ESCUELA TÉCNICA SUPERIOR DE INGENIERÍA (ICAI)
MÁSTER EN INGENIERÍA INDUSTRIAL

STUDY OF THE ENERGY CONSUMPTIONS IN SPAIN FOR THE ENERGY POVERTY ANALYSIS

Autor: Javier Cortizas Arnoso
Director: Pablo Frías Marín

Madrid
Julio 2018

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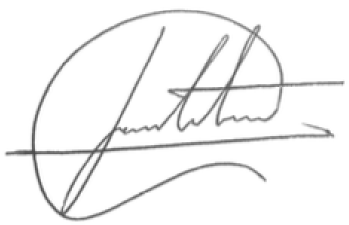

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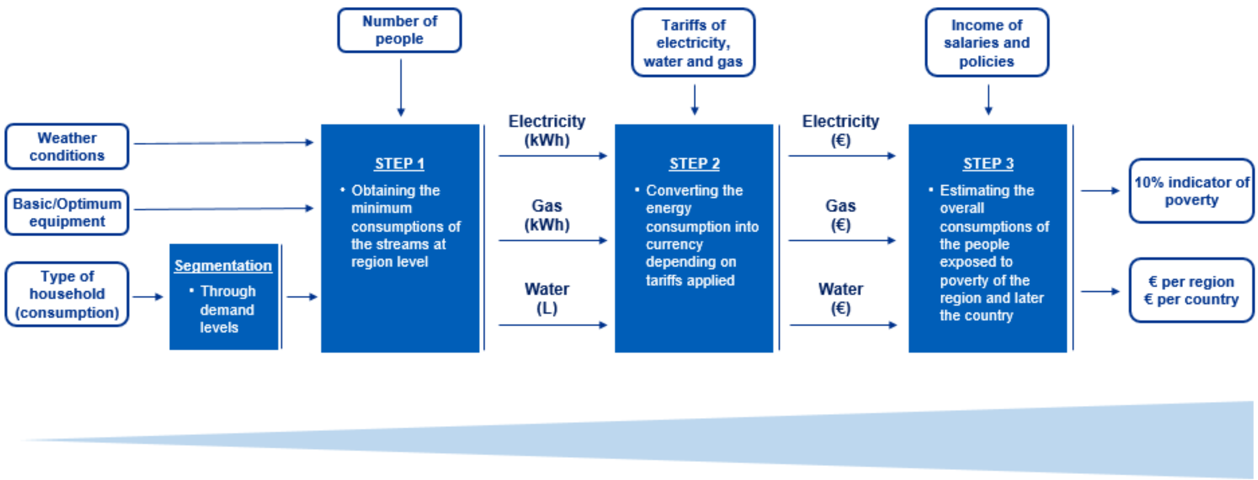
Entidad colaboradora: Universidad Pontificia de Comillas, ICAI

RESUMEN

La pobreza energética es un tema cada vez de mayor preocupación es España. Se estima que aproximadamente dos millones de hogares presentan problemas para pagar los costes energéticos del hogar, no siendo posible el que mantengan dicho hogar a una temperatura adecuada durante los meses de invierno o que presenten atrasos en el pago de las facturas. La Unión Europea es consciente del problema y por ello está integrando medidas para solucionarlo, como las directivas 2009/72/EC en cuanto a medidas a aplicar con consumidores vulnerables en términos de electricidad y 2009/73/EC para los consumidores de gas. En España, en su lugar, en octubre del año 2017 entró en vigor la medida contra la pobreza energética más importante dada en el país, el Real Decreto 897/2017. En él se define el nuevo bono social, derogando el anterior de 2014, e incluye nuevos términos como la fijación de límites de consumos máximos sobre los que se aplicará el descuento en la factura eléctrica. Con ello, el Estado español pretende mejorar la situación del país y dedicar más gasto público a las familias necesitadas. El proyecto, a partir de la determinación de los consumos mínimos necesarios en una vivienda para garantizar unas condiciones de vida de confort estándar, realizando una segmentación a nivel provincial, evaluará el nivel de pobreza energética de las provincias y la actual medida en vigor explicada. Se comprobará si el bono social es suficiente o, por el contrario, son necesarias

diferentes medidas para encontrar una solución al problema que representa más de 7.000 muertes prematuras al año en el país.

El proyecto fija como uno de sus principales objetivos el desarrollo de una herramienta modelo en Excel que estime los consumos mínimos de las viviendas, a nivel de provincias, dependiendo de diferentes entradas de variables. Por ello, el análisis de sensibilidad será relativamente fácil para el usuario de la herramienta y el impacto de las tarifas de los streams energéticos podrá ser valorado instantáneamente. El esqueleto que sigue el modelo se puede apreciar en la siguiente figura:



Estructura del modelo de excel

La estructura está dividida en tres partes distintas. Primero, se calculan los consumos de las provincias dependiendo de diferentes variables de entrada, como pueden ser el número de personas que habitan en la vivienda, las condiciones climáticas de las provincias (que afectará en gran medida a la demanda de calefacción mínima necesaria), el caso básico u óptimo (dependiendo de los equipos instalados) o el tipo de viviendas (bloque o unifamiliar). Las unidades de los consumos que se devuelven en este punto son litros (L) para el agua y kWh para la electricidad y el gas. A continuación, en el paso 2, los consumos de las viviendas son convertidos a unidad monetaria (€).

Las tarifas que se aplican al consumo de gas y electricidad son las mismas para todas las provincias, son las Tarifas reguladas de Último Recurso (TUR) en el caso del gas y el Precio Voluntario al Pequeño Consumidor (PVPC) para el consumo eléctrico. Cabe destacar que el nuevo bono social considera necesario estar abonado a la tarifa de PVPC para ser solicitado. Esto es desconocido por muchos consumidores que, aunque estén en derecho de solicitarlo, no lo hacen. Por otro lado, la tarifa aplicada al agua dependerá de la provincia en cuestión, regiones como Murcia tienen precios más caros pero otras como Palencia el recurso es más barato. Por último, en el tercer paso se calcula la pobreza energética y el coste asociado a la solución del problema. Las entradas son índices salariales de las viviendas, como pueden ser el IPREM o el SMI, o la distribución salarial en sí del país.

La herramienta consta de un total de 38 hojas de Excel divididas en 5 secciones: Inputs y Outputs, Clasificación en niveles y provincias, Coeficientes, Consumos y Base de datos. En cuanto a la descripción de las secciones, cabe decir que la primera de ellas corresponde a la introducción de las variables de entrada al modelo y a la obtención de las variables de salida. El modelo, además, ofrece una clasificación de los consumos por niveles energéticos, dependiendo de la certificación energética de los edificios y de la zona climática. Además, reúne todos los datos con relación al cálculo de los consumos mínimos de las viviendas para su posterior modificación.

Gracias a la herramienta, el análisis regulatorio que se da en el paso tres de la estructura mostrada demuestra que para los índices de pobreza del 10% (porcentaje de población cuyo gasto energético anual supone más del 10% del ingreso del hogar), la nueva medida adoptada por el gobierno es más que insuficiente. Aproximadamente son 267 los millones de euros que el Estado destinará a ayudar a las familias en situación de pobreza energética. Además, es muy importante que en el futuro se dedique parte del presupuesto a cubrir las necesidades de los recursos de gas y agua, actualmente la ayuda es nula. Los euros necesarios que se estiman en el proyecto para erradicar la pobreza energética en España, y en comparación con la ayuda actual, son los siguientes:

Current investment			Needed investment		
Water	Electricity	Gas	Water	Electricity	Gas
0,00 €	267.497.707,70 €	0,00 €	635.755.050,15 €	709.217.199,35 €	645.053.196,96 €

Valores obtenidos de la inversión anual actual y necesaria en España

Comparación entre la inversión anual total actual y necesaria

Por lo tanto, el análisis realizado con ayuda de la herramienta sitúa la inversión anual actual como un 37,72% de la necesaria en términos de electricidad, pero un 13,44% de la necesaria contando los recursos de agua y gas mínimos.

El proyecto, además de mostrar la variación de los consumos energéticos y precios que afrontan las viviendas en el territorio español, ilustra la realidad que sufren más del 12% de los hogares en España en riesgo de pobreza energética y recalca la imprescindible y urgente ayuda que se debe establecer en el país.

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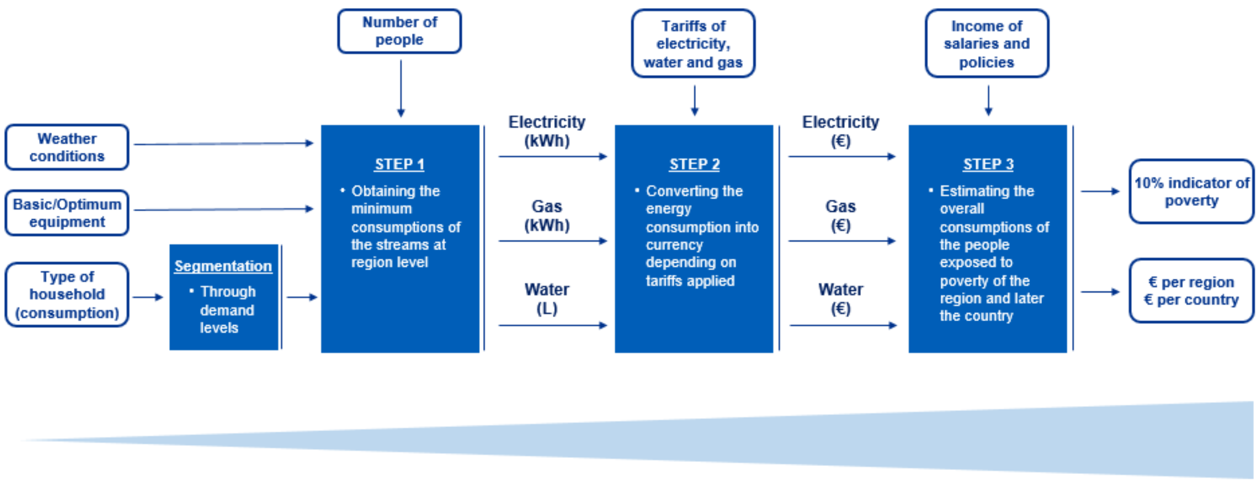
ABSTRACT

Energy poverty is a topic of increasing concern in Spain. It is estimated that approximately two million households have problems in paying their energy costs, being impossible for them to keep the household at an adequate temperature during the cold months or having arrears in the payment of bills. The European Union is aware of the problem and therefore is introducing measures to solve it, such as directive 2009/72/EC regarding measures to be applied with vulnerable consumers in terms of electricity or 2009/73/EC for gas consumers. In the case of Spain, in October 2017, the most important measure against energy poverty in the country came into effect, the Real Decreto 897/2017. It defines the new social bonus, revoking the previous one of 2014, and includes new terms such as the maximum consumption limits for the households on which the discount on the electric bill will be applied. With this, the Spanish State aims to improve the situation of the country and allocate more public spending to families in poverty. The project, based on the determination of the minimum consumptions needed in a house to guarantee standard living conditions, carries out a segmentation at the provincial level, and evaluates the energy poverty level of the regions. In addition, it measures the impact of the social bond mentioned. With this, it will be verified if the social bonus is sufficient or, on the other hand, different measures are necessary to find a solution to the problem that represents more than 7,000 premature deaths per year in the country.

The project establishes as one of its main objectives the development of a model tool in Excel that estimates the minimum consumptions of the households, per regions, and depending on different inputs of variables. Therefore, the sensitivity analysis will be relatively easy for the user of the tool and the impact of energy stream rates can be assessed instantaneously. The skeleton that follows the model can be seen in the following figure:



Structure of the excel tool

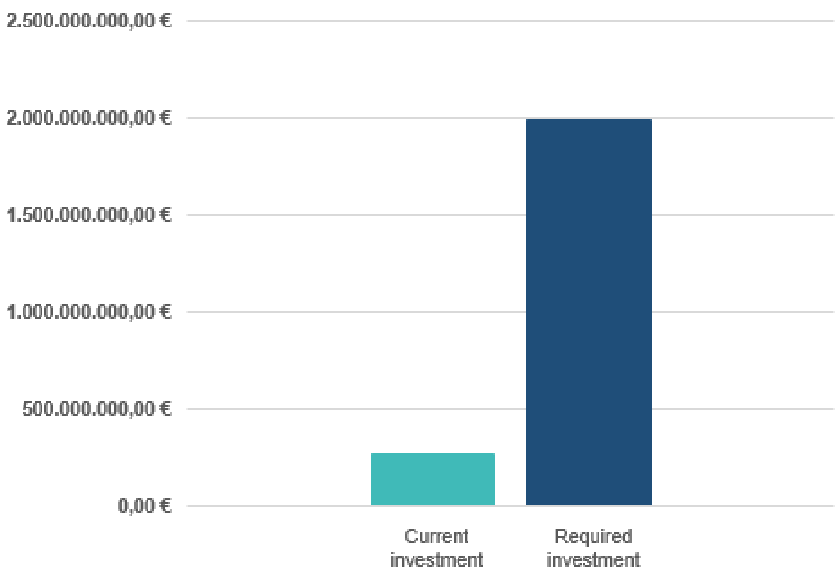
The structure is divided into three distinct parts. First, the consumptions of the regions are calculated depending on different input variables, such as the number of people living in the house, the climatic conditions of the regions (which will affect the minimum heating demand required), the basic or optimal case (depending on the equipment installed) or the type of housing (block or detached house). The units of consumption that are returned at this point are liters (L) for water and kWh for electricity and gas. Then, in step 2, the consumption of the houses is converted into a monetary unit (€). The tariffs that apply to the consumptions of gas and electricity are the same for all the regions, they are the regulated tariffs of last resource (TUR) in the case of gas and the Precio Voluntario al Pequeño Consumidor (PVPC) for the electric consumption. It should be noticed that the new social bonus considers necessary to be subscribed to the PVPC rate in order to apply for it. This is unknown by many consumers who, although they are entitled to request it, do not. On the other hand, the tariff applied to water will depend on the region. Murcia has more expensive prizes for example but in others like Palencia the resource is cheaper. Finally, in the third step, the energy poverty and the costs associated with solving the problem are calculated. The inputs are wage indicators of the households, such as the IPREM or the SMI, or the salary distribution of the country itself.

