80            | 24,85                              |
| <b>14:00</b> | 5,22            | 44,31                              | 5,76            | 29,82                              |
| <b>15:00</b> | 5,22            | 44,31                              | 5,76            | 29,82                              |
| <b>16:00</b> | 4,47            | 37,95                              | 5,76            | 29,82                              |
| <b>17:00</b> | 4,47            | 37,95                              | 5,61            | 29,04                              |
| <b>18:00</b> | 5,22            | 44,31                              | 3,84            | 19,88                              |
| <b>19:00</b> | 5,96            | 50,60                              | 4,80            | 24,85                              |
| <b>20:00</b> | 7,46            | 63,33                              | 5,76            | 29,82                              |
| <b>21:00</b> | 7,75            | 65,79                              | 5,95            | 30,80                              |
| <b>22:00</b> | 7,46            | 63,33                              | 5,76            | 29,82                              |
| <b>23:00</b> | 6,71            | 56,96                              | 5,76            | 29,82                              |
| <b>0:00</b>  | 2,98            | 25,30                              | 5,76            | 29,82                              |
| <b>Total</b> |                 | <b>848,914</b>                     |                 | <b>517,7</b>                       |

Table 8. Consumption of the modeling house separated in summer and winter.

In order to have also the average of both summer and winter consumption, the next table is made with the average of percentages and average of the consumptions, in order to see globally what is the monthly consumption with no differences between summer and winter, to apply more efficiently the tariffs that do not depend on the season.

|              | <b>Percentages<br/>(%)</b> | <b>Consumption<br/>per month<br/>(kWh)</b> |
|--------------|----------------------------|--|
| <b>1:00</b>  | 3,41                       | 22,59                                      |
| <b>2:00</b>  | 2,56                       | 16,96                                      |
| <b>3:00</b>  | 1,86                       | 12,57                                      |
| <b>4:00</b>  | 1,77                       | 11,80                                      |
| <b>5:00</b>  | 1,77                       | 11,80                                      |
| <b>6:00</b>  | 1,86                       | 12,57                                      |
| <b>7:00</b>  | 2,78                       | 18,83                                      |
| <b>8:00</b>  | 2,99                       | 20,41                                      |
| <b>9:00</b>  | 3,03                       | 20,60                                      |
| <b>10:00</b> | 3,11                       | 21,01                                      |
| <b>11:00</b> | 3,79                       | 25,77                                      |
| <b>12:00</b> | 4,35                       | 29,92                                      |
| <b>13:00</b> | 5,01                       | 34,58                                      |
| <b>14:00</b> | 5,49                       | 37,07                                      |
| <b>15:00</b> | 5,49                       | 37,07                                      |
| <b>16:00</b> | 5,12                       | 33,88                                      |
| <b>17:00</b> | 5,04                       | 33,49                                      |
| <b>18:00</b> | 4,53                       | 32,10                                      |
| <b>19:00</b> | 5,38                       | 37,72                                      |
| <b>20:00</b> | 6,61                       | 46,57                                      |
| <b>21:00</b> | 6,85                       | 48,30                                      |
| <b>22:00</b> | 6,61                       | 46,57                                      |
| <b>23:00</b> | 6,24                       | 43,39                                      |
| <b>0:00</b>  | 4,37                       | 27,56                                      |
| <b>Total</b> |                            | <b>683,14</b>                              |

*Table 9. Consumption of the modeling house for a whole year.*

With this calculations, it is possible to discuss whether is positive to have a spot tariff or a fixed tariff.

## 5 Electricity consumption of a shopping mall

Is it necessary to analyze the energy consumption of the shopping mall that is being studied.

According to the energy foundation of Madrid [13], the energy in the shopping malls are used for:

| Percentages | Usage                |
|-------------|----------------------|
| 41 - 42 %   | Lights               |
| 47 - 51 %   | Heating              |
| 4 - 5 %     | Mechanical Transport |
| 1 %         | Industrial Cold      |
| 3 - 5 %     | Others               |

Table 10. Percentages of energy in a shopping mall. Source: [13]

According to the Practical Guide of Saving and Efficiency Targeted to Traders [14], the average consumption of the shopping malls is 250 kWh/m<sup>2</sup> per year, being acceptable the range between 100-600 kWh/m<sup>2</sup>.

The shopping mall object of study is called “CC Arena” and it is located in Valencia. This shopping mall has 30000 m<sup>2</sup> of commercial area in where the consumption is being analyzed.

According to the Practical Guide of Saving and Efficiency Targeted to Traders and with the data that it is known from the shopping mall, the total consumption can be calculated as it is shown in the next equation:

$$Consumption = \frac{\text{Average consumption}}{m^2} * \text{Area} = 100 * 30000 = 30000 \frac{kWh}{year} \quad [6]$$

$$30000 \frac{kWh}{year} = 250 \frac{mWh}{month} \quad [7]$$

With the analysis of the electrical bills of the CC Arena, this table has been made in order to see the differences between the theoretical and the real consumption:

| Year              | 2017           |                |                |                |                |                |
|-------------------|----------------|----------------|----------------|----------------|----------------|----------------|
| kWh               | Jan            | Feb            | Mar            | Apr            | May            | Jun            |
| P1                | 50684          | 42602          |                |                |                | 28886          |
| P2                | 59374          | 48448          |                |                |                | 23933          |
| P3                |                |                | 46656          |                |                | 17423          |
| P4                |                |                | 51195          |                |                | 31168          |
| P5                |                |                |                | 74 761         | 85 401         |                |
| P6                | 62990          | 53468          | 51373          | 55 945         | 50 882         | 55209          |
| <b>Total(kWh)</b> | <b>173.048</b> | <b>144.518</b> | <b>149.233</b> | <b>130.706</b> | <b>136.283</b> | <b>156.619</b> |
| Year              | 2017           |                |                |                |                |                |
| Jul               | Aug            | Sept           | Oct            | Nov            | Dec            |                |
| 56804             |                |                |                |                | 44425          |                |
| 48721             |                |                |                |                | 51157          |                |
|                   |                | 32769          |                | 49599          |                |                |
|                   |                | 61580          |                | 46055          |                |                |
|                   |                |                | 86801          |                |                |                |
| 66299             | 166030         | 57220          | 60994          | 58150          | 84459          |                |
| <b>171824</b>     | <b>166.030</b> | <b>151.569</b> | <b>147.795</b> | <b>153.804</b> | <b>180.041</b> | <b>kWh</b>     |

Table 11. Analysis of Iberdrola Bills of the shopping mall.

The average of the consumptions is 153.123 kWh/month, which makes the difference of the theoretical and the real consumption significant (Difference of 38,8%). This difference can be explained because the shopping mall has a very significant open area, in which is not necessary the air conditioning system and the lights are less used because of the solar light.

This bill has different rows, due to the fact that there are different tariffs, hourly differentiated and different depends on the month. This is called an Access Tariff 6x, And it has six periods of the price of the energy.

|    | POWER TERM (€/kWh) | ENERGY TERM (€/kW day) |
|----|--------------------|------------------------|
| P1 | 0,107231           | 0,102496               |
| P2 | 0,053662           | 0,087325               |
| P3 | 0,039272           | 0,082939               |

|    |           |          |
|----|-----------|----------|
| P4 | 0,039272  | 0,071137 |
| P5 | 0, 039272 | 0,067193 |
| P6 | 0,017918  | 0,05472  |

*Table 12. Prices of the energy in the 6x. Tariff. Iberdrola. Source: Electrical bills of the shopping mall.*

According to these prices, the energy is calculated multiplying the power term price times the consumption in each period, plus the energy term times the days of the month.

According to the average consumption, the standard daily consumption can be calculated by dividing it by 30 (days/month), so the result is 5140,1 kWh/day, and with that, we can calculate the hourly consumption.

For doing that, there is no information available, so the procedure will be to suppose that the 80% of the energy is used in the time that the shopping mall is open (4083,28 kWh) and working, and the rest (20%, 1028,02 kWh) is used when the shopping mall is closed.

According to his webpage [15], the shopping mall is open from 10 to 20.

| <b>Hours</b> | <b>Consumption:</b> | <b>Hourly consumption:</b> |
|--------------|---------------------|----------------------------|
| 10:00-20:00  | 4083,28 kWh         | 408,328 kWh                |
| 20:01-09:59  | 1028,02 kWh         | 73,43 kWh                  |

*Table 13. Hourly consumption of a shopping mall.*



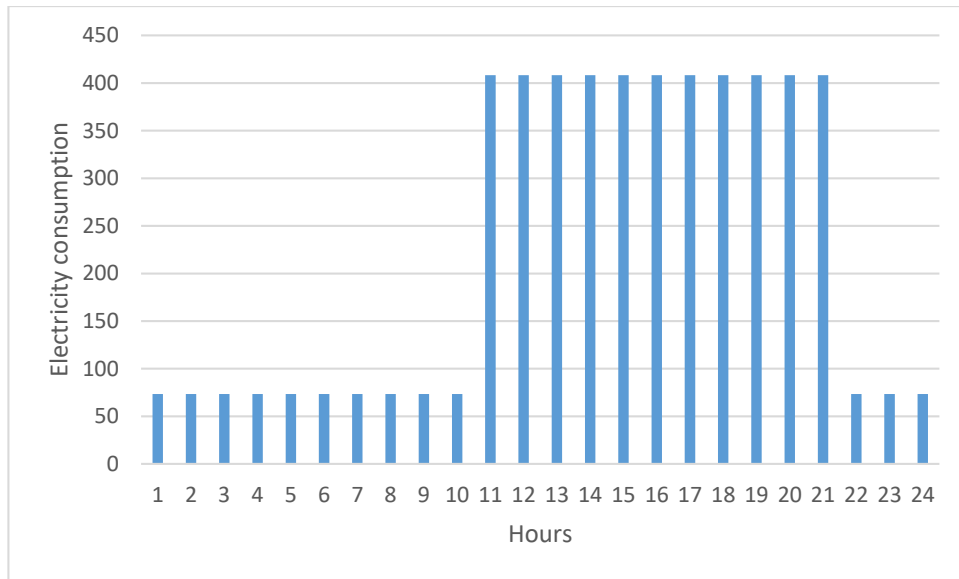


Figure 8. Hourly consumption of a shopping mall

## 6 Analysis of the different supplier companies of electrical energy.

The supplier companies as it is written in the thesis, are the companies that provide the different tariffs to the consumers, in order to let the consumers choose which company they want to hire, depending on the price and the origin of the energy.