The tool consists of a total of 38 Excel sheets divided into 5 sections: Inputs and Outputs, Classification in levels and regions, Coefficients, Consumptions and Database. Regarding the description of the sections, it can be said that the first one corresponds to the introduction of the input variables to the model and obtaining the output variables. The model also offers a classification of consumption by energetic levels, depending on the energy certification of the buildings and the climate area. In addition, it gathers all the data related to the calculation of the minimum consumptions of the households for its later modification if needed.

Thanks to the tool, the regulatory framework analysis performed shows that for the 10% energy poverty indicator (percentage of population whose annual energy expenditure supposes more than 10% of household income), the new measure adopted by the government is more than insufficient. There are approximately 267 million euros that the State will allocate to help families in situations of energy poverty, however, much more is required. In addition, it is very important that in the future, part of the budget is dedicated to cover the needs of gas and water resources, because currently the aid is null. The amount of euros needed that are estimated in the project, compared with the current amount allocated by the government are compared in the next figures:

Current investment			Needed investment		
Water	Electricity	Gas	Water	Electricity	Gas
0,00 €	267.497.707,70 €	0,00 €	635.755.050,15 €	709.217.199,35 €	645.053.196,96 €

Obtained values for the current and needed investments



Total current and needed investment comparison

Therefore, the analysis carried out with the help of the tool, places the current annual investment as the 37.72% of what is required in terms of electricity, but it is the 13.44% of what is needed counting the minimum water and gas resources.

The project, apart from calculating the differences between energy consumptions and prizes among the Spanish regions, illustrates the reality that the country is facing, more than 12% of the total households in Spain suffer from energy poverty, and emphasizes the urgent need of aid that must be established in the country.

STUDY OF THE ENERGY CONSUMPTIONS IN SPAIN FOR THE ENERGY POVERTY ANALYSIS

THESIS

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1. Introduction

The project will cover the analysis of energy poverty in Spain, where poverty is understood as the non-access to resources such as electricity, water or gas due to a lack of physical access to the resource or because of the impossibility to afford the bills. Thus, the first is known as energy access and the second as energy affordability. To properly treat energy poverty it is important to differentiate between these two scenarios, in order to focus the analysis of the energy poverty on different points of view. In other words, the causes of this same effect vary and will be treated distinctly during the analysis. Also, they are not static concepts; they experience evolution within the pass of the years. It is not the same to talk about the energy access in the middle 50's than nowadays. What we currently understand about satisfying energy needs is different and it involves talking about electricity, heating or water.

Moreover, currently, energy poverty is a major concern worldwide. The rate of new annual connections to electricity has increased over the past years, and forecasting studies about the projection show that this number will only keep increasing. Along with the positive impact of the energy access, the era we are experiencing is characterized by the expansion of the grid connections, improving the access, as said before, making the electricity resource more reliable and secure and by the fact that the declining cost of renewables makes the prizes of the electricity go down because of the zero cost of the raw material used to generate power. Lastly, the new business models that help financing and saving money enforce the access to energy. However, despite all these advantages and improvements there still exist obstacles to overcome in order to guarantee the solution to the problem of poverty. Worldwide, the major affected areas correspond with sub-Saharan Africa, Asia and India. Sub-Saharan Africa covers the major part of the lack of energy access with a share of 53% of the total, second India with 25% and then Asia with 19% (Figure 4). In the case of Spain, although the numbers are not comparable to the just mentioned countries, there are still approximately 1.8 million homes in a situation of energy poverty, what means that 10% of the total households of the country are lacking of essential services to develop a minimum satisfactory lifestyle. Because of this, the first part of the project will discuss the situation and the problem at distinct scope levels, focusing the analysis on Spain and its regions.

It is also important to mention that, for this study, there exist three main energy vectors or streams that explain the energy poverty of a household. These vectors correspond with electricity, heat and water. A minimum level of the vectors is necessary to have a household habitability and guarantee the welfare of the habitants. The energy vectors change to different conditions of the household, for instance, it has not the same facility to electricity a developed urban area with a great grid and connections than a rural area where the energy access is more complicated due to location and connection complexity. Because of this, the project will attend the different factors affecting the energy vectors and will discuss the conclusions in order to achieve equality between users, by examining all the normative and new implementations to consider.

Related to the explained about energy poverty, it is remarkable to describe the term of energy vulnerability, as it will appear during the development of the project. It is a wider concept than poverty and it is sometimes hard to clarify, but it is commonly understood and accepted as the susceptibility that characterizes a home to experience a situation in which the mentioned home does not receive an appropriate quantity of energy services [1]. In the case of the EU and Spain, which concern this document the most, the vulnerability can be understood as caused by internal factors or external factors. Among the internal, unexpected death of a familiar, job loss or illness can be counted whereas the external factors include economic crisis, loss of social bonds or change of government. Once this concept is understood it only increases the value of the complexity of energy poverty. Therefore, there exist other factors that will be considered concerning vulnerability and poverty, such as demographic location, politics or the already term explained of energy access. For this, not only the traditional income of the household, prize of energy and efficiency should be taken into account when analyzing the Spanish case.

Although it will be treated with more care, it should be kept in mind that in Spain, the situation with prizes of energy (electricity in particular) is not as good as in the rest of the European Union. To explain this, some figures will be shown next. The data are corrected by the PPS (Purchasing Power Standards), which is no more than a unit very similar to the euro, that compares the prizes of goods and services at different levels of prizes and salaries for the countries that form the EU. In other words, a single PPS unit could buy the same services and goods in every EU country, what eases the comparison among the countries [2].

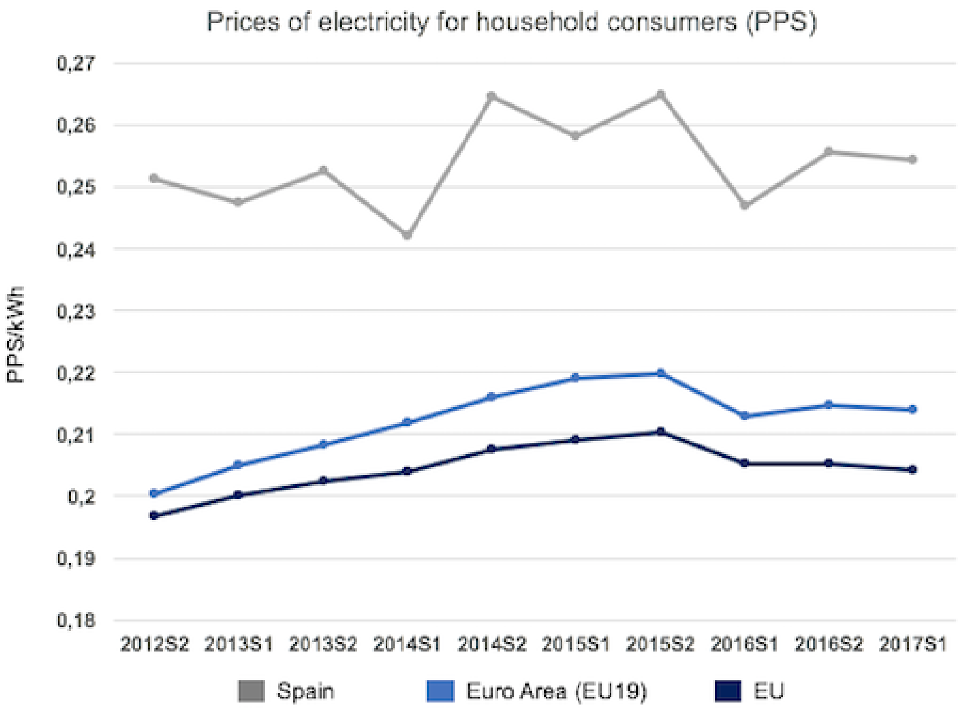

Figure 1. Electricity prizes comparison with Spain at EU levels

Regarding the figures above, Spain is a complex case of study, it is a EU country where the electricity price is higher than in the bulk part of the rest. Furthermore, evolution among the years is fluctuating and volatile, but always at a higher level than the EU average.

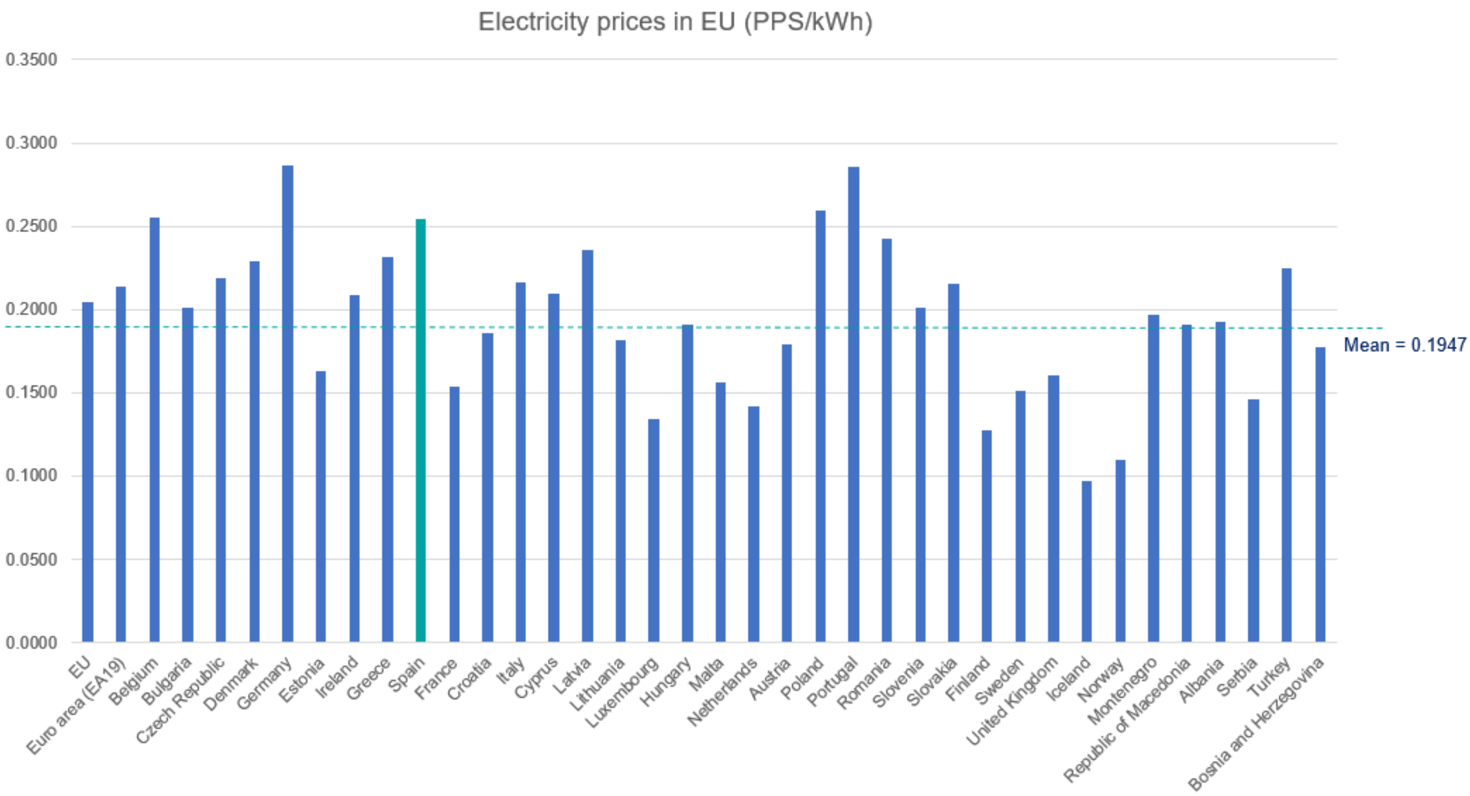

Figure 2. Electricity prizes of different countries members of the EU in 2017 (PPS/kWh)

From Figure 2 it can be concluded than, in terms of PPS/kWh, and being the average of 2017 equal to 0.1955, Spain electricity prize is above average. The current prize of electricity corrected by PPS in Spain for 2017 was 0.2543. Thus, there is an increment of 30.1% of the average prize in the EU, what shows that Spain is facing a difficult problem. Because of this factor, the GDP of Spain has to be analyzed. The main reason of this is to explain if there is a correlation between energy prizes and poverty, so that if the GDP per capita of Spain is higher than the average of the EU, the number of households suffering from this would not be high. In the Figure 3 shown below the GDP per capita in Spain in nominal terms can be seen and compared with the EU19 area [3]:

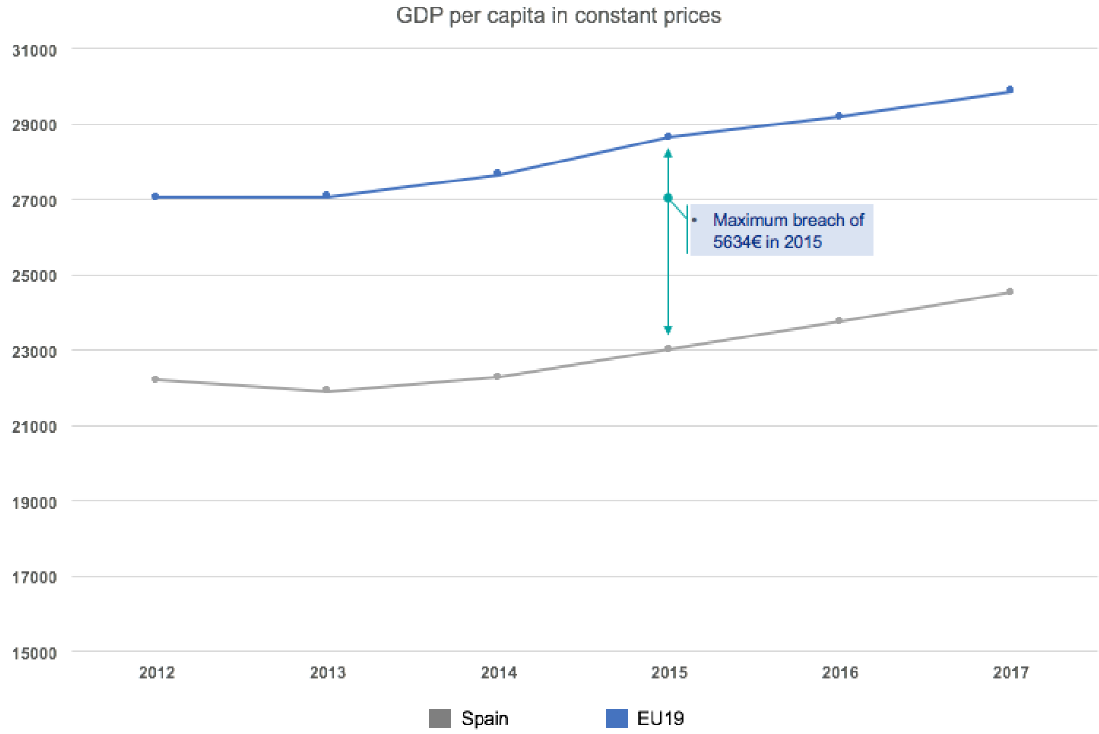

Figure 3. GDP per capita comparison between Spain and EU19 in constant prices

As it can be seen, during the past years the GDP per capita in Spain has been lower than in the rest of the EU19 area, what means that, given the prizes of electricity higher than the rest and the economic power of the population lower, the situation is favorable to experience a tough energy poverty scenario. In fact, the difference between Spain and the EU19 average is always around 5.000 €, which supposes a lot of money that the population lacks to afford the payment of the bill. Thus, the project requires special attention at the country and its different regions, because of the criticality and exposure the households experiment. Figure 3 shows the sensibility energy poverty has in Spain, where citizens do not have the same facilities as in other EU countries. In fact, Spain has approximately 4 million people suffering from energy poverty, from a total in Europe of 54 million, what supposes a 7,41% of the total of all the EU area. This means that in Europe, almost 8 people out of 100 suffering from energy poverty are Spaniards.

On the other hand, another part of the project will be analyzing current laws facing energy poverty trying to solve the problem, and designing new strategies to deal with it in Spain. The European Union currently is advancing throughout laws and new measures into a scenario where energy poverty is no more a second problem but one of the most important ones. For example, on November 30 of 2016 the European Comission presented new measures [4] in order to modernize the EU economy through leading the change into the energy transition, by replacing old and contaminant energy sources into renewable sources. With this, the EU wants to make the system more efficient, and to provide a fair deal to consumers, which for this project is the most important goal to achieve and the one that must be taken into account with more care. Also, the EU approved recently a proposal for a revised drinking water directive (98/83/EC) to improve the quality of drinking water and provide greater access to citizens. Efforts trying to solve the problem are necessary, as said before, and the EU knows it, so the forecast is that new measures like these will come into force soon. Furthermore, nowadays, concerning the Spanish territory and government, it is true that the country is putting more effort trying to solve the situation and help the families and users suffering of energy poverty. However, the regulations are still insufficient so additional measures have to be planned and entering into force as soon as possible. For example, on October 7 of 2017, the Spanish government approved a new decree (RD 897/2017) [5] which defines a new social bond to fight against energy poverty, introducing remarkable new improvements in comparison with the past bonds, such as the new definition of vulnerable consumers at risk of social exclusion that oblige the different regions of the national territory to pay for the 50% of the electricity bill of this type of consumers. This social bond is crucial and will affect energy poverty in the country directly. Therefore, the aim of this part of the project is to analyze if the current measures will have a huge impact and change the situation or the will not be necessary enough. New strategies to face the situation will be analyzed if needed, by suggesting policies that could help affected households.

Finally, to perform the analysis, evaluate the scenario and extract valuable conclusions, an Excel tool will be developed. The main purpose of the tool will be to quantify the energy poverty under different scenarios of relevant variables such as location, number of members in the family, age, etc. These variables must be taken into consideration because the consumptions are different for each household and region. Thus, the energy bill will not be the same, and the definition of vulnerable consumer could be biased, so the segmentation is truly important.

2. State of art

2.1. Energy poverty and access to energy review

Once the description of the concepts of energy poverty and energy access are covered, it is important to state numbers about the current situation in the world, EU and later focusing on Spain. The number of people without access to electricity is decreasing as the years go by. In the year 2000, the total amount of people affected was equal to 1.7 billion, and in 2016 it was of 1.1 billion, what supposes a decrease of a 35.3%. Moreover, it is expected that this number will even decrease more, reaching by 2030 the 674 million. This means that the Compound Annual Growth Rate will be -3.44%, and that the governments are organizations are concerned about this fact and trying to solve it. Since 2012, more than 100 million people have gained electricity access [6]. According to the report the number of people without access to electricity from developing countries, in Asia, led by India have made significant progress, reaching an electrification rate of 89% in 2016; China, made huge progress too, it reached total electrification in 2015. However, the bulk majority of the people suffering of this problem are from Sub-Saharan Africa, as it can be seen in the next figure:

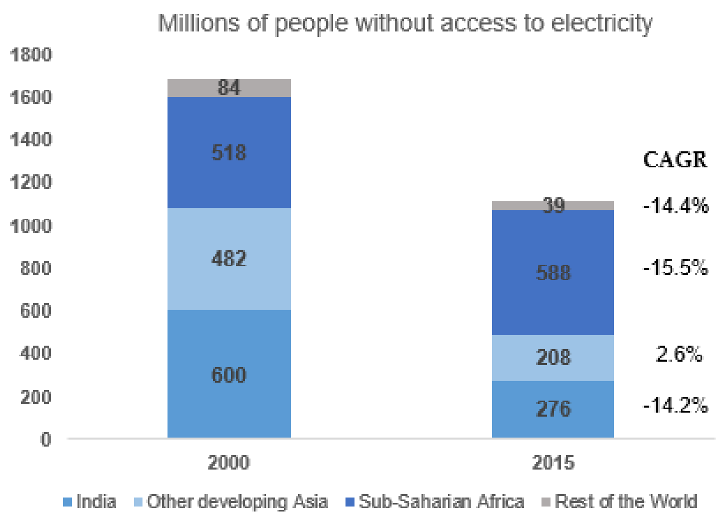

Figure 4. Millions of people without access to electricity classified by region

The results of the data analysis of Figure 4 justify the premise stated before, the world is evolving to a better situation than before, with negative Compound Annual Growth Rates. However, there is much pace to cover in Africa, which has the worst scenario of the world with 588 million people lacking electricity access. It is important to mention that in the case of the resource needed to generate electricity, 70% of the people that gained access during this period 2000-2015 used fossil fuels. In fact, almost all of those who gained energy access to electricity was because of new grid connections, with generation from fossil fuels. In particular, since 2000, new access has come from 45% coal, 19% natural gas and 7% oil. Nevertheless, renewables are starting to gain popularity, as in the case of Europe, which is trying to convert and replace the old and obsolete system of generation towards a more efficient and low cost generation system. It is expected that the distribution will continuously change and that by 2022, renewable generation will consist of 30% of the total generation worldwide [7]. It means that it is expected that global renewable electricity capacity will expand by over 920 GW, an increase of 43%, and in particular, that solar PV will accelerate its growth the most. In fact, counting with the growth of solar PV source of energy, wind and solar together will represent more than 80% of global renewable capacity growth in the next five years [7]. Thus, as there exist a correlation between developing and installing new renewables sources of energy and the decrease of energy poverty, these data is truly decisive for the case discussed here. With this 30% of generation consisting on renewables, there will be more measures to face the energy poverty problem, as more families will take an advantage of more affordable prizes of energy.

In addition, in the case of access to clean cooking facilities, which is another important issue when talking about poverty, there exist 2,775 million people lacking of it. This document will not contain an evaluation or analysis of the clean cooking facilities worldwide or in Spain, as it is not an objective, and it will be focused on energy poverty understood as explained before, impossibility to afford the bills.

2.2. The case of Europe

In Europe, as the study developed by the Agency for the Cooperation of Energy Regulators [8] explains, public service obligations foresee the right for consumers to be connected to the electricity grid at an affordable price. The Official Directive 2009/72/EC [9] of the European Parliament and of the Council of 13 July 2009 states clearly, in its Article 3, that Governments and Public Authorities can influence on service providers with the purpose of ensuring the fairness of price. Also, they could influence obligations with character of security, regularity or quality of the service. The Directive describes that it is necessary the supply of electricity to vulnerable consumers, but the term of vulnerable consumer in the European Union depends on the State Member, so there is not yet consensus on establishing standards.

On the other hand, regarding at Gas policies, the Directive 2009/73/EC [10] offers the same privileges as those defined for electricity. The importance relies on the power the EU gives to each state and the influence the government can use to define the policies of the gas retailers. Moreover, as with the Directive 2009/72/EC, the EU defines its determination to enforce the use of renewable energy and high efficiency. In fact, the rights of the vulnerable clients and the measures to adopt by suppliers are pretty similar to those described on the previous directive.

However, the situation is quite different from the idyllic scenario where poverty is not a concern anymore. The next figure shows the percentage of population of different countries in the EU that experience difficulties to pay the bill of utilities, according to [11]. It reflects the percentage of population that cannot maintain a proper level of temperature at their household:

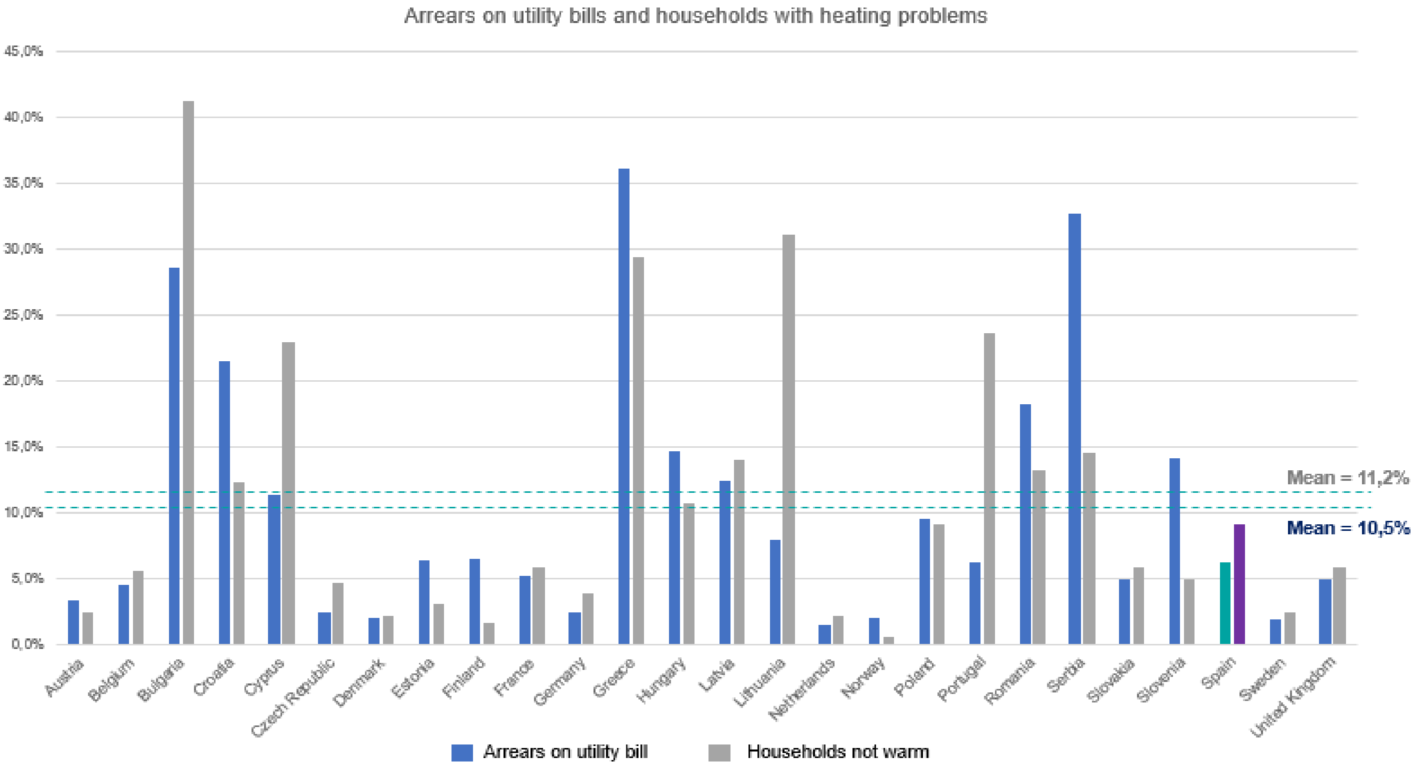

Figure 5. Percentage of population with arrears on utility bills and problems to maintain temperature, EU