In this section, the different companies and tariffs that they offer are explained, in order to see the variety of tariffs that can be chosen by the consumers.

There are five main marketing companies that supplies energy in Spain. In the next figure it is seen the ranking of the Spanish marketing companies:



Figure 9. Ranking of the marketing companies in Spain. Source: [16].

As it is visible in the figure, Endesa, Iberdrola, Gas Natural Fenosa, EDP, and Fortia are the main companies in this sector. Viesgo, which was one of the main companies now is in the seventh place, and the fifth main company is Fortia.

To see this information more clear, based on the information of “El independiente newspaper” [17], two tables have been made in order to see the different market share percentages of both free market and regulated market:

| <b>Company</b>     | <b>Market Share</b> |
|--------------------|---------------------|
| Endesa Energía     | <b>46,4 %</b>       |
| Iberdrola Comer.   | <b>30,9 %</b>       |
| Gas Natural S.U.R. | <b>19,0 %</b>       |
| Others             | <b>3,7 %</b>        |

|              |                                       |
|--------------|---------------------------------------|
| <b>TOTAL</b> | <b>12.205.238 millions of clients</b> |
|--------------|---------------------------------------|

*Table 14. Regulated Gas and Light Market Share. Source: [17].*

| <b>Company</b>     | <b>Market Share</b>                   |
|--------------------|---------------------------------------|
| Iberdrola Clientes | <b>38,2 %</b>                         |
| Endesa Energía     | <b>30,7 %</b>                         |
| Gas Natural Fenosa | <b>13,5 %</b>                         |
| Grupo EDP          | <b>5,0 %</b>                          |
| Viesgo Energía     | <b>2,4 %</b>                          |
| Others             | <b>10,2%</b>                          |
| <b>TOTAL</b>       | <b>16.880.387 millions of clients</b> |

*Table 15. Free Gas and Light Market Share. Source: [17].*

The information in both tables, has been analyzed the 31th of December of 2017.

According to this two tables, there are more clients in the free market rather than the regulated market in Spain. That is an interesting fact that could be explained due to the diversity of marketing companies that sells electricity in Spain (according to literature, around 450 companies).

## 6.1 Endesa

Endesa is the leader in the Spanish electrical sector, and is the second operator in Portugal according to Endesa webpage [18].

His principal business is the generation, distribution and direct marketing of the electricity. His principal activity is developed essentially in Spain and Portugal. The Enel Group has the 70,1 % of Endesa, and is a multinational energy company and a leader operator in the worldwide electricity and gas markets in Europe and Latin America.

In the next figure, from the webpage of Endesa [19], it is seen the total generated energy in the mainland (Spain and Portugal).

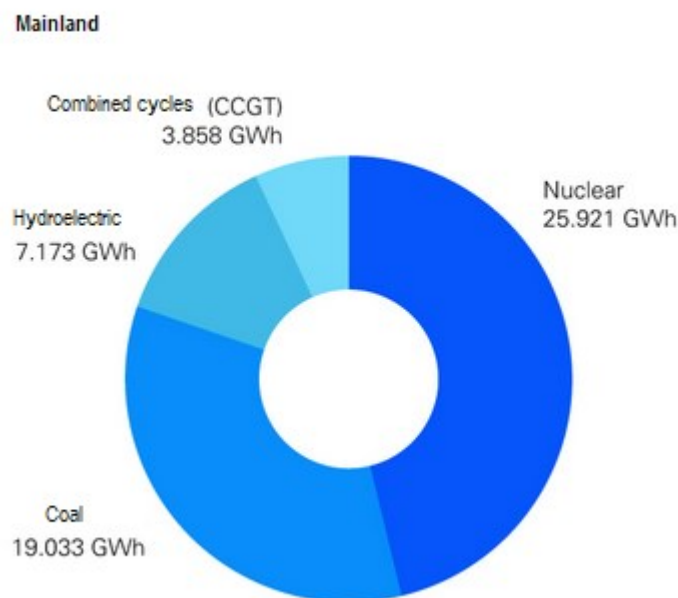


Figure 10. Total Generation of electrical energy of Endesa Source: [19].

In the next table, the number of clients are shown, differentiated into regulated market clients and free market clients.

| Number of clients | Thousands |
|-------------------|-----------|
| Regulated Market  | 5.593     |
| Free market       | 5.423     |

Table 16. Number of clients of Endesa. Source: [19].

### 6.1.1 Regulated market

Endesa is one company allowed to offer the *PVPC*. For doing that, in their webpage there are a section showing the prices of the energy in real time and also the average price of

the daily energy and the cheapest and the most expensive hours, as it is seen in the next figure:

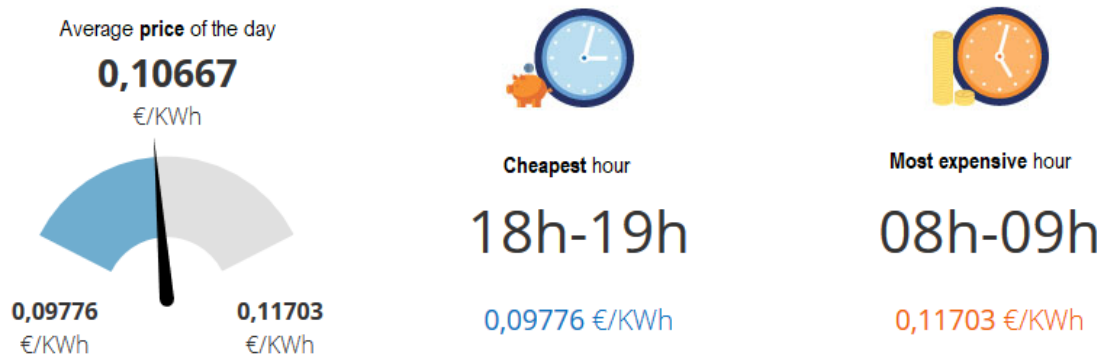


Figure 11. Information of the energy prices extracted from [20].

From this webpage, also can be extracted a table of the energy prices evolution, in order to calculate when is cheaper to use the energy.

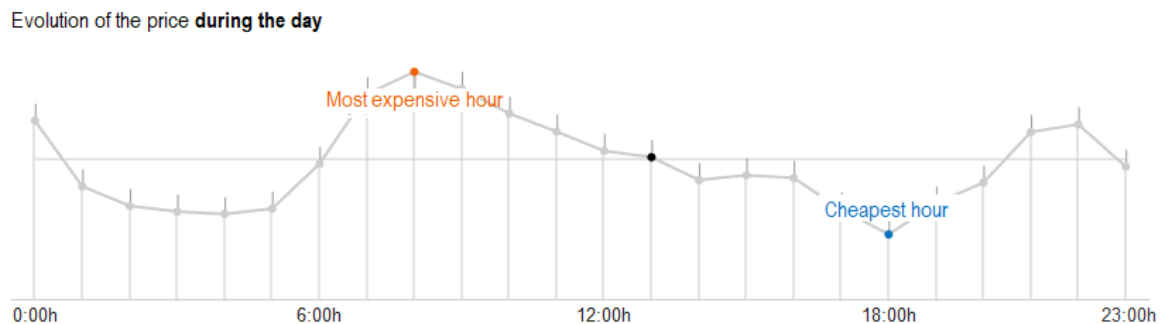


Figure 12. Evolution of the energy prices in the free market. Source: [20]

In order to avoid this price changes, and to know what is the real cost of the energy during the days, Iberdrola also has free market tariffs, that are being explained in the following sections.

## 6.1.2 Free market tariffs

### 1.1.1. One Light

This plan has no hourly discrimination, so you pay the same without hourly discrimination. This is a tariff that guarantees an stable price of the energy.

| Conditions    | Fixed Power Term   | Energy Term (Consumption) |
|---------------|--------------------|---------------------------|
| Power < 10 kW | 3,429702€/kW month | 0,117412 €/kWh            |

Table 17. One light plan from Iberdrola. Source: [21].

### 1.1.2. One Night Light

This tariff is made for the people that uses more the energy at nights, so the price of the energy is lower at night.

| Conditions    | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term   | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|---------------|-------------------------------|-------------------------------|--------------------|---|---|
| Power < 10 kW | 22:00-12:00                   | 23:00-13:00                   | 3,429702€/kW month | 0,065289 €/kWh                            | 0,144483 €/kWh                                |

Table 18. One night light plan from Iberdrola Source: [22]

This table and the next ones, indicates the hours of energy saving, which are the hours when the energy is cheaper, the fixed power term, which has to be paid and remains constant with the energy hired, and the energy term, which is the price that has to be paid depending on the consumption of energy. The promoted period is the period in where the energy is cheaper, so is the one that corresponds to the hours of energy saving, and it is also called off-peak period.

### 1.1.3. Tempo Happy

This tariff is interesting because you can choose 2 hours per day or 1 whole day per week to have the energy at zero cost.

| Conditions    | Hours of energy saving                    | Fixed Power Term    | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|---------------|---|---------------------|---|---|
| Power < 10 kW | You get to choose 2 hours/ 1 day per week | 3,984651 €/kW month | 0 €/kWh                                   | 0,140847 €/kWh                                |

Table 19. Tempo happy plan from Iberdrola Source: [23]

#### 1.1.4. Tempo you always win

| Conditions    | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term    | Energy Term (Consumption) | Discount |
|---------------|-------------------------------|-------------------------------|---------------------|---------------------------|----------|
| Power < 10 kW | 22:00-12:00                   | 23:00-13:00                   | 3,785418 €/kW month | 0,133661€/kWh             | *        |

Table 20. Tempo you always win plan Source: [24]

\*The off peak consumption that overcomes the 50% of the total consumption gives additional discount of the energy. For example, if the off peak consumption represents a 58% of the total energy, a discount of 8% is applied to the bill.