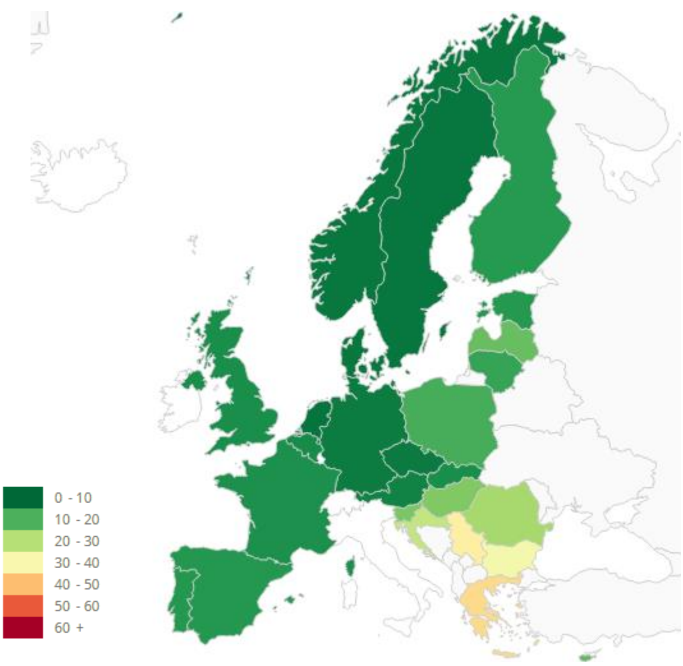

Figure 6. Map of EU for arrears

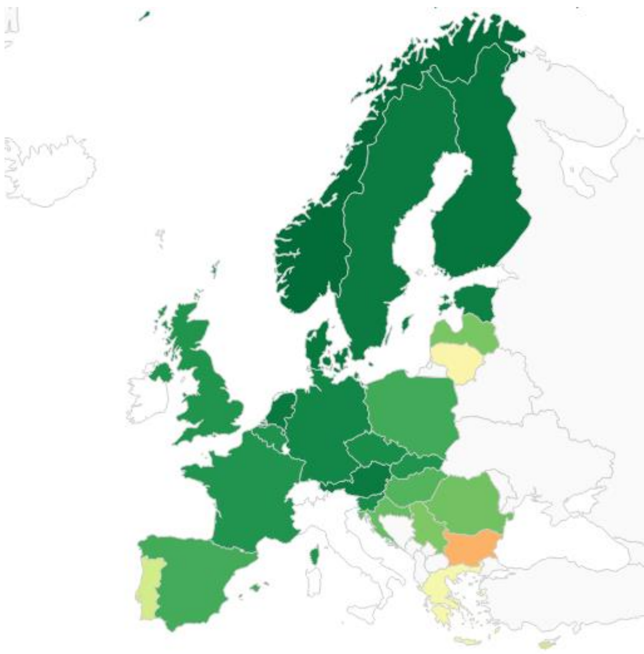

Figure 7. Map of EU for warmth

With Figures 6 and 7, the snapshot of the data shown in Figure 5 is much clearer. It can be said that the countries forming the north of the region are the ones suffering the least of these two variables analyzed. In Figure 6, the criteria used to determine if a household can maintain a proper level of temperature was survey type. Population of those countries were asked the following question: "Can your household afford to keep its home adequately warm?" Then again, to obtain results for the arrear on the utility bill, the question was: "In the last twelve months, has the household been in arrears, i.e. has been unable to pay on time due to financial difficulties for utility bills (heating, electricity, gas, water, etc.) for the main dwelling?"

As it can be seen, the countries that establish the east of Europe are the most affected ones. Of course, there exist different factors to make allowance for, as the average temperature of the countries varies, but it is something the governments and authorities already know, so the policy should adequate to these distinct situations. The main conclusion from both types of figures are:

- Countries like Netherlands, Sweden, Denmark or Norway experiment the best situation in the UE, both percentages are below 3,0%. Policies like the use of renewables to make electricity more affordable or social protection work great in there.
- Disparities between values of the variables change the most in Lithuania, arrears on electricity bills include the 8,0% of the population of the country, whereas the inability to keep a proper temperature in a household reaches 31,2% of the population. Portugal is a good example of imbalance, although arrears are below the European mean, the impossibility of the 23,6% of the population to adequate the temperature of the household makes huge impact.

- Worst scenario comprehends the case of Serbia (32,7%, 14,5%), Greece (36,2%, 29,4%) and Bulgaria (28,7%, 41,3%). As said before, the situation gets much worse in the countries located in the west.

- Spain, although it has been described before that the energy poverty is a great problem, has levels of arrears and ability to maintain the proper temperature of the household lower than the European mean. Arrears are of 6,2%, 4,3 points lower than the average, and the second variable analyzed is of 9,2%, which is 2 points below too. In the context of the performance of the EU this are good news, however, for the situation of the population suffering from this they are not. Being below the average only means that measures must continue, the policies towards a solution are pointing the good direction. The case of Spain will be explained with much more detail in the next chapters and sections. Moreover, the figure does not include the most part of the countries. When taking into account the full data for EU, shown in Figure 9, it can be noticed that Spain has similar problems than the average.

Related with the concept of arrears, it has to be said that in all member states apart from France, which has a different system but with similar characteristics, exist a last resort supplier of electricity. The last resort supplier is automatically assigned to serve the customer when: the final household does not find a supplier in the free market (no energy supplier is willing to sign a contract with the customer) or the final household consumer is dropped by its current supplier because of non-payment. In the case of gas, there is no supplier of gas in Bulgaria, Finland, France, Greece, Slovenia, Cyprus, Malta and Norway.

When electricity and gas delays in the payment happen, the disconnection process takes different days depending on the country too. The average duration of the disconnection process across Europe is of 32 days for electricity and 30 for gas. Apart from this, the process is quite different for each country, for example in Spain, Luxembourg or France, between others, the final household consumers must be given notice about disconnection longer before the disconnection occurs. Also, the disconnections can be restricted for some days of the week or periods of the year, this depends on the policies achieved by governments.

However, it is very complicated to achieve a good database with the same measures of every country, as each state member deals with the energy poverty with its own policies.

As a result of the difficulty to measure the energy poverty itself in Europe, and of the distinct methods that every country applies what results in disparity of measurement, the EU has agreed in the article 29 of the draft of the new Directive about electricity markets that the state members will be soon obligated to count with a measurement system of energy poverty. With the system, the EU will be able to monitor the number of households in situation of poverty and to inform every two years to the European Commission.

The adoption of this homogeneous measurement system for the state members is great for Spain, as the problem will get more seriousness and the impact of the measure will be better understood.

2.3. Energy poverty in Spain

It has already been discussed in the introduction that Spain is one of the countries of the European Union where the prices of the energy are truly high but the GDP per capita is lower than the average. As said before, this means that in Spain there exist difficulties to afford the prices of the energy streams (electricity, water and gas) so the energy poverty is quite sensible in the territory. Thus, the government is nowadays more concerned and trying to correct the situation by helping the households that experience this impossibility to have the minimum living conditions. The social bond published in October 2017 by the

Spanish government had this primary goal. Because of this, the impact of the measure will be analyzed from deep inside, but first it is important to review the actual numbers and data that the country is experiencing.

In the case of Spain, it is estimated by the report Pobreza energética en España. Análisis económico y propuestas de actuación [12] that a 10% of the Spanish households are in a situation of energy poverty what means that approximately 1.8 million homes do not have income to pay for the electricity bill, gas or similar.

Furthermore, some useful data are:

- Approximately 11% of the households declared unable to maintain a comfortable temperature during the winter
- 8% had problems with the time period to pay the bill
- 6% said that more than the 15% of the income of the household was designated to pay the cost of energy and 21% experienced difficulties according to the application of the minimum income standard focused indicator, explained in the next paragraphs
- Another indicator analyzed showed that 7% of the Spanish households are classified as energy poverty sufferers so that their income is lower than the minimum established of 648 €/month

Because of this, and now having a better idea of the problem, energy poverty in Spain is a major concern that should be treated with respect and involve all the possible resources and efforts to solve it. One of the main objectives of the project, therefore, is to evaluate the impact of the minimum consumptions in a household and how the situation could be treated.

There are many indicators that try to measure the energy poverty but the most popular ones are: MIS (Minimum Income Standard) and LIHC (Low

Income/High Cost). The MIS indicator is useful to know the income of the household after the energy expenses. and the LIHC relates the cost of energy in a household and its income. The project will focus on the 10% indicator of poverty. This indicator is used to classify a household in danger of poverty if the expenditure in energy is higher than the 10% of the household income. In addition, and following the standard defined in the draft being elaborated about electricity markets by the European Union, according to the report Pobreza energética en España 2018. Hacia un Sistema de indicadores y una estrategia de actuación estatales [13], the current indicators that will be used in the future that describe the energy poverty of a state member of the EU are:

- Impossibility to keep the household at an adequate temperature during the cold months
- Arrears on energy streams bills due to economic difficulties
- 2M (twice the median): households where the energetic spending over the income suppose twice the median of the country
- HEP (Hidden Energy Poverty): households where the energetic spending is below half of the median of the country

The document calculates the indicators from two main studies, developed by the Instituto Nacional de Estadística (INE) [14]. The first one is called Encuesta de Condiciones de Vida (ECV) and its main objective is to elaborate a database to compare the distribution of income and the social exclusion in Spain, in the European context. The second document used to elaborate those indicators is named Ecuesta de Presupuestos Familiares (EPF), and it gives information about the households spending distribution. Moreover, it reflects the characteristics that the households have along the national territory.

Once understood and defined the indicators, they can be showed for the country in order to have a snapshot of the current panorama and the evolution during the last years, to evaluate the performance. These mentioned indicators will be showed in comparison with the European average.

In the next figure the data for the period 2007-2016 is shown for the impossibility to keep the household at an adequate temperature indicator in Spain and also compared with the European countries enabling the EU28:

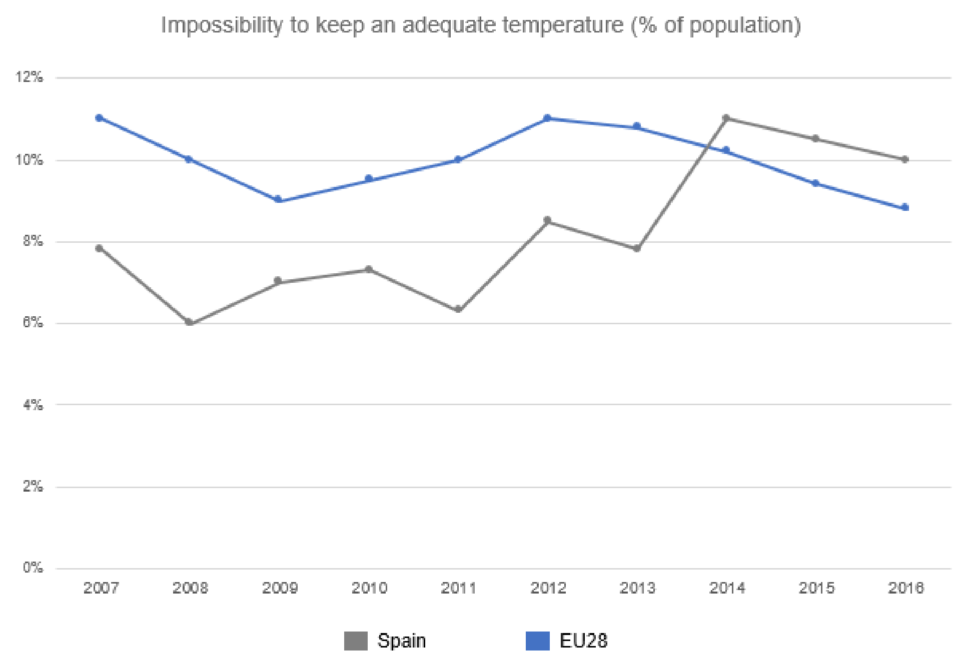

Figure 8. Impossibility to keep the household at an adequate temperature evolution in Spain

The significance of the figure above relies on the fact that Spain, during the first years of the period, performed better than the average of the EU28 but in the last years the indicator shows a worse scenario. Nowadays, and since 2014, Spain finds more difficult to keep the households during the cold months of the year at an adequate temperature. It means that approximately 4.6 million people living at inadequate conditions.

Furthermore, it is important to show values for arrears on utility bills:

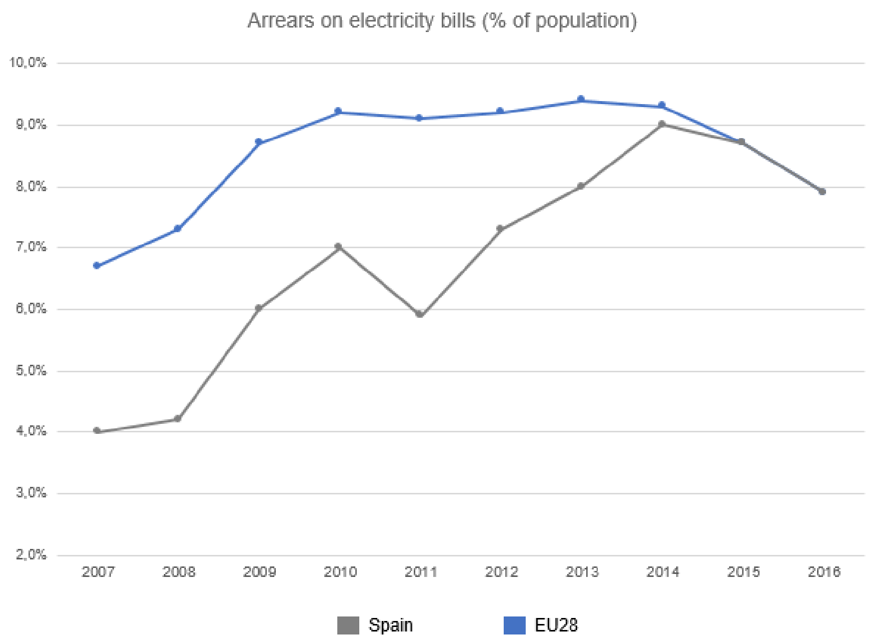

Figure 9. Arrears on electricity bills in Spain in comparison with the EU

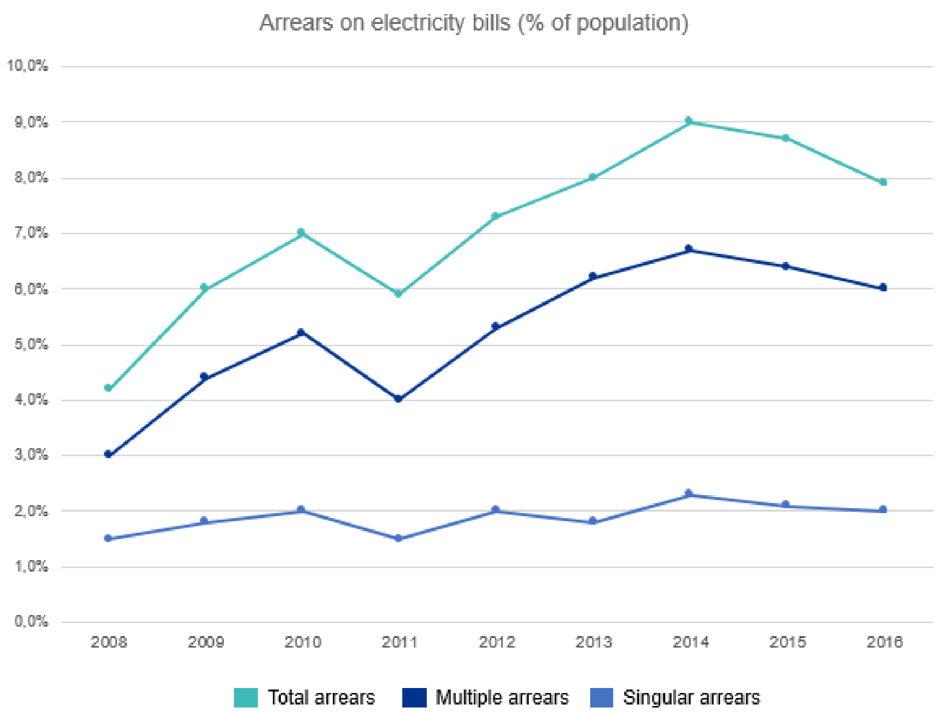

Figure 10. Arrears in energy bills depending on type in Spain

Also, in the case of arrears on electricity bills, Spain is performing similar to the EU28 average. The difference between the average and the country has approximately been worse for Spain over the years, so the past measure that the government approved was useless. Population in Spain is facing huge difficulties to pay for the electricity bill at the end of the month. Additionally, if a household experience a delay, regarding at Figure 10, it is more common that such household will experience another delay in the same year.

The situation of the different regions is not equal, what means that depending on the territory the energy poverty scenario is not the same. There are provinces that are more affected by the poverty such as Castilla – La Mancha, Comunidad Valenciana and Murcia, regarding at the report [13]. There are also differences between the areas of these regions, distinguishing between rural and urbanized areas, where the suffering of poverty is the worst is in the rural areas. To support this, the LIHC indicator for the rural areas is 13% whereas it has a value of 8%. Other factors exist affecting the energy poverty of the households, for example the characteristics of the habitants (age, studies of themselves…) or the equipment the buildings have (type of heating system, square meters…) but the most important is, as said before, the income of the household itself and the high prizes of the energy, existing a strong correlation between energy poverty and the economic situation.

On the other hand, the Ministerio de Energía has just approved a social bond in favor of the vulnerable consumers that will be calculated based on the household income and will limit the amount of subsidized electricity. The term of vulnerable consumer will be applicable to people whose income reach different quantities based on the IPREM depending on the number of people living in the household. This new bond will be applicable in Spring 2018 and will fight against the future rising of the electricity prizes in Spain. With the measure, retailers will be forced to communicate the non-payments in a maximum period of two months and the period of electricity of electricity cut is extended to four months. Furthermore, in the case of non-payment the company providing electricity will have to inform the consumer the possibility of the new social bond. There have been attempts this year of approving another significant social bond for the gas resource, but in Spain is not considered yet a basic and necessary service.

Lastly, regarding at the case of Spain discussed in this chapter, it is important to have a vision of the final consumptions at the end of the year that the country has. This has to be taking into account because, as the excel tool will return values of consumptions, it will be used for a sanity check to evaluate if the hypothesis adopted are correct or other data should be used instead. Also, the values give the idea of how the distribution between industry, domestic use of energy and services is:

	Industry	Domestic	Services	Total
Water (hm^3)	16.078,98	2.269,97	567,49	18.916,46
Electricity (GWh)	108.431,64	69.647,50	59.390,86	237.470,00
Gas (GWh)	202.844,00	53.510,00	35.573,00	315.997,00

Table 1. Yearly consumptions of the energy streams in the Spanish peninsula

Also, these consumptions can be represented in the next figures:

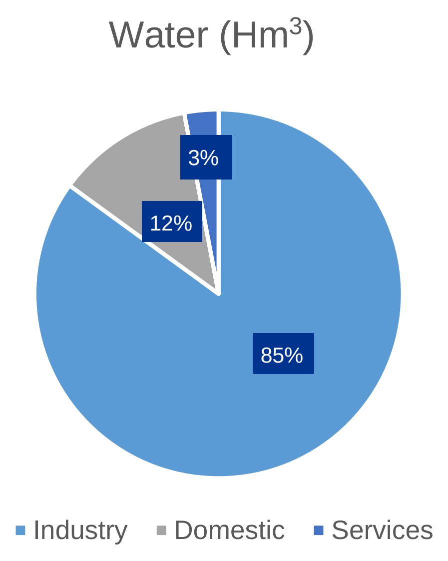

Figure 11. Consumption share of water per sector in the Spanish peninsula

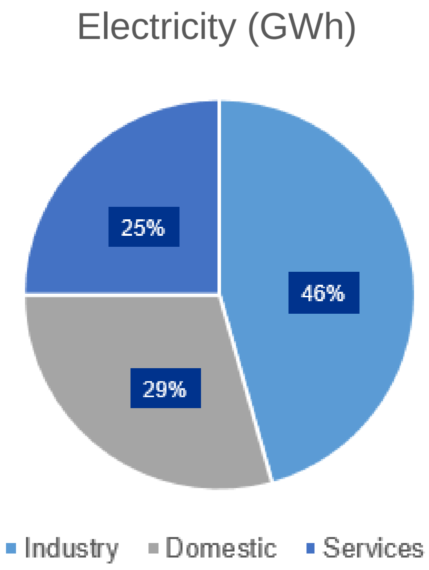

Figure 12. Consumption share of electricity per sector in the Spanish peninsula

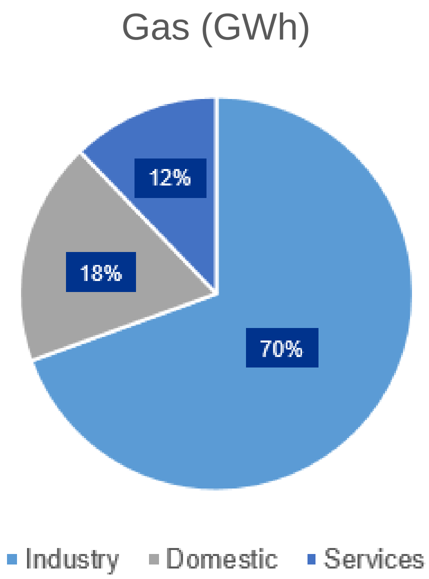

Figure 13. Consumption share of gas per sector in the Spanish peninsula

The data collected and showed in the different figures correspond with the year 2016 and only with the territory of the Iberian Peninsula, excluding the islands, which are out of scope of the study. As it can be seen, the most inequality in the share distribution between industry, domestic use and services is the stream of water. This is mainly because in Spain the primary sector, and, in particular agriculture, is really dependent on the water supply. The resource of water is highly valued in regions such as Murcia or Andalucía, where water supply for plantations is more than necessary.

In addition, the share is approximately the same when regarding at the electricity and gas consumptions of the country. In the case of electricity both consumptions are around 25% of the total, on the other hand, domestic and services consumptions of gas are approximately of 15%.

Besides giving an idea of the situation in Spain, having the numbers of the consumptions will help the tool. As stated in the previous paragraph, it will be much easier to check if the outputs achieved from the different steps described in the methodology of the tool are correct. Therefore, if the outputs given do not correspond with the domestic consumptions of the country, Table 1, the inputs will be revised in order to correct possible errors. Reliability is very important for the tool and the overall study of the thesis.

2.4. Motivation of the project

The energy poverty was always an objective of debate. It was always argued if it is a different kind of poverty, maybe secondary, or if it is a primary source of poverty. In fact, the energy poverty has not been classified many times as poverty and because of this the solutions proposed to this particular problem were not as good as the adopted for the others. In the case of Spain, there is much work to do yet and much pace to solve the difficulty.

For all of this, the motivation of the project is born. In the opinion of the author it is really valuable for a developed country as Spain to have a policy that covers the problem of energy poverty and that allows every user the access to energy. It is not possible that many families with low income cannot afford the electricity bill or the gas bill because of the high price and even paying taxes to the government. Spain nowadays is characterized as a welfare state so it has to demonstrate that.

There exist other studies concerning energy poverty in Spain. In fact, this project is done to develop a deeper analysis of the Spanish case using data and knowledge from another study that was severely superficial, only developed for a part of Cataluña [15]. In this study, the excel tool used calculates the amount of money that should be provided to households affected by energy poverty to cover the basic necessities of natural gas, water and electricity. It also uses many different factors, such as equipment of the household, consumptions and different people living in there to obtain data of scenarios and valid conclusions. With the objective of improving the excel tool, in this project the analysis will be more detailed so that the estimated error will be minimized. Furthermore, the study will be updated with the poverty indicator of the 10%, that will measure the percentage of population whose energy bill supposes more than the 10% of the income, and per region. Also, the basic assumptions will be modified to adapt the study to a more real case and to conclude in a better way.

According to the described before, and to support this, there are approximately 1.8 million homes in Spain that do not have energy access and, what in fact is even worse, it causes seven thousand (7,000) deaths per year in the country.

The situation of economy recovery is a good scenario to adopt new measures and fight this. The GDP of Spain is growing and it is expected to keep growing although the difficulties that is now suffering the country, so if it is growing that means no other than a recovery of the economy. With this surplus of spending and receiving from the government of Spain, some additional measures could be adopted. By saying this, we can assure that the macro force of the economy in Spain is an advantage to solve the situation described in this document.

The analysis of the data of consumptions and the later evaluation will allow the author to design new policies to face the current energy poverty. For this, the motivation relies on governments and administrations to adopt the policies and then be more concerned about this problem that makes many families in Spain have very difficult times. Furthermore, the excel tool will go beyond the scope of the actual social bond. Investments concerning water and gas too will be calculated.

3. Objectives

The objectives of the project are:

- Development of a method to calculate technical energy consumptions in Spain (electricity, gas and water)
- Calculate energy consumptions for different regions and scenarios in Spain
- Implement the method and calculations in an Open Source tool in Excel
- Evaluate current policies of Energy Poverty in Spain and propose new strategies

When calculating the consumers profile depending on the region of the Spanish territory, the method applied will be very technical, from an engineering perspective. This fact is important to remark in order to define and specify the method to apply in the calculations, because there is not a particular way to calculate the mentioned profiles so it has to be determined.

Moreover, these objectives derive from the state of art of the project and from the motivation. Although the most primary objectives have been clarified it is possible that secondary objectives appear during the development of the project, what will not change the scope of the study at all but add value to itself.

4. Methodology

The methodology of the project can be explained and divided into two parts. At first, the steps to follow to obtain the model and one of the objectives of the thesis, which is to analyze the impact of the energy poverty in the country, are shown in the following figure:

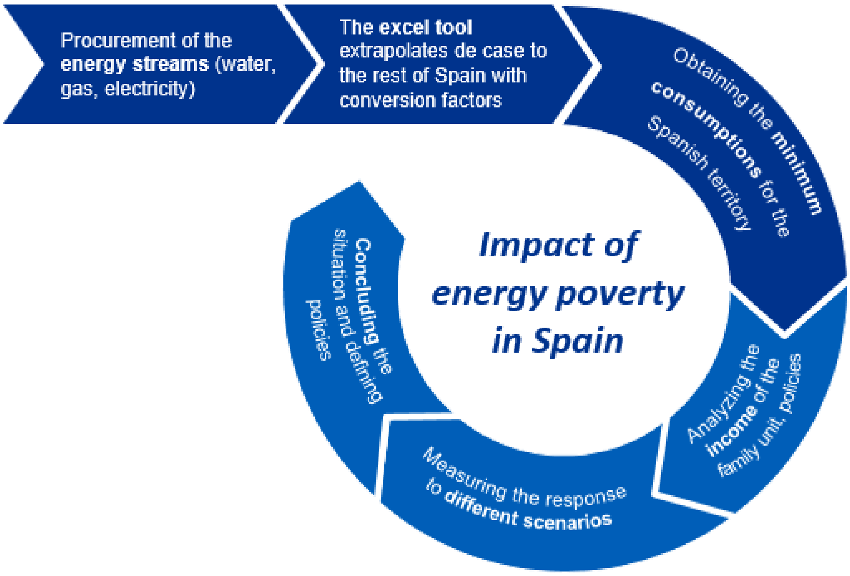

Figure 14. Steps to follow during the development of the thesis

The first steps concern the identification of the demands of the three different energy vectors affecting the households in the situation of poverty (electricity, water and gas). Once the inputs of the model are defined, the excel tool will do the rest and will obtain the minimum consumptions for the Spanish regions and for the overall territory, first in L for water and kWh for electricity and gas, and then will convert these units into €. It is important to say that another factors will be introduced, such as the income of the household itself, or the estimated number of households affected. With this, the necessity of the country will instantly be identified and only by changing parameters, the sensibility of the study will be truly crucial to see how the different helps provided by the country influence the households and how the regions distribute themselves.