#### 1.1.5. Tempo night

| Conditions    | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term    | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|---------------|-------------------------------|-------------------------------|---------------------|---|---|
| Power < 10 kW | 22:00-12:00                   | 23:00-13:00                   | 3,785418 €/kW month | 0,076787€/kWh                             | 0,154314€/kWh                                 |

Table 21. Tempo night plan Source: [25]

#### 1.1.6. Tempo green Super off peak

This tariff is really interesting, because it has three periods on the energy. The standard off peak and peak periods plus a period called “Super off Peak” in which the energy has the lowest price.

| Conditions    | Hours of off peak energy  | Hours of super off peak energy | Fixed Power Term    | Off peak Energy Term | Super Off Peak Energy Term | Peak Energy Term |
|---------------|---------------------------|--------------------------------|---------------------|----------------------|----------------------------|------------------|
| Power < 10 kW | 23:00-1:00 and 7:00-13:00 | 1:00-7:00                      | 3,785418 €/kW month | 0,093027 €/kWh       | 0,071872 €/kWh             | 0,162194 €/kWh   |

Table 22. Tempo green Super Off peak plan Source: [26]

## 6.2 Iberdrola

Iberdrola is the second marketing company in terms of number of consumers in Spain. With more than 170 years of experience, Iberdrola is an international energetic leader: it produces and supplies electricity to more than 100 millions of people in the countries that it supplies. These countries can be seen in the next figure, extracted from the webpage of Iberdrola [27]:

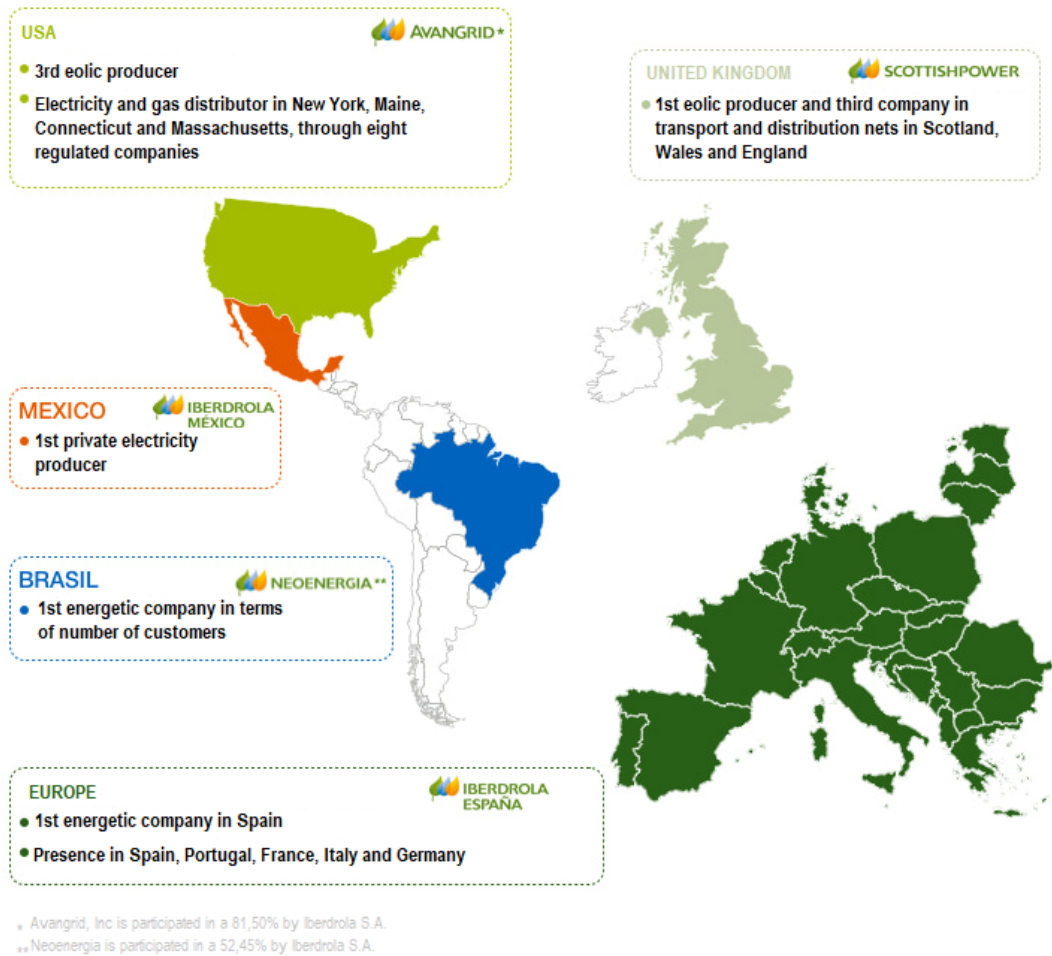


Figure 13. Presence of Iberdrola in the world. Source [27]. Translated by Gonzalo Pedrosa.

Iberdrola is the number one company in terms of wind energy generation. During 2016, 63% of the energy generated by the company has been proven to be renewable energy. Is the number one company in Spain in terms of consumption. This company gets the electricity from different sources, according to their webpage, the total installed capacity is 25,934 MW, distributed as is visible in Figure [14]:



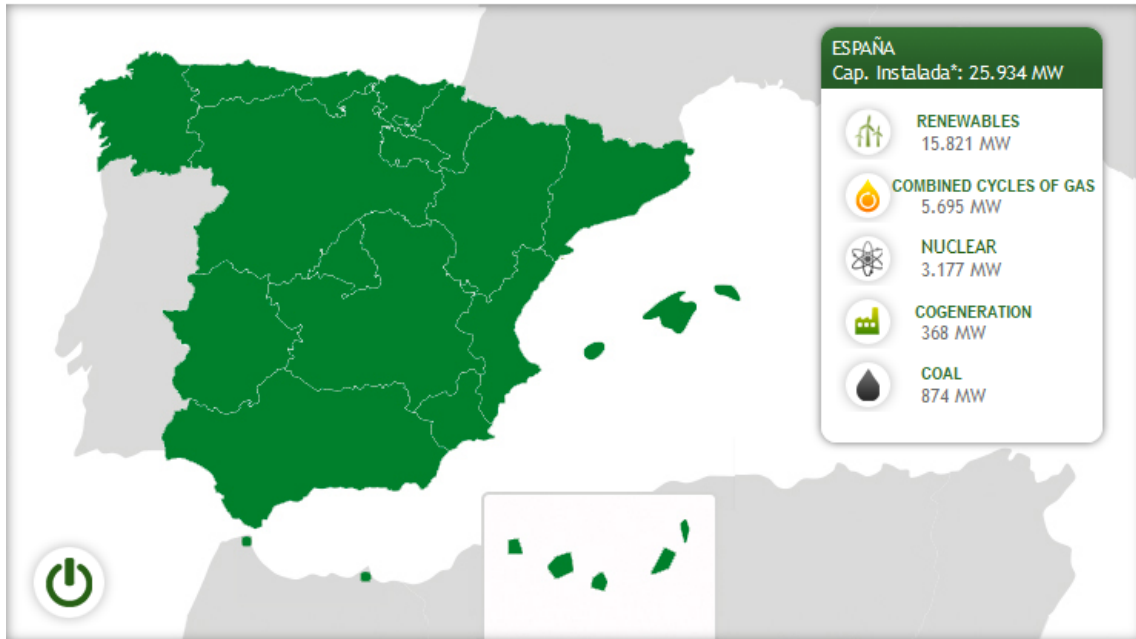


Figure 14. Division of the power plants installed and used by Iberdrola to generate electricity. Source: [28].

Translated by Gonzalo Pedrosa

As it is visible also, Iberdrola has a large quantity of renewable energy production. In the next table, the sources of energy are being exposed and also their percentages in terms of quantity:

| Source           | Net output (GW/h) | Percentage of production (%) |
|------------------|-------------------|------------------------------|
| Renewable energy | 19.897            | 28,80                        |
| Nuclear          | 23.249            | 33,65                        |
| Fuel/gas         | 3.812             | 5,52                         |
| Coal             | 2.642             | 3,82                         |
| Natural gas      | 16.891            | 24,44                        |
| Cogeneration     | 2.607             | 3,77                         |
| Total            | 69.098            |                              |

Figure 15. Production of energy of Iberdrola. 2017 Source: [29].

Iberdrola is one of the companies that has the right to offer the *PVPC*, and for applying it, the company has created the company Iberdrola Comercializador de Referencia, which is a company dependent on Iberdrola, but only manages the regulated market for his consumers.

### 6.2.1 Regulated market

### 1.1.1. PVPC

As it has been said before, this price is regulated by the electricity market, so it is impossible to indicate the energy price per hour. However, this information can be found in [30], webpage that belongs to the REE.

### 1.1.2. Fixed price

The fixed price is fixed for a year and cannot change during this period. Iberdola has a permanence of 1 year if you decide to take this tariff.

| <b>Power Term (€/kW year)</b> | <b>Energy Term (€/kWh)</b> |
|-------------------------------|----------------------------|
| 38,043426                     | 0,145760                   |

Table 23. Fix price of Iberdrola Comercializador de Referencia. Source: [31]

This company also has different tariffs in the free market depending on what the consumer needs.

## 6.2.2 Free market tariffs

### 1.1.1. Night Plan

This plan is made for the consumers that uses the energy during the night, allowing them to pay the cheapest price at night.

| <b>Conditions</b>       | <b>Hours of energy saving Winter</b> | <b>Hours of energy saving Summer</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b> | <b>Energy Term (Consumption) Not promoted period</b> |
|-------------------------|--------------------------------------|--------------------------------------|-------------------------|--|--|
| <b>Power &lt; 10 kW</b> | 22:00-12:00                          | 23:00-13:00                          | 42,043426 €/kW year     | 0,069775 €/kWh                                   | 0,148533 €/kWh                                       |
| <b>Power &gt; 10 kW</b> | 22:00-12:00                          | 23:00-13:00                          | 49,532016 €/kW year     | 0,088131 €/kWh                                   | 0,152312 €/kWh                                       |

Table 24. Night Tariff of Iberdrola. Source: [32].