Second, the model will have the structure showed in the next figure:

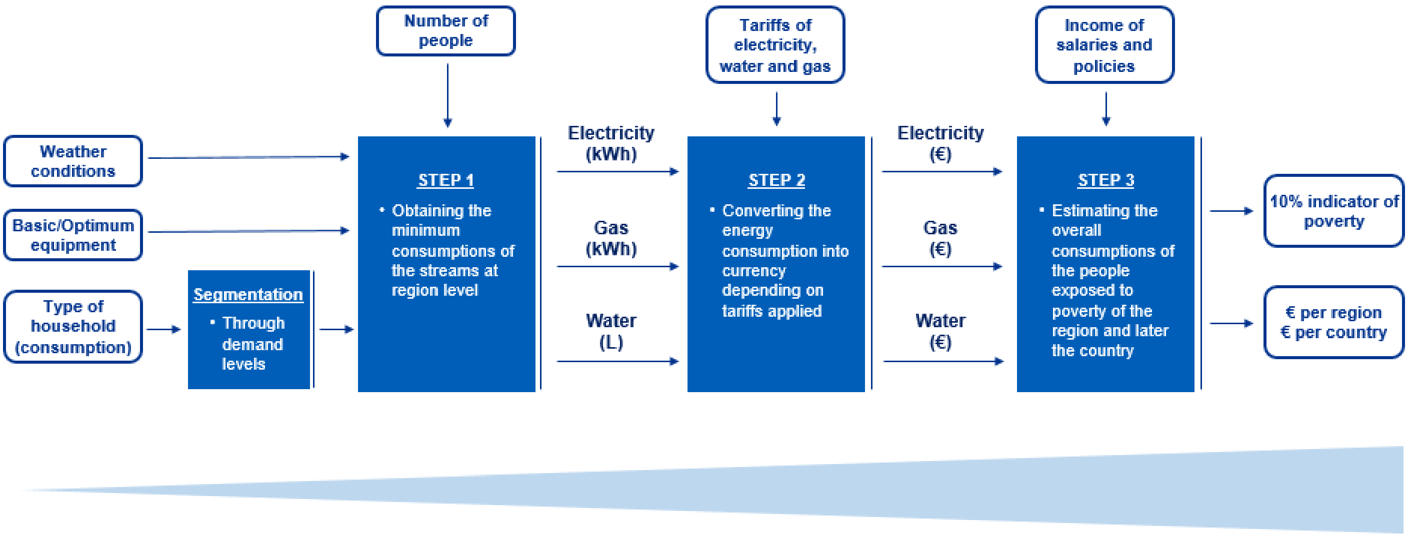

Figure 15. Structure of the model

Figure 15 describes the skeleton of the excel model and how the minimum consumptions will be calculated. The boxes colored in blue symbolize the calculations the excel model will do using the inputs and therefore, obtaining the desired outputs. The inputs used for the model are:

- Weather conditions
- Type of household, depending on the consumption and energetic certification
- Equipment of the household, depending on factors such as if air conditioning installation is provided. For this, Optimum equipment is characterized with not only basic items.
- Number of people living in the household
- Tariffs of energy streams
- Income of the household and social policies

Furthermore, the model introduces several outcomes in the intermediate levels, but the final output will be the total amount of euros needed to find a feasible solution to the problem with the energy poverty indicator of the 10%.

In the Step 1 of the model, which is the first one that introduces calculations with the input variables of number of people living in the household, weather conditions, the classification of optimum or basic consumption and the type of household, will return the minimum consumptions of the energy streams in liters and kWh, dividing them by regions.

Moreover, the Step 2 will add the conversion of these mentioned units of the streams into €. Thus, this step will convert the energy into economy by applying the price policies of the country. Gas and electricity have the same regulations for the regions, however, water policies are different depending on the geography [16]. These prices are represented in the next figure:

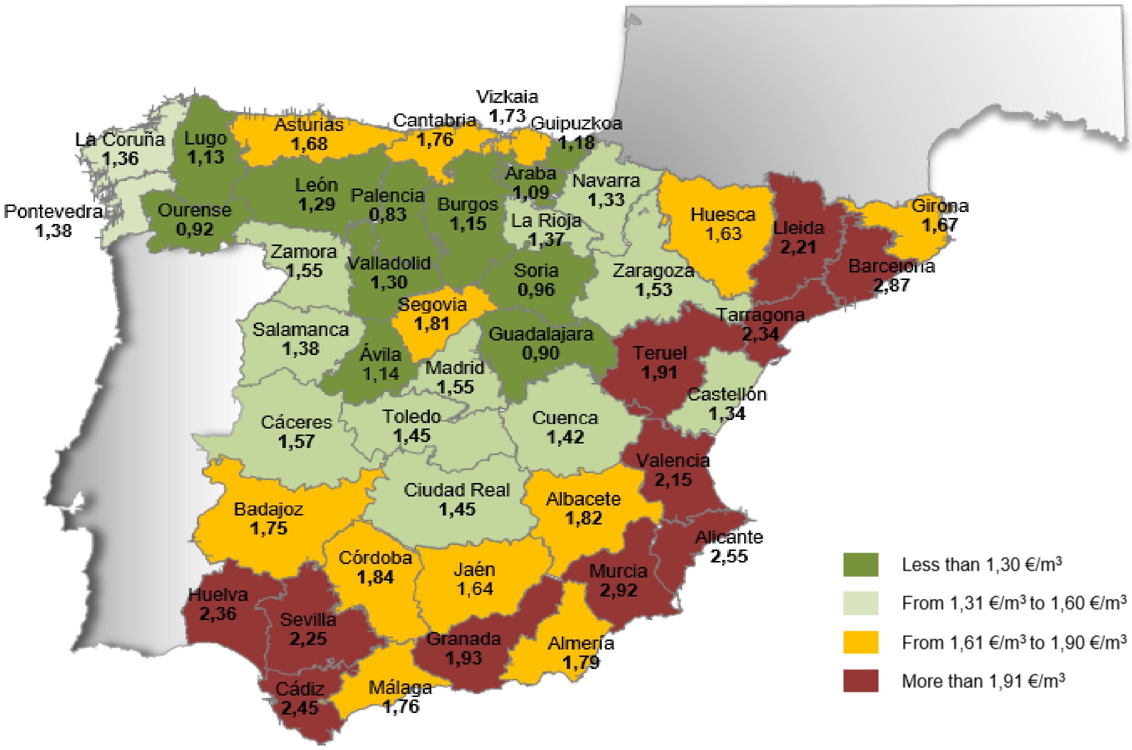

Figure 16. Prices of water per region (€/m³)

The gas policy corresponds with the tariff defined in the BOE num. 315 of 2017 [17]. In this modification of the law, the new tariffs of last resource are:

	Tariff	
	Fixed cost - (€/client)/month	Variable cost - cent/kWh
TUR 1. Consumption equal or lesser than 5.000 kWh/year	4,28	5,371476
TUR 2. Consumption greater than 5.000 kWh/year and equal or lesser than 50.000 kWh/year	8,44	4,684076

Table 2. Gas tariffs of last resource

The electricity that will be applied in the model [18], along with the gas and water tariffs already showed, will be the following:

Precio Voluntario al Pequeño Consumidor	Power (€/year)	Energy (€/kWh)
Tariff 2.0A	141,9175	0,12159

Table 3. Precio Voluntario al Pequeño Consumidor, electricity tariff

This tariff is defined in the BOE num. 77 of 2014 [18] and it includes all the measures applied to consumers that are protected, what means consumers that are in a situation of impossibility to afford a standard electricity tariff. The government with the measure of the BOE tries to help these vulnerable consumers by charging them less for the energy resource.

Lastly, the third step of the tool, Step 3 in the figure, will englobe measures of poverty in Spain, such as the minimum salary for an employee in Spain (SMI) or the IPREM, and the social bonus entered into force in October 2017. The final output will return the amount of money that would be needed in order to correct the poverty plus the energy poverty indicator. This will involve both the region scope and the nationwide scope.

In addition, the variables of control will also lead to sensitivity analysis in the different steps of the tool. With this, it will be much easier to understand the effects of a distinct type of social help by the government of Spain, as the output achieved will deliver a fast response which will let us know if the type of bonus is proper or not. This is a brilliant way of the tool to add value, as the evaluation of the effect of the different inputs and parameters will be instantaneous and will led to adopt effective responses.

5. Description of the tool

The tool elaborated with the purpose of fulfilling the objectives, and following the structure already described, is an excel file which, giving the different inputs regarding at energy prices, consumptions and so on will return outputs related with energy consumptions of energy levels and regions, economic factors, and poverty indicators of the mentioned regions.

At first, there exist a need to distinguish the three different energy streams that will define the tool: water, electricity and gas. The outputs of steps 1 and 2 following the scheme of Figure 15 correspond with these streams and will conclude the minimum consumptions of the households for every region of the Spanish peninsula.

The decision to build the model in an excel tool lies in the simplicity to understand the tool for every user, as it will be very easy to identify the inputs to introduce. Also, the results will be clear and will deliver fast conclusions about the impact of the different inputs. With this, sensibility analysis, by slightly changing the variables, will be simple too. In addition, a previous tool was developed with other purpose in this program, and, because of the fact that the model is superficially based on the previous approach, excel was the program chosen. Thus, as excel offers an easy understanding for every user and compatibility with almost every computer, plus the knowledge of the author to program using this software, plus the previous studies developed, excel was the most suitable to run the model.

In total, the model of the tool counts with 38 sheets, and it is divided into 5 sections, that will be explained next and are presented in the next chart:

Section	Sheet name
INPUTS & OUTPUTS	INPUTS
	Elect. Y Gas Provincias Anual
	Elect. Y Gas Niveles Anual
	Precios por Provincia Anual
	Precios por Nivel Anual
	Total precios por Provincia
	Pobreza 10%
LEVELS AND REGIONS	Nivel de provincia
	Provincias
	Nivel 1
	Nivel 2
	Nivel 3
	Nivel 4
	Nivel 5
	Nivel 6
COEFFICIENTS AND POPULATION	Coeficientes
	Poblacion
CONSUMPTIONS	Agua
	ACS
	Calefaccion
	Cocina
	Lavadora
	Television
	Iluminacion
	Refrigerador
	Ordenador
	Refrigeracion
DATABASE	PreciosAgua
	DistribucionSalarios
	DemandaNuevoUnifamiliar
	DemandaNuevoBloque
	DemandaExistUnifamiliar
	DemandaExistBloque
	CantidadHogaresNuevosExistentes
	ZonaClimatica
	ClasificacionNiveles
	PoblacionViviendas
	TablaDinamicaZona

Table 4. Sections and sheets that form the tool

5.1. Inputs and Outputs

This section of the tool actually was the last part elaborated, as it returns the results by entering the input variables. The Inputs and Output section allows the user to introduce the desired data in the INPUTS sheet and, by running different macros, the model is capable to give the minimum consumptions for a household segmented into two different levels: the first one corresponds with the classification performed into energetic levels and, on the other hand, the second one corresponds with the regions of the Spanish territory themselves, without classifying the energy consumptions of them.

There are three distinct types of outputs. First, the tool delivers the consumptions of the three streams in energy units and liters (kWh and L), using the data of the other sheets. It is important to mention that there will always be two scenarios for the streams, a basic consumption scenario and an optimal consumption scenario, depending on the equipment of the household. Also, as not every household has gas installation, the excel is capable to return the consumptions differentiating if the household counts with both streams or only with electricity. However, this will be explained with more detail on the section that is related to consumptions.

Second, depending on the tariffs applied, the model converts the previous units achieved into monetary units, that is to say, the minimum amount that a household needs to cover it basic and optimal needs of the energy streams is achieved. The data that the tool delivers in this phase is very significant, as the amount of money for energy expenses that a household needs depending on the region gives the user a snapchat of the costs that families have to afford.

Third, the toll will measure the percentage of population in danger of poverty, and will be used to calculate the necessary investment to solve the problem per region and nationwide.

Now, the sheets that form the section of Inputs & Outputs will be explained in order to understand how the excel tool adds value to the study.

5.1.1. INPUTS

The first sheet of the model has the main purpose to declare all the variable that will influence the consequent outputs. The format of the sheet can be appreciated next:

INTRODUCIR VARIABLES

	Gas TUR. 1	Gas TUR. 2	Electricidad 2.0 A
Fijo €/mes	4,28	8,44	
Consumo gas €/kWh	0,0537	0,0468	
Impuesto especial sobre hidrocarburos €/kWh	0,00234	0,042	
Alquiler de contador €/dia	0,041	0,041	
Potencia contratada kW			3,45
Potencia €/kW/año			41,15
Energía €/kWh			0,121
Impuesto electricidad			5,11%
Alquiler equipos €/dia			0,026
Bono Social			0,00%
IVA	21%	21%	21%

	Agua
Cuota de servicio €/mes	11,87
IVA	10%

CALCULAR NIVELES

CALCULAR PROVINCIAS

BORRAR

BORRAR

Figure 17. Format of the INPUTS sheet, including tariffs and commands to operate the tool

As it can be seen, there are three tariffs differentiated. The Gas TUR. 1 for gas consumers that not exceed 5000 kWh per year, Gas TUR. 2 for the rest of gas consumers, and last the electricity tariff, also called Precio Voluntario al Pequeño Consumidor. It must be said that this electricity tariff is required nowadays to demand the social bond.

The sheet allows the user to introduce the next data, that will define the outputs for monetary consumptions:

- *Fixed cost (€/month)*

  Euros per month that gas consumers are obligated to pay

- *Gas consumption tariff (€/kWh)*

  Variable cost associated with the gas consumption per month

- *Special tax (€/kWh)*

  Tax associated with the resources employed to generate gas

- *Rental of measurement equipment (€/day)*

  The measurement system is not property of the user, so it requires a rental fee

- *Contracted power (kW)*

  Amount of kW contracted with the supplier

- *Power (€/kW/year)*

  Amount of euros that a kW costs per year

- *Energy (€/kWh)*

  Price that a kWh of electricity has

- *Electricity tax (%)*

  Percentage of the bill that consists in tax

- *Social bond (%)*

  Percentage of the bill afforded by the government

- *IVA (%)*

  Tax collected by the government applied to all the tariffs

- *Service fee (€/month)*

  Monthly fee related to water consumption, similar to the fixed cost concerning gas consumption

The sheet also includes four buttons, that are related to macros that make the tool to run the model. With a simple click, the button "CALCULAR NIVELES" makes the user reach the results with the variables introduced for the energetic levels, whereas the button "CALCULAR PROVINCIAS" returns the prizes for the regions.

Lastly, below both of the buttons there exist commands that erase all the values obtained, called "BORRAR". They were included to facilitate the sensibility analysis and try more than one scenario.

5.1.2. Elect. y Gas Provincias Anual

In this sheet, the consumptions of the streams (water, electricity and gas) are calculated from the data collected in the sections of consumptions and database. The level of segmentation of the sheet is in regions, and there is another one gathering them into the energetic levels.

In addition, there are two different cases that must be explained. As it might be obvious, not all the households in the country use the same stream for heating, there are some which use electricity systems and others which use gas. Because of this, the two mentioned cases were calculated. The first one is distinguishing households using gas for heating, cooking and hot water purposes where the second is assuming that these demands are covered with electricity. The prices will vary as the tariffs applied are not the same, therefore.

The figure exhibited shows how the consumptions appear in the excel tool:

Consumos
Anual

Provincia	Miembros	Electricidad y Gas: Agua L	Electricidad y Gas: Electricidad Basico kWh	Electricidad y Gas: Electricidad Optimo kWh	Electricidad y Gas: Gas Basico kWh	Electricidad y Gas: Gas Optimo kWh
A Coruña	1	39.055,00	750,59	933,09	2.441,21	4.286,67
	2	78.110,00	829,45	1.011,95	2.468,09	4.659,58
	3	117.165,00	963,59	1.173,74	2.494,97	5.263,16
	4	156.220,00	1.042,45	1.252,60	2.521,85	5.636,06
	5	195.275,00	1.138,38	1.348,53	2.548,73	6.124,30
	TOTAL	87.685,28	870,30	1.063,39	2.474,68	4.841,62
Albacete	1	39.055,00	750,59	1.264,38	3.255,46	5.752,32
	2	78.110,00	829,45	1.370,85	3.282,34	6.247,36
	3	117.165,00	963,59	1.578,65	3.309,22	7.054,51
	4	156.220,00	1.042,45	1.685,12	3.336,10	7.549,55
	5	195.275,00	1.138,38	1.817,87	3.362,97	8.200,64
	TOTAL	96.566,64	892,57	1.468,37	3.295,04	6.629,43
Alicante	1	39.055,00	750,59	2.376,84	1.238,73	2.122,20
	2	78.110,00	829,45	2.576,02	1.265,61	2.314,73
	3	117.165,00	963,59	2.938,32	1.292,49	2.617,70
	4	156.220,00	1.042,45	3.137,50	1.319,36	2.810,23
	5	195.275,00	1.138,38	3.393,85	1.346,24	3.057,97
	TOTAL	91.053,54	878,37	2.709,48	1.274,52	2.424,74

Anual

Miembros	Electricidad: Agua L	Electricidad: Electricidad Basico kWh	Electricidad: Electricidad Optimo kWh
1	39.055,00	3.142,49	5.133,17
2	78.110,00	3.247,69	5.577,40
3	117.165,00	3.408,15	6.330,57
4	156.220,00	3.513,35	6.774,80
5	195.275,00	3.635,62	7.349,12
TOTAL	87.685,28	3.294,98	5.807,20
1	39.055,00	3.940,29	6.900,50
2	78.110,00	4.045,49	7.492,01
3	117.165,00	4.205,95	8.490,64
4	156.220,00	4.311,15	9.082,15
5	195.275,00	4.433,42	9.852,84
TOTAL	96.566,64	4.121,05	7.963,88
1	39.055,00	1.964,30	4.456,18
2	78.110,00	2.069,50	4.843,99
3	117.165,00	2.229,96	5.503,14
4	156.220,00	2.335,16	5.890,95
5	195.275,00	2.457,43	6.390,05
TOTAL	91.053,54	2.127,14	5.085,24

Figure 18. Look of values obtained for the annual consumptions in the regions

As it can be seen, both of the cases are separated. Then, it has to be stated what terms form the streams consumptions. The water consumption will be developed later, so it will not be included. The basic case is taking into account the basic values of the diverse sheets and the optimal the others. This is deeper explained along this chapter of the document.

- *Case electricity and gas*

$$Electricity_{basic} = (washing\ machine + television + illumination + refrigerator) \cdot \frac{1}{efficiency} \quad (I)$$

$$Electricity_{optimal} = (electricity_{basic} + computer + air\ conditioning) \cdot \frac{1}{efficiency}$$

(II)

$$Gas_{basic} = (ACS_{basic} + heating_{basic} + kitchen_{basic}) \cdot \frac{1}{efficiency}$$

(III)

$$Gas_{optimal} = (ACS_{optimal} + heating_{optimal} + kitchen_{optimal}) \cdot \frac{1}{efficiency}$$

(IV)

- *Case electricity only*

$$Electricity_{basic} = ((washing\ machine + television + illumination + refrigerator) + gas_{basic}) \cdot \frac{1}{efficiency}$$

(V)

$$Electricity_{optimal} = ((electricity_{basic} + computer + air\ conditioning) + gas_{optimal}) \cdot \frac{1}{efficiency}$$

(VI)

In the Figure 18, the consumptions are classified depending on the number of people living in the household, but it is also outstanding to get the results of the average household for further achievement of poverty indicators. Because of this, there is an extra row on the tool that calculates the average consumption taking into account the distribution of the households in the corresponding region.

5.1.3. Elect y Gas Niveles Anual

The sheet is very similar to the one described above, with the difference that the segmentation is done throughout energetic levels. The procedure to obtain the values is exactly the same as for the one for regions, but the values are taken from different tables in the sheets. It is not worth to write the equations again as they follow the logic of the preceding equations.

The aspect of the consumptions in the sheet is:

Nivel	Miembros	Electricidad y Gas				
		Agua L	Electricidad Basico kWh	Electricidad Optimo kWh	Gas Basico kWh	Gas Optimo kWh
	1	39.055,00	750,59	1.800,39	650,14	1.062,75
	2	78.110,00	829,45	1.951,53	677,02	1.166,99
1	3	117.165,00	963,59	2.233,77	703,90	1.322,80
	4	156.220,00	1.042,45	2.384,91	730,78	1.427,05
	5	195.275,00	1.138,38	2.577,21	757,65	1.557,07
	1	39.055,00	750,59	1.416,43	1.300,76	2.233,86
	2	78.110,00	829,45	1.563,22	1.327,64	2.435,70
2	3	117.165,00	963,59	1.764,48	1.354,52	2.754,17
	4	156.220,00	1.042,45	1.883,62	1.381,40	2.956,00
	5	195.275,00	1.138,38	1.823,11	1.408,27	3.216,16
	1	39.055,00	750,59	996,69	2.494,82	4.383,16
	2	78.110,00	829,45	1.081,02	2.521,70	4.764,10
3	3	117.165,00	963,59	1.251,94	2.548,57	5.381,09
	4	156.220,00	1.042,45	1.336,26	2.575,45	5.762,03
	5	195.275,00	1.138,38	1.439,39	2.602,33	6.261,00
	1	39.055,00	750,59	2.433,10	1.273,19	2.184,24
	2	78.110,00	829,45	2.637,13	1.300,07	2.381,94
4	3	117.165,00	963,59	3.007,55	1.326,95	2.693,51
	4	156.220,00	1.042,45	3.211,58	1.353,83	2.891,21
	5	195.275,00	1.138,38	3.474,31	1.380,70	3.145,85
	1	39.055,00	750,59	1.671,45	2.771,76	4.881,67
	2	78.110,00	829,45	1.812,01	2.798,64	5.304,15
5	3	117.165,00	963,59	2.076,64	2.825,52	5.990,37

Nivel	Miembros	Electricidad		
		Agua L	Electricidad Basico kWh	Electricidad Optimo kWh
	1	39.055,00	1.387,60	2.841,67
	2	78.110,00	1.492,80	3.094,94
1	3	117.165,00	1.653,26	3.529,85
	4	156.220,00	1.758,46	3.783,13
	5	195.275,00	1.880,73	4.102,83
	1	39.055,00	2.025,08	3.605,16
	2	78.110,00	2.130,27	3.949,71
2	3	117.165,00	2.290,74	4.463,01
	4	156.220,00	2.395,94	4.779,91
	5	195.275,00	2.518,21	4.974,29
	1	39.055,00	3.195,01	5.291,30
	2	78.110,00	3.300,21	5.748,88
3	3	117.165,00	3.460,67	6.524,32
	4	156.220,00	3.565,87	6.981,89
	5	195.275,00	3.688,14	7.573,90
	1	39.055,00	1.998,06	4.573,22
	2	78.110,00	2.103,26	4.970,95
4	3	117.165,00	2.263,73	5.646,65
	4	156.220,00	2.368,93	6.044,39
	5	195.275,00	2.491,19	6.556,61
	1	39.055,00	3.466,36	6.454,50
	2	78.110,00	3.571,56	7.009,01
5	3	117.165,00	3.732,02	7.946,00

Figure 19. Aspect of the values of consumptions for the energetic levels

They also appear depending on the number of people and for the case with households equipped with gas and households only with electricity installation.

5.1.4. Precios por Provincia Anual

After the procurement of the consumptions for the regions and levels, the step two of the methodology described enters into force. Here, the tool calculates the final prizes that a household would have to pay for the minimum consumptions per year, by adding the results of the three streams. Then, from the values obtained from the sheets concerning demands in L and kWh, these formulas have to be applied to obtain the costs:

$$Prize_{water} = \left(\frac{Cosnumption\ (L)}{1000\ (\frac{L}{m^3})} \cdot prize_{region} \left(\frac{€}{m^3} \right) + service\ (€) \right) \cdot (1 + IVA)$$

(VII)

$$Prize_{electricity} = \left[\left(Consumption\ (kWh) \cdot energy \left(\frac{€}{kWh} \right) \cdot (1 - bond) + power \left(\frac{€}{\frac{kW}{year}} \right) \cdot contracted\ power\ (kW) \right) \cdot \left((1 + tax) + rental\ (€) \right) \right] \cdot (1 + IVA)$$

(VIII)

$$Prize_{gas} = \left[Consumption\ (kWh) \cdot \left(gas\ consumption\ tariff\ \left(\frac{€}{kWh} \right) + tax\ \left(\frac{€}{kWh} \right) \right) + fixed\ cost\ (€) + rental\ (€) \right] \cdot (1 + IVA)$$

(IX)

It must be stated that the tool runs the calculations just by clicking the buttons located in the sheet “INPUTS”. The program also distinguishes between what tariff to apply depending on the constraints they have.

Finally, the structure of the sheet is exactly the same as the one for the consumptions, already shown in Figure 18, with the only difference that, as it is obvious, the data shown are values of prizes per year.

5.1.5. Precios por Nivel Anual

Following the lines of the consumptions performed for the segmentation throughout levels, this sheet does the same but for the annual prizes the households would face for minimum comfortable living conditions.

The figures are obtained by applying the formulas just described concerning the energetic streams, and the look of the sheet is the same than the one used for exhibiting the minimum consumptions.

5.1.6. Total Precios por Provincias

The only purpose of this part of the excel book is to show the average total prizes for every region of the Spanish peninsula. It is a summary then of the sheet collecting the values for the annual prizes. It is also divided between the electricity plus gas case and the only electricity case.

Values are exported from this sheet to build the subsequent sheets about poverty indicators, that will be explained in the next chapter.

The aspect of the sheet is in line with the related excel sheets, and is the following one:

Provincia	Electricidad y Gas: Agua €	Electricidad y Gas: Electricidad Basico €	Electricidad y Gas: Electricidad Optimo €	Electricidad y Gas: Gas Basico €	Electricidad y Gas: Gas Optimo €	Electricidad: Agua €	Electricidad: Electricidad Basico €	Electricidad: Electricidad Optimo €
Granada	298,30	770,76	982,24	270,46	741,62	298,30	1.193,72	1.825,58
Guadalajara	298,66	770,96	855,79	295,24	823,13	298,66	1.249,01	1.813,50
Guipuzkoa	295,09	769,90	799,73	270,36	738,35	295,09	1.192,63	1.638,49
Huelva	303,37	772,26	1.068,11	158,48	229,95	303,37	946,20	1.400,99
Huesca	290,11	768,69	855,07	330,21	927,17	290,11	1.324,51	1.958,78

Figure 20. Example of values showing the annual prices depending on region

5.1.7. Pobreza 10%

This sheet is one of the most important ones of the entire document, as it returns the outputs for the third step of the overall scheme of the tool, exposed in Figure 15. The theory behind the sheet lies in the poverty indicator of 10%. This indicator states that a household in danger of energy poverty is the one which the annual bill of energy costs supposes at least a 10% of the annual income of the household. At this point is where the sheet called "DistribucionSalarios" of the "Database" section comes into play. Crossing the salary distribution of the country with the minimum consumptions of the regions the indicator can be built. It shows the percentage of population depending on the region and the case analyzed that is in danger of energy poverty, what means the households in which the energy costs are more than the 10% of the income, as just stated. It must be said that the approximation done to obtain the final amount of people per region is a linear interpolation from the data of salary distribution.