### 1.1.2. Summer Plan

This plan is made for the summer period, because the saving time does not depend on the hours, but depends on the dates. So this tariff is perfect for summer cottages.

| Conditions    | Period of energy saving | Fixed Power Term    | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|---------------|-------------------------|---------------------|---|---|
| Power < 10 kW | 15/06-15/09             | 42,043426 €/kW year | 0,074613 €/kWh                            | 0,168531 €/kWh                                |
| Power > 10 kW | 15/06-15/09             | 49,532016 €/kW year | 0,103852 €/kWh                            | 0,174732 €/kWh                                |

Table 25. Summer plan of Iberdrola. Source: [33].

### 1.1.3. Choose 8 hours Plan

This plan is really interesting because you get to choose in which hours you want to pay less. And also is really interesting because you have the right to change the hours whenever. By choosing this plan you will get 100% renewable energy.

| Conditions    | Hours of energy saving Summer | Fixed Power Term    | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|---------------|-------------------------------|---------------------|---|---|
| Power < 10 kW | Chosen by the consumer        | 42,043426 €/kW year | 0,074613 €/kWh                            | 0,168531 €/kWh                                |
| Power > 10 kW |                               | 49,532016 €/kW year | 0,103852 €/kWh                            | 0,174732 €/kWh                                |

Table 26. Choose 8 hours Plan of Iberdrola. Source: [34].

### 1.1.4. Stable Plan

This plan has no hourly discrimination, so you pay the same without hourly discrimination.

| Conditions    | Fixed Power Term    | Energy Term (Consumption) |
|---------------|---------------------|---------------------------|
| Power < 10 kW | 42,043426 €/kW year | 0,123988 €/kWh            |
| Power > 10 kW | 0,123988 €/kWh      | 0,131941 €/kWh            |

Table 27. Stable Plan of Iberdrola. Source: [35].

### 1.1.5. Weekend Plan

This plan makes the weekends the energy saving periods, so is perfect for the people that do not spend time at home in the week days, but in the weekends they do.

| <b>Conditions</b>       | <b>Period of energy saving</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b> | <b>Energy Term (Consumption) Not promoted period</b> |
|-------------------------|--------------------------------|-------------------------|--|--|
| <b>Power &lt; 10 kW</b> | Weekends                       | 42,043426€/kW year      | 0,074613 €/kWh                                   | 0,168531 €/kWh                                       |
| <b>Power &gt; 10 kW</b> | Weekends                       | 49,532016€/kW year      | 0,103852 €/kWh                                   | 0,174732 €/kWh                                       |

Table 28. Weekend Plan of Iberdrola. Source: [36].

### 1.1.6. Winter Plan

This plan is the opposite as the Summer Plan, so it is made for spending the winter without paying the energy at high prices. This plan is really interesting due to the fact that in winter the electricity is more expensive than in summer (according to our data of Iberdrola).

| <b>Conditions</b>       | <b>Period of energy saving</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b> | <b>Energy Term (Consumption) Not promoted period</b> |
|-------------------------|--------------------------------|-------------------------|--|--|
| <b>Power &lt; 10 kW</b> | 01/12-01/03                    | 42,043426 €/kW year     | 0,074613 €/kWh                                   | 0,168531 €/kWh                                       |
| <b>Power &gt; 10 kW</b> | 01/12-01/03                    | 49,532016 €/kW year     | 0,103852 €/kWh                                   | 0,174732 €/kWh                                       |

Table 29. Summer Plan of Iberdrola. Source: [37].

### 6.3 Gas Natural Fenosa

Gas Natural Fenosa is the third marketing company in terms of number of consumers. Born in 1999, this multinational company works with more than 30 countries and has more than 18 million of delivery points. This company also generates electricity and gas. In Spain this company is the leader in natural gas distribution.

The generated energy in Spain is visible in the next table, extracted from the Gas Natural Fenosa webpage [38]:

|   |                              |        |
|---|------------------------------|--------|
| <b>Electricity generation capacity (MW)</b> |                              | 12.716 |
| <b>Generation (MW)</b>                      |                              | 11.569 |
|   | Hydraulic (MW)               | 1.954  |
|   | Nuclear (MW)                 | 604    |
|   | Coal (MW)                    | 2.010  |
|   | Combined cycles (MW)         | 7.001  |
| <b>Renewables and cogeneration</b>          |                              |        |
|   | Eolic (MW)                   | 979    |
|   | Small hydro (MW)             | 110    |
|   | Cogeneration and others (MW) | 58     |
| <b>Electricity sales</b>                    |                              | 36.384 |
|   | Free market (MW)             | 31.067 |
|   | Regulated Market (MW)        | 5.217  |

Table 30. Data of generated and sales electricity in Spain of Gas Natural Fenosa. Source: [38].

As it is seen in the table, this company is more appreciated by the consumers because of the free market, and not the regulated market.

Gas Natural Fenosa is one of the companies that has the right to offer the *PVPC*, so that is the reason because the electricity sales can be divided into free market and regulated market.

As it is also visible in the next figure, Gas Natural Fenosa has his activity of distributing energy in more than 30 countries, this map is available at Iberdrola webpage [39]:

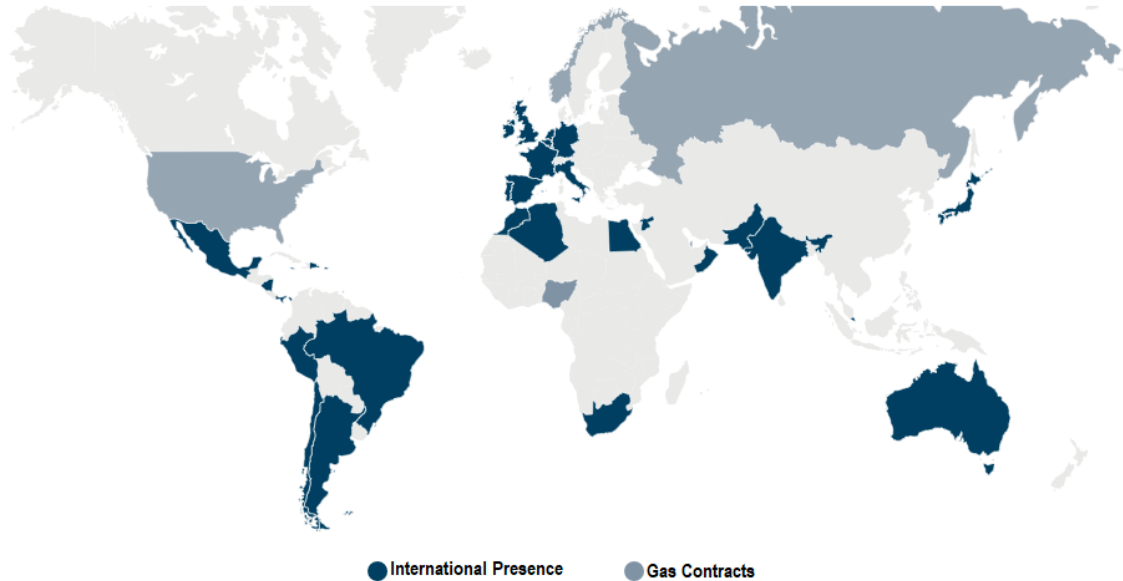


Figure 16. International Presence of Gas Natural Fenosa. Source: [39]. Translated by Gonzalo Pedrosa.

With respect to the regulated market, the prices of the energy are the same no matter with company is chosen, so as the webpage does not have any important information of the regulated market energy, the information explained from Endesa and Iberdrola are also valid to Gas Natural Fenosa.

Gas Natural Fenosa has their free market tariffs organized in some groups that are being explained in the next section:

### 6.3.1 Free market tariffs

#### 1.1.1. Flat tariffs

The flat tariffs are made so that the monthly price of the energy is fixed.

The monthly price depends exclusively on the electricity consumption as the next table (whose information has been extracted from Gas Natural Fenosa webpage [40]) shows:

| Tariff        | Maximum consumption per year (kWh /year) | Price €/month |
|---------------|--|---------------|
| Micro Light   | 1.500                                    | 32            |
| Mini Light    | 2.500                                    | 42            |
| Average Light | 4.000                                    | 55            |
| Maxi Light    | 5.500                                    | 73            |
| Extra Light   | 7.000                                    | 89            |

Table 31. Flat tariffs of Gas Natural Fenosa depending on the consumption. Source: [40].

#### 1.1.2. Stable tariffs

The stable tariffs are made so that you pay depending on how much energy is consumed. This tariff is divided depending on how the yearly consumption is:

| <b>Conditions</b>                    | <b>Fixed Power Term</b> | <b>Energy Term (Consumption)</b> |
|--------------------------------------|-------------------------|----------------------------------|
| <b>Consumption &lt;2500 kWh/year</b> | 41,293426<br>€/kW year  | 0,146051<br>€/kWh                |
| <b>Consumption &gt;2500 kWh/year</b> | 42,693426<br>€/kW year  | 0,146051<br>€/kWh                |

Table 32 Stable tariffs of Gas Natural Fenosa depending on the consumption. Source: [41].

### 1.1.3. Eco tariffs

The eco tariffs are made so that the energy that you consume is only extracted from renewable sources. Also this tariff has different modalities:

| <b>Tariffs</b>             | <b>Hours of energy saving Winter</b> | <b>Hours of energy saving Summer</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b>                       | <b>Energy Term (Consumption) Not promoted period</b> |
|----------------------------|--------------------------------------|--------------------------------------|-------------------------|--|--|
| <b>Light</b>               | None                                 | None                                 | 42,693426<br>€/kW year  | 0,140750<br>€/kWh  | 0,140750<br>€/kWh                                    |
| <b>Night Light</b>         | 22:00-12:00                          | 23:00-13:00                          | 42,693426<br>€/kW year  | 0,083872<br>€/kWh  | 0,166059<br>€/kWh                                    |
| <b>Tri-Time zone Light</b> | 23:00-1:00 and 07:00-13:00           | 01:00-7:00                           | 42,693426<br>€/kW* year | Off peak:<br>0,092307<br>€/kWh<br>Super off peak:<br>0,075635<br>€/kWh | 0,167566<br>€/kWh                                    |

Table 33. Eco tariffs of Gas Natural Fenosa depending on the hourly discrimination. Source: [42].

As it is seen in the table, the different tariffs depend on the hourly discrimination that is preferable in each situation. The light tariff is used for people who do not need hourly discrimination, the night light tariff is used for people who consumes more energy at night, so the energy is cheaper at nights, and the tri time zone tariff has two period of saving energy, the off peak period, and the super off period.

### 1.1.4. Flexible tariffs

This tariff has hourly discrimination, so that the cheapest hours depends on winter or summer.

| <b>Tariffs</b>     | <b>Hours of energy saving Winter</b> | <b>Hours of energy saving Summer</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b> | <b>Energy Term (Consumption) Not promoted period</b> |
|--------------------|--------------------------------------|--------------------------------------|-------------------------|--|--|
| <b>Night Light</b> | 22:00-12:00                          | 23:00-13:00                          | 42,693426<br>€/kW year  | 0,086179<br>€/kWh                                | 0,172692<br>€/kWh                                    |

*Table 34. Flexible tariffs of Gas Natural Fenosa depending on the hourly discrimination. Source: [43].*



## 6.4 EDP

EDP Spain is a company based on generation, distribution and marketing of electrical energy and gas.

It has an installed capacity of 5.722 MW and in 2016 their production of energy was 13.985 GWh, according to their webpage [44] divided into:

| Energy generated        | Quantity (GWh) | Percentage |
|-------------------------|----------------|------------|
| Hydraulic               | 930            | 7 %        |
| Wind                    | 4.926          | 35 %       |
| Coal                    | 5.150          | 37 %       |
| Combined cycle          | 1.640          | 12 %       |
| Nuclear                 | 1.239          | 9 %        |
| Cogeneration and others | 100            | 1 %        |

Table 35. Division of the generated energy of EDP Spain. Source: [44].

For the distribution, 9.190 GWh of energy are distributed with a net of 20.520 km.

For the marketing, it has 18.192 GWh of marketing electricity.

In Spain is the fourth company, with a market share of 8,6 %, with 1.498.156 clients in Spain.

### 6.4.1 Regulated market

According to the regulated market, Gas Natural Fenosa in his webpage has a table with the reference prices of the current month, to make an idea of how much you may pay for the monthly energy.

### 6.4.2 Free market tariffs

According to their webpage, the different tariffs for the free market and the prices of the energy are visible in the next table:

| Type                             | Name                 | Fixed power term (€/kW month) |         |          | Energy term (€/kWh) |          |          |
|----------------------------------|----------------------|-------------------------------|---------|----------|---------------------|----------|----------|
|                                  |                      | P1                            | P2      | P3       | P1                  | P2       | P3       |
| Power<br><= 10KW                 | Price Light EDP 1    | 3,503605                      | N/A     | N/A      | 0,135959            | N/A      | N/A      |
| Power<br><= 10KW                 | Price Light EDP 1 DH | 3,503605                      | N/A     | N/A      | 0,159068            | 0,076993 | N/A      |
| Power<br>> 10 kW and<br><= 15 kW | Price Light EDP 2    | 3,755181                      | N/A     | N/A      | 0,159504            | N/A      | N/A      |
| Power<br>> 10 kW and<br><= 15 kW | Price Light EDP 2 DH | 3,703716                      | N/A     | N/A      | 0,187311            | 0,087428 | N/A      |
| Power<br>> 15 kW                 | Price Light EDP 3    | 3,394074                      | 2,03646 | 1,357618 | 0,140726            | 0,119397 | 0,094928 |

Table 36. Different tariffs of free market from EDP. Source: [45].

Depending on the consumption and the hourly discrimination, any tariff can be chosen (if the hired power is suitable).

With respect to the hourly discrimination, the period 1 is considered the peak period, the period where the energy is more expensive, the period 2 is considered the off peak period, where the energy is cheaper than period 1, and the period 3 is considered the super off peak, in where the price of the energy is the cheapest.

The period 1 is considered between 13:00-23:00, the period 2 between 23:00-1:00 and 7:00-13:00, and the period 3 from 1:00 to 7:00, according to Gas Natural webpage [46].

## 6.5 Viesgo

Viesgo is a company that generates, distributes and sells energy in Spain. This company was founded in 1906, and nowadays it has more than 730.000 clients (according to Viesgo webpage [47])

This company operates both in free market and regulated market.

In the next figure, extracted from Viesgo webpage [48], it is defined the different power plants that owns Viesgo and that are used in order to generate the electrical energy required.

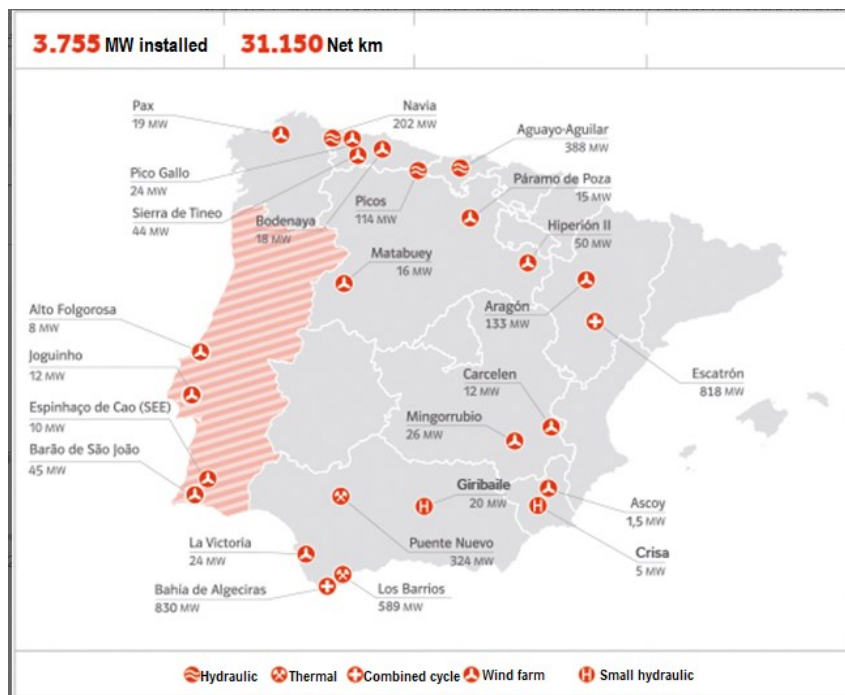


Figure 17. Map with the different power plants of Viesgo. Source: [48]. Translated by Gonzalo Pedrosa.

### 6.5.1 Free market tariffs

In the next table, the different tariffs are summarized in order to see them easier:

| Tariffs            | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term  | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|--------------------|-------------------------------|-------------------------------|-------------------|---|---|
| Good Bye Surprises | None                          | None                          | 0,149515 €/kW day | 0,158819 €/kWh                            | 0,158819 €/kWh                                |
| Your moment        | 22:00-12:00                   | 23:00-13:00                   | 0,149515 €/kW day | 0,095288 €/kWh                            | 0,190533 €/kWh                                |

Table 37. Different tariffs of Viesgo. Sources: [49] and [50].

As seen, Viesgo only has two tariffs, “Good bye surprises” does not have hourly discrimination but “Your moment” has.

## 6.6 Escandinavia electricity

Escandinavia electricity is a company that belongs to the Fortium Group, which counts with a strong presence in Europe, with more than 15 million of consumers. It was established in 2008 in Spain, but originally was founded in 1898 in Sweden. This information can be found in the Escandinavia electricity webpage [51].

Apart from the distribution and marketing electricity, is one of the most important hydroelectric energy producer.

This company sells energy 100 % renewable, and operates only in the free market. One interesting fact about this company according to the CCHSBCN report [52] is that their approach to the energy market is to offer the Scandinavian concept of energy supply, based in transparency, simplicity, fair prices and energy 100% renewable.

### 6.6.1 Free market tariffs

Escandinavia energy has two types of tariffs, based on the hourly discrimination. The "DAG" tariff has no hourly discrimination, but the "NATT" does have. Also the price of the energy depends on the hired power, being 10 Kw the limit of the two prices.

| Name of the tariff | Conditions    | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term   | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|--------------------|---------------|-------------------------------|-------------------------------|--------------------|---|---|
| <b>NATT</b>        | Power < 10 kW | 22:00-12:00                   | 23:00-13:00                   | 0,107000 €/ kW day | 0,078000 €/kWh                            | 0,156000 €/kWh                                |
| <b>DAG</b>         | Power < 10 kW | None                          | None                          | 0,107000 €/kW day  | None                                      | 0,129000 €/kWh                                |
| <b>NATT</b>        | Power > 10 kW | 22:00-12:00                   | 23:00-13:00                   | 0,125000 €/ kW day | 0.090000 €/kWh                            | 0,171000 €/kWh                                |
| <b>DAG</b>         | Power > 10 kW | None                          | None                          | 0,125 €/kW day     | None                                      | 0,145000 €/kWh                                |

Table 38. Tariffs of Escandinavia Electricity. Source: [51]

## 6.7 Holaluz

Holaluz is a company that sells 100% renewable energy, and also is a company that allows the consumers to generate their electricity with solar panels or wind turbines.

This company was founded in 2010 in Barcelona. In August 2017 this company had more than 100.000 clients, so it is considered a small company compared with the largest companies in the sector.

The marketing energy comes from different renewable sources as visible in next figure obtained from Holaluz webpage [53]:

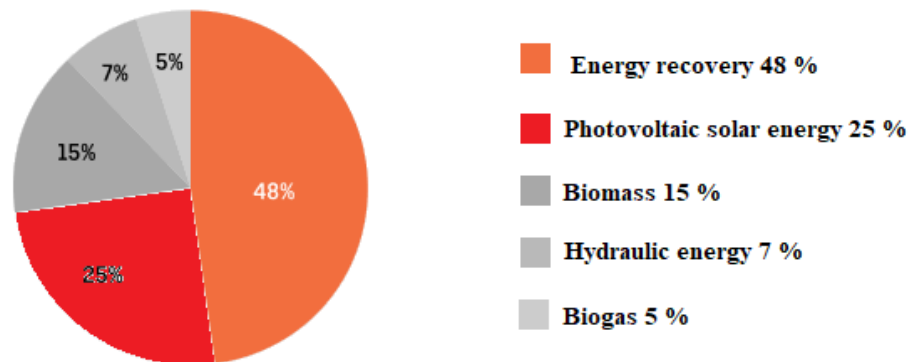


Figure 18. Summary of the different energy sources used by Holaluz. Source: [53] . Translated by Gonzalo Pedrosa

Energy recovery is the name of an energy source that recovers the residues inherit energy and avoids the degradation process of them. The residues used are paper, cardboard, plastics and some organic residues.

This company only works in the free market, and for that market it has different tariffs according on what are the needs of the consumers:

### 6.7.1 Free market tariffs

#### 1.1.1. One price

This tariff does not have hourly discrimination, so the price of the energy is fixed and does not depend on the time of the energy consumption.

| Conditions    | Fixed Power Term       | Energy Term (Consumption) |
|---------------|------------------------|---------------------------|
| Power < 10 kW | 38,043585<br>€/kW year | 0,123000 €/kWh            |
| Power > 10 kW | 38,043585<br>€/kW year | 0,139000 €/kWh            |

Table 39. One price tariff of Holaluz. Source: [54]

### 1.1.2. Two prices

This tariff has hourly discrimination, depending on when is the energy consumption you will have to pay more if you consume in the hours of not promoted period, and less if you consume in the hours of saving energy.

| <b>Conditions</b>       | <b>Hours of energy saving Winter</b> | <b>Hours of energy saving Summer</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b> | <b>Energy Term (Consumption) Not promoted period</b> |
|-------------------------|--------------------------------------|--------------------------------------|-------------------------|--|--|
| <b>Power &lt; 10 kW</b> | 22:00-12:00                          | 23:00-13:00                          | 38.043585<br>€/kW year  | 0,079000<br>€/kWh                                | 0,155000<br>€/kWh                                    |
| <b>Power &gt; 10 kW</b> | 22:00-12:00                          | 23:00-13:00                          | 44.444590<br>€/kW year  | 0,089000<br>€/kWh                                | 0,167000<br>€/kWh                                    |

Table 40. Two prices tariff of Holaluz. Source: [55]

## 6.8 Gesternova

Gesternova is an electricity marketing company founded in 2005 that also produces the energy with 100% renewable sources. Is an independent company, so they only use the renewable energy that they produce.

Gesternova focus his activity in Spain, in where it has more than 22.000 clients, the energy generated in 2017 was 870 GWh; and the sold energy was 580 GWh. But it has being growing in the last years, due to the fact that people is starting to believe in renewable sources more than contaminant sources of energy. This information can be checked in their webpage [56].

### 6.8.1 Free market tariffs

This tariffs are made for houses with a consumption of less than 10 kW.

| Name of the tariff  | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term            | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period |
|---------------------|-------------------------------|-------------------------------|-----------------------------|---|---|
| <b>Me Cambio</b>    |                               |                               | 42,043426<br>€ / kW<br>year |   | 0,11400<br>€/kWh                              |
| <b>Easy 2.0 A</b>   |                               |                               | 42,043426<br>€ / kW<br>year |   | 0,13616<br>€/kWh                              |
| <b>Easy 2.0 DHA</b> | 22:00-12:00                   | 23:00-13:00                   | 42,043426<br>€ / kW<br>year | 0,076539<br>€/kWh                         | 0,159688<br>€/kWh                             |

Table 41. Different tariffs of Gesternova. Source: [57]

There are two tariffs that are hourly independent, so the difference of them is the following: In the first tariff (“Me cambio”), the price of the energy is the price that indicates the table, but in the second tariff (“Easy 2.0 A”) the price indicated in the table is approximate, because the price of the energy is calculated based on the price in the electrical Pool.

In the electrical Pool, the price of the energy of a day is decided the previous day at 12:00h based on the offers and the demand of energy.



## 6.9 Lucera

According to Lucera webpage, [58], this company, founded in 2014, uses 100% of renewable energy.

The particularity of Lucera, is that they do not earn money depending on the consumption, they only earn 3,9 €/month per client.

This company only operates in the free energy market.

### 6.9.1 Free market tariffs

Lucera only offers tariffs for houses with less than 10kW of power, and has three tariffs depending on the hourly discrimination.

#### 1.1.1. Tariff 2.0A with no hourly discrimination

| Conditions    | Fixed Power Term     | Energy Term (Consumption) | Lucera benefits |
|---------------|----------------------|---------------------------|-----------------|
| Power < 10 kW | 0,104228<br>€/kW·day | 0,118180 €/kWh            | 3,9 €/month     |

Table 42. Tariff 2.0A with no hourly discrimination of Lucera. Source: [59]

#### 1.1.2. Tariff 2.0 DHA with 2 discriminating periods

| Conditions    | Hours of energy saving Winter | Hours of energy saving Summer | Fixed Power Term     | Energy Term (Consumption) Promoted period | Energy Term (Consumption) Not promoted period | Lucera benefits |
|---------------|-------------------------------|-------------------------------|----------------------|---|---|-----------------|
| Power < 10 kW | 22:00-12:00                   | 23:00-13:00                   | 0,104228<br>€/kW·day | 0,066597<br>€/kWh                         | 0,139914<br>€/kWh                             | 3,9<br>€/month  |

Table 43. Tariff 2.0 DHA with two discrimination periods of Lucera. Source: [59]

#### 1.1.3. Tariff 2.0 DHS with 3 discriminating periods

| <b>Conditions</b>       | <b>Hours of off peak energy</b> | <b>Hours of super off peak energy</b> | <b>Fixed Power Term</b> | <b>Off peak Energy Term</b> | <b>Super Off Peak Energy Term</b> | <b>Peak Energy Term</b> |
|-------------------------|---------------------------------|---------------------------------------|-------------------------|-----------------------------|-----------------------------------|-------------------------|
| <b>Power &lt; 10 kW</b> | 23:00-1:00 and 7:00-13:00       | 1:00-7:00                             | 0,104228 €/kW day       | 0,073964 €/kWh              | 0,058812 €/kWh                    | 0,142024 €/kWh          |

Table 44. .Tariff 2.0DHS three discrimination periods of Lucera. Source: [59]

## 6.10 Gana energía

Gana energía is an energy marketing company that sells 100% renewable energy in Spain. It was founded in 2015 in order to break the oligopoly of the energy market.

This company allows the clients to choose whatever day of the month to pay the electrical bill, giving the client the power to choose.

### 6.10.1 Free market tariffs

This company offers the clients two different tariffs with no hourly discrimination:

The first one is called “Gana 10 Sin mas”, and the particularity of this tariff is that the price of the energy is based in the price of the energy cost.

The second tariff is called “Gana 10 Online” and it fixes a price for the energy that has to be paid and does not depend on the consumption time.

| Tariff                 | Fixed Power Term       | Energy Term (Consumption)     | Gana Energía benefits |
|------------------------|------------------------|-------------------------------|-----------------------|
| <b>Gana 10 sin mas</b> | 0,104229<br>€ kW/day * | Cost of the energy production | 0,1166 €/day          |
| <b>Gana 10 online</b>  | 0,107229<br>€ kW/day * | 0,122300 € kWh<br>*           |                       |

Table 45. Not hourly discriminated tariffs of Gana Energía. Sources: [60] and [61].

\*Those prices does not include the cost derived from the application of the electric tax (5,113%), the VAT (21%) and the meter tax.

The company also has two different tariffs with hourly discrimination:

The first one is called “Gana 10 Sin rollos DHA”, and the particularity of this tariff is that you pay a fixed price of the energy depending on the time.

The second tariff is called “Gana 10 Sin más DHA” and the particularity of this tariff is that the price of the energy is based in the price of the energy cost (in peak and off peak periods).

| <b>Name of the tariff</b>     | <b>Hours of energy saving Winter</b> | <b>Hours of energy saving Summer</b> | <b>Fixed Power Term</b> | <b>Energy Term (Consumption) Promoted period</b> | <b>Energy Term (Consumption) Not promoted period</b> | <b>Gana Energia benefits</b> |
|-------------------------------|--------------------------------------|--------------------------------------|-------------------------|--|--|------------------------------|
| <b>Gana 10 Sin rollos DHA</b> | 22:00-12:00                          | 23:00-13:00                          | 0,118187 €kW/day*       | 0,0698 €/kWh*                                    | 0,1398 €/ kWh*                                       | None                         |
| <b>Gana 10 sin Más DHA</b>    | 22:00-12:00                          | 23:00-13:00                          | 0,104229 € kW/day*      | Cost of the energy production                    | Cost of the energy production                        | 0,1166 €/day*                |

Table 46. Hourly discriminated tariffs of Gana Energia. Sources: [62] and [63].

## 7 Analysis of tariffs and companies

In this section, all the tariffs are being analyzed for the house model case, in order to determinate the yearly price of the energy, with the objective of choosing the best option for the house.

To achieve this objective, the information has been put in excel sheets, separated by companies (because there are many tariffs per company, and doing it all in the same table would be a mess). So whenever all the companies are analyzed, the information of the best tariff for the case will be clear.

In order to start our analysis, the first thing to have clear is the consumption of the energy. To make the consumption more clear, the next table contains the consumption separated in summer and winter, and the global consumption (assumed as an average of summer and winter), so whenever the tariff implies separated prices between summer and winter, the information used is the one with winter and summer consumption. In the formulas, one thing to have in mind is that there are 5 months with winter tariff and 7 with summer tariff, as seen in Table [7]. In the next table, also is calculated the total monthly consumption both in summer and winter, so for the next calculations is easier to proceed. If some company has any different separation of periods or something particular, will be explained in each company section.

| <b>TIME</b>  | <b>WINTER<br/>CONSUMPTION<br/>(KWh/month)</b> | <b>SUMMER<br/>CONSUMPTION<br/>(KWh/month)</b> | <b>AVERAGE MONTHLY<br/>CONSUMPTION<br/>(KWh/month)</b> |
|--|---|---|--|
| <b>1:00</b>  | 25,3  | 19,88   | 22,59  |
| <b>2:00</b>  | 19,02   | 14,91   | 16,96  |
| <b>3:00</b>  | 15,2  | 9,94  | 12,57  |
| <b>4:00</b>  | 13,67   | 9,94  | 11,8   |
| <b>5:00</b>  | 13,67   | 9,94  | 11,8   |
| <b>6:00</b>  | 15,2  | 9,94  | 12,57  |
| <b>7:00</b>  | 22,75   | 14,91   | 18,83  |
| <b>8:00</b>  | 25,3  | 15,53   | 20,41  |
| <b>9:00</b>  | 25,3  | 15,89   | 20,6   |
| <b>10:00</b>   | 25,3  | 16,72   | 21,01  |
| <b>11:00</b>   | 31,66   | 19,88   | 25,77  |
| <b>12:00</b>   | 37,95   | 21,9  | 29,92  |
| <b>13:00</b>   | 44,31   | 24,85   | 34,58  |
| <b>14:00</b>   | 44,31   | 29,82   | 37,07  |
| <b>15:00</b>   | 44,31   | 29,82   | 37,07  |
| <b>16:00</b>   | 37,95   | 29,82   | 33,88  |
| <b>17:00</b>   | 37,95   | 29,04   | 33,49  |
| <b>18:00</b>   | 44,31   | 19,88   | 32,1   |
| <b>19:00</b>   | 50,6  | 24,85   | 37,72  |
| <b>20:00</b>   | 63,33   | 29,82   | 46,57  |
| <b>21:00</b>   | 65,79   | 30,8  | 48,3   |
| <b>22:00</b>   | 63,33   | 29,82   | 46,57  |
| <b>23:00</b>   | 56,96   | 29,82   | 43,39  |
| <b>0:00</b>  | 25,3  | 29,82   | 27,56  |
| <b>TOTAL<br/>CONSUMPTION</b>                                       | <b>848,77</b>                                 | <b>517,54</b>                                 | <b>683,13</b>  |
| <b>TOTAL<br/>CONSUMPTION IN<br/>PEAK HOURS<br/>(kWh/month)</b>     | <b>470,81</b>                                 | <b>278,52</b>                                 |  |
| <b>TOTAL<br/>CONSUMPTION IN<br/>OFF PEAK HOURS<br/>(kWh/month)</b> | <b>377,96</b>                                 | <b>239,02</b>                                 |  |
|  | <b>Peak hours: 12:00-<br/>21:59</b>           | <b>Peak hours: 13:00-<br/>22:59</b>           |  |

Table 47. Consumption in each period (summer and winter) and in the average of summer and winter.

In addition, to complete this table, the next table is made for those tariffs that have the “super off peak” period, in where the energy has the cheapest price. Those tariffs do not have differences between summer and winter, so the energy consumption is calculated in the average consumption.

| <b>IN CASE OF SUPER OFF PEAK TARIFFS</b>           | <b>Monthly Consumption (kWh/month)</b> |
|--|--|
| <b>PEAK HOURS (13-22:59)</b>                       | 387,35                                 |
| <b>SUPER OFF PEAK HOURS (1-6:59)</b>               | 88,29                                  |
| <b>OFF PEAK HOURS (23:00-00:59 and 7:00-12:55)</b> | 207,49                                 |

Table 48. Consumption separated in off peak, peak and super off peak periods.

The calculations are very simple, if the tariff depends on the period (summer or winter), the price of the energy/year is the following:

$$\begin{aligned} \text{Price of energy per year} = & \text{Fixed power term} * \text{Hired power} + 5 \text{ months} * \\ & (\text{Consumption}_{\text{peak hours,winter}} * \text{Price}_{\text{peak hours}} + \text{Consumption}_{\text{off peak hours,winter}} * \\ & \text{Price}_{\text{off peak hours}}) + 7 \text{ months} (\text{Consumption}_{\text{peak hours,summer}} * \text{Price}_{\text{peak hours}} + \\ & \text{Consumption}_{\text{off peak hours,summer}} * \text{Price}_{\text{off peak hours}}) \quad [8] \end{aligned}$$

If the tariff does not depend on the summer or winter period and the price is fixed, the equation is the following:

$$\begin{aligned} \text{Price of the energy per year} = & \text{Fixed power term} * \text{Hired power} + 12 \text{ months} * \\ & (\text{Average monthly consumption} * \text{Energy Term}) \quad [9] \end{aligned}$$

For the fixed power term, the house that is being analyzed has a hired power of 6,9 kW.

The first company that is been analyzed is Endesa:

| <b>TARIFFS</b>                               | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(SUPER<br/>OFF<br/>PEAK)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|--|--|---|---|---|---|
| <b>One light</b>                             | 41,156424                                    | 0,117412  |   |   | 1246,48533  |
| <b>One light<br/>Night</b>                   | 41,156424                                    | 0,065289  | 0,144483                                      |   | 1138,410158   |
| <b>Tempo<br/>Happy*</b>                      | 47,815812                                    | 0   | 0,140847                                      |   | 1324,184977   |
| <b>Tempo you<br/>always win**</b>            | 45,425016                                    | 0,133661  |   |   | 1409,126678   |
| <b>Tempo night</b>                           | 45,425016                                    | 0,076787  | 0,154314                                      |   | 1251,139703   |
| <b>Tempo green<br/>super off<br/>peak***</b> | 45,425016                                    | 0,093027  | 0,162194                                      | 0,071872  | 1375,115775   |

Table 49. Summary of Endesa tariffs.

\*In the tariff tempo happy, according to Iberdrola, you have the right to choose 2 hours where the price of the energy consumption will be zero. According to Table [47], the hours where the energy is more expensive (where the consumption is higher) are between 20:00 and 22:00, so the price of the energy in that period will be zero.

\*\*In the tariff tempo you always win, if the consumption in off peak period is higher than 50% of the total consumption, you get a discount, but in our case the situation does not happen, so the discount is not applied.

\*\*\* The price of the energy is calculated in this way:

$$\begin{aligned}
 \text{Price of energy per year} = & \text{Fixed power term} * \text{Hired power} + \\
 & 12 \text{ months} (\text{Consumption}_{\text{peak hours, summer}} * \text{Price}_{\text{peak hours}} + \\
 & \text{Consumption}_{\text{off peak hours, summer}} * \text{Price}_{\text{off peak hours}} + \\
 & \text{Consumption}_{\text{super off peak hours, summer}} * \text{Price}_{\text{super off peak hours}} ) [10]
 \end{aligned}$$

According to the data in the table, the best tariff for our case is *One light Night*.

The second company that is been analyzed is Iberdrola.



| <b>TARIFFS</b>                   | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(SUPER<br/>OFF<br/>PEAK)</b> | <b>TOTAL<br/>PRICE<br/>OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|----------------------------------|--|---|---|---|---|
| <b>Fixed price</b>               | 38,043426                                    |   | 0,14576                                       |   | 1457,393476   |
| <b>Night Plan</b>                | 42,043426                                    | 0,069775  | 0,148533                                      |   | 1177,943765   |
| <b>Summer<br/>plan*</b>          | 42,043426                                    | 0,074613  | 0,168531                                      |   | 1470,051695   |
| <b>Choose 8<br/>hours plan**</b> | 42,043426                                    | 0,074613  | 0,168531                                      |   | 1302,623775   |
| <b>Stable plan</b>               | 42,043426                                    |   | 0,123988                                      |   | 1306,498709   |
| <b>Weekend<br/>Plan***</b>       | IMPOSIBLE                                    | TO  |   |   | FIGURE IT OUT   |
| <b>Winter<br/>plan****</b>       | 42,043426                                    | 0,074613  | 0,168531                                      |   | 1376,726317   |

Table 50. Summary of Iberdrola tariffs

\*For calculating the summer plan price, according to our estimation, there are no ways to calculate the consumption exactly, so the way to proceed is to separate the consumption in the summer, in where three months are considered in off peak, and the rest are considered peak, and for that, the equation used is the following:

$$\begin{aligned}
 & \text{Price of energy} = \text{Energy term} * \text{Hired power} + \\
 & \text{Monthly consumption}_{\text{summer}} * 3 \text{ months} * \text{Price}_{\text{off peak hours}} + \\
 & (\text{Monthly consumption}_{\text{summer}} * 4 \text{ months} + \text{Monthly consumption}_{\text{winter}} * \\
 & 5 \text{ months}) * \text{Price}_{\text{peak hours}} \quad [11]
 \end{aligned}$$

\*\*In the choose 8 hours plan, the hours chosen to be off peak hours are between 20:00-24:00 and 13:00-17:00, due to the fact that the consumption is higher in those periods of time. (According to Table [9]).

\*\*\* It is impossible to estimate the consumption of energy in the weekends with the procedure that is on, so this tariff is calculated.

\*\*\*\*The calculation of the winter plan price is similar than the summer plan, but now the equation is the following:

*Price of energy*

$$\begin{aligned}
 &= \text{Energy term} * \text{Hired power} + \text{Monthly consumption}_{\text{winter}} \\
 &* 3 \text{ months} * \text{Price}_{\text{off peak hours}} \\
 &+ (\text{Monthly consumption}_{\text{summer}} * 7 \text{ months} \\
 &+ \text{Monthly consumption}_{\text{winter}} * 2 \text{ months}) * \text{Price}_{\text{peak hours}} \quad [12]
 \end{aligned}$$

The third company is Gas Natural:

| <b>TARIFFS</b>                 | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(SUPER<br/>OFF<br/>PEAK)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|--------------------------------|--|---|---|---|---|
| <b>Stable tariff</b>           | 42,69342<br>6                                | 0,146051  |   |   | 1491,864001   |
| <b>Light Plan</b>              | 42,69342<br>6                                | 0,14075   | 0,14075                                       |   | 1401,812812   |
| <b>Light Night</b>             | 42,69342<br>6                                | 0,083872  | 0,166059                                      |   | 1308,082001   |
| <b>Tri time zone<br/>light</b> | 42,69342<br>6                                | 0,092307  | 0,167566                                      | 0,075635  | 1383,432044   |
| <b>Flexible<br/>tariff</b>     | 42,69342<br>6                                | 0,086179  | 0,172692                                      |   | 1344,848079   |

Table 51. Summary of Gas Natural tariffs

The fourth company is EDP:

| <b>TARIFFS</b>       | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|----------------------|--|---|---|---|
| <b>Stable tariff</b> | 42,04326                                     | 0,135959  |   | 1404,646869   |
| <b>Light Plan</b>    | 42,04326                                     | 0,076993  | 0,159068                                      | 1248,999294   |

Table 52. Summary of EDP tariffs

The fifth company is Viesgo

| <b>TARIFFS</b>                | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|-------------------------------|--|---|---|---|
| <b>Good Bye<br/>Surprises</b> | 54,572975                                    | 0,158819  |   | 1678,500867   |
| <b>Your<br/>moment</b>        | 54,572975                                    | 0,095288  | 0,190533                                      | 1536,053921   |

Table 53. Summary of Viesgo tariffs

The sixth company is Escandinavia Electricity:

| <b>TARIFFS</b> | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(SUPER<br/>OFF<br/>PEAK)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|----------------|--|---|---|---|---|
| <b>DAG</b>     | 39,055                                       | 0,129   |   |   | 1326,98022  |
| <b>NATT</b>    | 39,055                                       | 0,078   | 0,156   |   | 1218,76446  |

Table 54. Summary of Escandinavia Electricity tariffs

The seventh company is Holaluz

| <b>TARIFFS</b>        | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|-----------------------|--|---|---|---|
| <b>ONE PRICE</b>      | 38,043585                                    | 0,123   |   | 1270,815377   |
| <b>TWO<br/>PRICES</b> | 38,043585                                    | 0,079   | 0,155   | 1211,044947   |

Table 55. Summary of Holaluz tariffs

The eighth company is Gesternova

| <b>TARIFFS</b>          | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(SUPER<br/>OFF<br/>PEAK)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|-------------------------|--|---|---|---|---|
| <b>Me cambio</b>        | 42,04342<br>6                                | 0,114   |   |   | 1224,635159   |
| <b>Easy 2.0<br/>DHA</b> | 42,04342<br>6                                | 0,076539  | 0,159688                                      |   | 1250,051153   |
| <b>Easy 2.0</b>         | 42,04342<br>6                                | 0,13616   |   |   | 1406,295748   |

Table 56. Summary of Gesternova tariffs

The ninth company is Lucera

| <b>TARIFFS</b>                 | <b>FIXED<br/>POWER<br/>TERM<br/>(€/year)</b> | <b>ENERGY<br/>TERM<br/>(OFF<br/>PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(PEAK)<br/>(€/kWh)</b> | <b>ENERGY<br/>TERM<br/>(SUPER<br/>OFF<br/>PEAK)</b> | <b>TOTAL<br/>PRICE OF<br/>THE<br/>ENERGY<br/>(€/year)</b> |
|--------------------------------|--|---|---|---|---|
| <b>2.0 A</b>                   | 38,04322                                     | 0,11818   |   |   | 1278,10004  |
| <b>2.0 DHA</b>                 | 38,04322                                     | 0,066597  | 0,139914                                      |   | 1148,725816   |
| <b>Tri time zone<br/>light</b> | 38,04322                                     | 0,073964  | 0,142024                                      | 0,058812  | 1169,125797   |

Table 57. Summary of Lucera tariffs

In Lucera, the final price of the energy is calculated similar to the cases before, but with the particularity that a new term has to be added to the final price. This term represents the quantity that Lucera earns for each client, and this price is 3,9 €/month.

The tenth company is GanaEnergia

| <b>TARIFFS</b>            | <b>FIXED POWER TERM (€/year)</b> | <b>ENERGY TERM (OFF PEAK) (€/kWh)</b> | <b>ENERGY TERM (PEAK) (€/kWh)</b> | <b>ENERGY TERM (SUPER OFF PEAK)</b> | <b>TOTAL PRICE OF THE ENERGY (€/year)</b> |
|---------------------------|----------------------------------|---------------------------------------|-----------------------------------|-------------------------------------|---|
| <b>Gana 10 Online</b>     | 39,13858<br>5                    | 0,1223                                |                                   |                                     | 1319,432501                               |
| <b>Gana 10 sin rollos</b> | 43,13825<br>5                    | 0,0698                                | 0,1398                            |                                     | 1194,803034                               |

Table 58. Summary of Ganaenergia tariffs

The other tariffs of Gesternova depend on the price of the energy production, so it is impossible to make a real estimation of the energy price.

To make this information more complete, it has also been calculated a bill using the tariff of the regulated market (PVPC). The information of the prices of the energy has been extracted from CHC webpage [64]:

|                  | <b>FIXED POWER TERM (€/month)</b> | <b>ENERGY TERM (€/kWh)</b> |
|------------------|-----------------------------------|----------------------------|
| <b>January</b>   | 38,043426                         | 0,143382                   |
| <b>February</b>  | 38,043426                         | 0,141613                   |
| <b>March</b>     | 38,043426                         | 0,140433                   |
| <b>April</b>     | 38,043426                         | 0,135761                   |
| <b>May</b>       | 38,043426                         | 0,139111                   |
| <b>June</b>      | 38,043426                         | 0,138441                   |
| <b>July</b>      | 38,043426                         | 0,137741                   |
| <b>August</b>    | 38,043426                         | 0,136409                   |
| <b>September</b> | 38,043426                         | 0,138209                   |
| <b>October</b>   | 38,043426                         | 0,139789                   |
| <b>November</b>  | 38,043426                         | 0,143039                   |
| <b>December</b>  | 38,043426                         | 0,14365                    |

Table 59. Prices of the regulated market in 2017. Source: [64].

$$\text{Total price of the energy} = \text{Fixed power term} * 12 * \text{Energy hired} + \sum \text{Energy term} * \text{Monthly Consumption} [13]$$

Depending on the summer or winter period, the consumption would change, as it is shown in table [47].

With this information, and applying the equation, the result is that with regulated market, the price of the electricity is 1366,588 €/year.

With all this information, now the next table shows all the best tariffs of each company, in order to choose the cheapest tariff for our case:

| <b>COMPANY</b>          | <b>NAME OF THE TARIFF</b> | <b>PRICE OF THE YEARLY ELECTRICITY (€)</b> |
|-------------------------|---------------------------|--|
| <b>GANANERGIA</b>       | Gana 10 sin rollos        | 1194,80                                    |
| <b>LUCERA</b>           | 2.0 DHA                   | 1148,73                                    |
| <b>GESTERNOVA</b>       | Me cambio                 | 1224,64                                    |
| <b>HOLALUZ</b>          | TWO PRICES                | 1211,04                                    |
| <b>ESCAND ENER</b>      | NATT                      | 1218,76                                    |
| <b>VIESGO</b>           | Your moment               | 1536,05                                    |
| <b>EDP</b>              | Light Plan                | 1249,00                                    |
| <b>GAS NATURAL</b>      | Light Night               | 1308,08                                    |
| <b>IBERDROLA</b>        | Night Plan                | 1177,94                                    |
| <b>ENDESA</b>           | One light Light           | 1138,41                                    |
| <b>REGULATED MARKET</b> | PVPC                      | 1366,59                                    |

*Table 60. Summary of the best tariffs of each company.*

According to our calculations, the two best companies are Endesa and Lucera. The difference between them is negligible (10€ per year), so the decision of choosing one or another depends on the client.

The main advantage of Endesa is that is a big company (actually is the first one in clients in Spain), so the supply is really guaranteed, and you are assured that you will not get electricity blackouts because of the energy production, because Endesa is also a electricity generator, so they control the energy production also.

The main advantage of Lucera is that is a small company, and uses 100% renewable energy. Also that their prices are competitive, and by choosing Lucera, you contribute to open the energy market, and finish with the oligopoly that exists.

For the shopping mall case, there is no available tariffs, due to the fact that every electrical company makes a different offer to each big surface, in order to give them the best tariff possible. In order to get this information, it is necessary to know some information about the shopping mall that only the owner could know, for that reason this part of the thesis can not be fully completed, but the shopping mall part is valid to see one example of how the big surfaces consume electrical energy and one example of a big surface tariff.

## 8 Conclusions

The Spanish Electrical Market has been subject to change during the last twenty years. The evolution of the market started in 1997 and ended in 2014. During this process, the different activities related to the energy market (generation, distribution, transport and marketing) have been suffering changes in order to establish the market liberalization.

The result of this process is seen in the current Spanish Energy Market, which can be considered a liberalized market, in where any citizen is able to choose any company to provide them the electrical energy. Every company transports the energy through the Spanish Electrical Net (REE), a company founded for that; and to distribute the energy to the final consumers, they use the distribution nets that the five main companies have.

As a liberalized market, the companies are allowed to enter the market as marketing companies (companies that can sell energy to final consumers). Because of that reason, more than 350 companies have been founded in order to participate in the electrical market and try to break the oligopoly that exists with the five main companies.

The five main companies (Endesa, Iberdrola, Viesgo, Gas Natural Fenosa, and EDP) compete both in the free and regulated market, but the rest of the companies compete in the free market.

The free market allows the companies to offer the energy at any price, so the companies take benefit of that and have different tariffs based on the consumption of the clients.

Based on the analysis on the different companies and their tariffs plus the information calculated of the house and the information obtained by the electrical bills of the house, this example has been calculated in order to see a real case of the electricity market for a small consumer.

The results shows that Endesa is the best company followed by Lucera, but the results only are suitable for this case, that means that for another consumer the best company and tariff may differ. This information is interesting, and can explain why is Endesa the biggest company in terms of number of consumers in Spain since it has more variety of tariffs, that allows the clients to choose the cheapest tariff for them.

For the case of the shopping mall, is impossible to consult the tariffs for big surfaces, because the information needed is only available for the owner of the big surface.



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