The next figure show the structure of the sheet and how the indicator appears:

Beneficios del hogar si el gasto en energia es el 10% del salario

Provincia	Agua+Elect+Gas Basico €	Agua+Elect+Gas Optimo €	Agua+Elect Basico €	Agua+Elect Optimo €
A Coruña	13.040,41	14.942,55	14.291,22	18.157,31
Albacete	13.763,82	20.142,85	15.695,33	21.609,12
Alicante	12.289,41	15.887,29	12.544,40	17.096,66
Almeria	12.213,71	16.096,65	12.175,28	16.728,22
Araba	14.029,70	20.821,33	16.552,54	22.887,09
Asturias	13.328,39	18.525,07	15.045,73	19.682,24
Avila	17.380,37	23.050,75	18.145,74	25.983,18
Badajoz	13.127,68	17.821,11	14.271,24	20.893,84
Barcelona	12.819,22	14.970,93	13.700,48	17.465,74
Burgos	17.360,59	23.008,95	18.127,45	25.934,00
Caceres	13.051,92	17.995,35	14.261,58	21.145,52
Cadiz	12.305,82	15.408,69	12.332,27	16.181,81
Cantabria	13.035,25	14.922,34	14.258,39	18.090,28
Castellon	12.440,34	15.352,05	12.858,32	16.899,40
Ciudad Real	13.649,76	20.895,08	15.420,46	22.193,71
Cordoba	12.534,90	17.462,32	12.936,52	19.001,92
Cuenca	14.371,24	22.068,78	17.170,88	24.426,46
Girona	13.415,01	19.034,33	15.043,04	20.142,19
Granada	13.395,29	20.221,64	14.920,28	21.238,81
Guadalajara	13.648,53	19.775,68	15.476,70	21.121,57
Guipuzkoa	13.353,52	18.331,78	14.877,27	19.335,78
Huelva	12.341,07	16.014,38	12.495,75	17.043,66
Huesca	13.890,11	20.723,45	16.146,24	22.488,94
Jaen	13.039,28	18.430,92	14.033,23	21.206,56
La Rioja	13.530,00	19.414,51	15.370,35	20.732,49
Leon	14.683,55	22.777,14	17.996,92	25.628,41
Lleida	13.421,13	20.323,08	15.108,98	21.483,91
Lugo	14.304,92	21.581,66	17.162,15	23.952,91

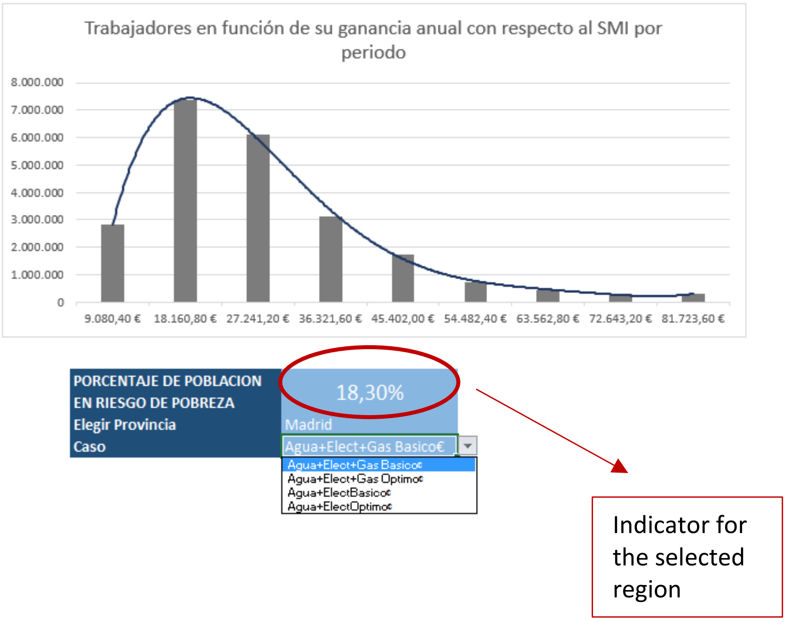

Figure 21. Structure of the 10% poverty indicator sheet

To change the region and evaluate the indicator in another one, the user just selects it in the drop-down box that will appear when clicking on the cell "Elegir Provincia".

5.2. Levels and Regions

The second section of the tools is related to the segmentation performed into levels and regions. The classification into energetic levels has the main objective to make groups with the regions of Spain distinguishing between climate zones. To explain this, it is important to know that the climate is quite different among the Spanish territory, and this means that the demand of heating power is not the same for a household located in Ourense than for a household located in Cordoba, for example. The buildings built in an area that faces cold winters will require a higher amount of energy than others located in warmer areas.

Because of this, and, as said before, to group regions with similar climate conditions, the energetic level classification was required. There exist 6 levels, depending also if the building is new (construction after 2006) or old (construction before 2006). This has to be done because the buildings have different characteristics concerning efficiency. The demand is higher in older buildings than in more recent households.

5.2.1. Nivel de provincia

The sheet called "Nivel de provincia" registers the demands of water (ACS), electricity and gas for the energetic levels. Also, the coefficients including the distribution of the new and old buildings, the type of building and the energy efficiency coefficients.

The levels in which the classification was made are:

- *Level 1*

  Regions with warm climate, according to Table 28, and new buildings. The hypothesis for this level was that, as the region requires less heating demand and the buildings are of recent construction, the final demand for the level would be the minor one.

The regions that belong to the level are:

Region
Alicante
Almeria
Cadiz
Castellon
Cordoba
Huelva
Malaga
Murcia
Sevilla
Tarragona
Valencia

Table 5. Regions that make up the first energy level

- *Level 2*

Level 2 corresponds with regions located in mixed climate conditions, with cold winter but hot summer months too. The buildings included here are also new, using the same hypothesis than for level 1.

Region
A Coruña
Albacete
Badajoz
Barcelona
Caceres
Cantabria
Ciudad Real
Granada
Guadalajara
Guipuzkoa
Jaen
Lleida
Madrid
Pontevedra
Toledo
Vizkaia
Zaragoza

Table 6. Regions that make up the second energy level

- *Level 3*

Level 3 includes cold regions, in accordance with Table 28. This segmentation is characterized by the regions of the Spain that face the worst weather conditions. Buildings of this area require a huge amount of heating power to maintain a basic comfortable living conditions.

The regions included are the following:

Region
Araba
Asturias
Avila
Burgos
Cuenca
Girona
Huesca
La Rioja
Leon
Lugo
Navarra
Ourense
Palencia
Salamanca
Segovia
Soria
Teruel
Valladolid
Zamora

Table 7. Regions that make up the third energy level

- *Level* 4

On the other hand, regions that belong to this classification are the same that for level 1, showed in Table 5.

However, there is a distinction between the type of building considered for this level. On the previous levels only recent building with lesser consumption were taken into account. Now, the fourth level classification collects the data of the buildings that were built before 2006, what means, buildings that require a higher demand of streams to maintain the same living conditions.

- *Level* 5

The segmentation criteria used for this level is the same than for the level just explained, level 4. The regions included here are the ones with mixed climate conditions, matching the ones showed before in Table 6.

- *Level* 6

  Levels used to classify old buildings in the worst conditions for basic demands, following the regions in Table 7.

In addition, the sheet appearance is shown in the next figure:

Nivel	Provincia	Certificado	Coeficiente nuevos	Coeficiente existentes	Coeficiente Unifamiliar	Coeficiente Bloques	Calefaccion ponderado	Coeficiente calefaccion	Refrigeracion ponderado	Coeficiente refrigeracion	ACS ponderado	Coeficiente ACS
Nivel 1 Nuevos, Calor	Alicante	ABCD	0,0725	0,9275	0,3015	0,6985	16,15	0,32	18,96	1,41	13,66	1,22
	Almeria	ABCD	0,1711	0,8289	0,3721	0,6279	14,15	0,22	22,30	1,41	13,77	1,22
	Cadiz	ABCD	0,0475	0,9525	0,4749	0,5251	12,89	0,22	17,83	1,14	14,39	1,22
	Castellon	ABCD	0,0944	0,9056	0,3028	0,6972	25,67	0,32	15,01	0,94	13,89	1,22
	Cordoba	ABCD	0,0484	0,9516	0,6259	0,3741	32,76	0,66	28,53	1,39	15,22	1,22
	Huelva	ABCD	0,0824	0,9176	0,5839	0,4161	17,80	0,22	23,03	0,22	14,87	1,22
	Malaga	ABCD	0,1024	0,8976	0,2538	0,7462	16,14	0,29	17,93	1,42	13,42	1,22
	Murcia	ABCD	0,1023	0,8977	0,3321	0,6679	24,18	0,33	14,49	1,08	14,03	1,22
	Sevilla	ABCD	0,0624	0,9376	0,5831	0,4169	23,19	0,41	29,23	1,40	14,87	1,22
	Tarragona	ABCD	0,0872	0,9128	0,4635	0,5365	28,38	0,37	20,06	1,40	14,53	1,22
	Valencia	ABCD	0,0636	0,9364	0,2562	0,7438	24,94	0,30	14,16	1,05	13,68	1,22
Nivel 2 Nuevos, Mixto	A Coruña	ABCD	0,0905	0,9095	0,1548	0,8452	32,57	0,57	0,00	0,00	13,74	1,22
	Albacete	ABCD	0,1145	0,8855	0,2326	0,7674	54,47	1,04	10,68	0,68	14,22	1,22
	Badajoz	ABCD	0,0823	0,9177	0,6284	0,3716	36,32	0,77	22,13	1,39	15,49	1,22
	Barcelona	ABCD	0,0473	0,9527	0,2668	0,7332	32,33	0,62	9,09	0,65	14,03	1,22
	Caceres	ABCD	0,1150	0,8850	0,5864	0,4136	41,66	0,76	24,16	1,40	15,40	1,22
	Cantabria	ABCD	0,1155	0,8845	0,2790	0,7210	38,11	0,63	0,00	0,00	14,34	1,22
	Ciudad Real	ABCD	0,1089	0,8911	0,3868	0,6132	53,28	1,12	15,40	0,94	14,86	1,22
	Granada	ABCD	0,0703	0,9297	0,4453	0,5547	45,64	0,70	14,82	1,13	14,99	1,22
	Guadalajara	ABCD	0,1477	0,8523	0,4286	0,5714	60,86	1,14	9,34	0,75	15,16	1,22
	Guipuzkoa	ABCD	0,0865	0,9135	0,0857	0,9143	49,00	0,96	0,00	0,00	13,61	1,22
	Jaen	ABCD	0,0814	0,9186	0,5050	0,4950	33,12	0,72	27,10	1,40	14,52	1,22

Figure 22. Structure of the sheet containing the classification into levels

The data contained in the sheet reflects the provinces included in each level and the characteristics of the buildings, with the different coefficients applied to them to calculate the final consumptions.

The column that is referred to the certificate of the building was designed following the hypothesis in which the recent households have a better energetic certificate, corresponding with letters ABCD. The Real Decreto 235/2007 [19] describes all the details of the certification that the buildings have to fulfill to be approved by this law.

The coefficients of this sheet have to be carefully explained, as there are weights considered for the calculations, plus denormalization coefficients to calculate the final demand per level. Thus, the coefficients are explained next:

$$C_{new\ buildings} = \frac{New\ buildings\ (after\ 2006)}{Total\ number\ of\ buildings}$$

(X)

$$C_{old\ buildings} = \frac{Old\ buildings\ (before\ 2006)}{Total\ number\ of\ buildings}$$

(XI)

$$C_{detached\ house} = \frac{Detached\ households}{Total\ number\ of\ households}$$

(XII)

$$C_{block} = \frac{Blocks\ of\ flats}{Total\ number\ of\ households}$$

(XIII)

$$Demand_{resource\ weighted} = C_{detached} \cdot Demand_{detached} + Demand_{block} \cdot C_{block}$$

(XIV)

$$C_{resource\ denormalized} = C_{detached} \cdot C_{denormalized,detached} + C_{block} \cdot C_{denormalized,block}$$

(XV)

$$C_{denormalized,old} = \frac{IO}{IS}$$

(XVI)

$$C_{denormalized,new} = \frac{IR}{IS}$$

(XVII)

Many coefficients used at this point of the tool appear and are declared in other sheets of the document. However, and to pursue the easy understanding for the user, all of them are related and a single change in one sheet will update the rest of them, synchronizing the excel book and avoiding looking for other factors to update too.

Finally, the sheet shows the values of the energy streams that will be used for the Inputs & Outputs section.

5.2.2. Provincias

The sheet with the name of "Provincias" has the same objective as the sheet just explained above. The difference here is that there is no segmentation through energetic levels. Therefore, the data is just exposed distinguishing by the region, not by groups.

Coefficients shown correspond with the household type in order to get the final demands of the streams and then achieve conclusion with the sheets conforming the first section, Inputs & Outputs.

The rows of the tool in here are related to the building construction type, as the Figure 23 exhibits:

Provincia	Tipo	Certificado	Coeficiente nuevos	Coeficiente existentes	Coeficiente Unifamiliar	Coeficiente Bloques	Calefaccion ponderado	Coeficiente calefaccion	Refrigeracion ponderado	Coeficiente refrigeracion	ACS ponderado	Coeficiente ACS
Alicante	Nuevo	ABCD	0,0725	0,9275	0,3015	0,6985	16,15	0,32	18,96	1,41	13,66	1,22
Alicante	Existente	EFG	0,0725	0,9275	0,3197	0,6803	58,06	0,73	33,08	1,23	13,74	1,00
Almeria	Nuevo	ABCD	0,1711	0,8289	0,3721	0,6279	14,15	0,22	22,30	1,41	13,77	1,22
Almeria	Existente	EFG	0,1711	0,8289	0,5283	0,4717	40,83	0,61	40,62	1,23	14,48	1,00
Cadiz	Nuevo	ABCD	0,0475	0,9525	0,4749	0,5251	12,89	0,22	17,83	1,14	14,39	1,22
Cadiz	Existente	EFG	0,0475	0,9525	0,4898	0,5102	42,03	0,63	30,79	1,11	14,45	1,00
Castellon	Nuevo	ABCD	0,0944	0,9056	0,3028	0,6972	25,67	0,32	15,01	0,94	13,89	1,22
Castellon	Existente	EFG	0,0944	0,9056	0,3050	0,6950	72,47	0,73	26,03	1,07	13,90	1,00
Cordoba	Nuevo	ABCD	0,0484	0,9516	0,6259	0,3741	32,76	0,66	28,53	1,39	15,22	1,22
Cordoba	Existente	EFG	0,0484	0,9516	0,5232	0,4768	71,84	0,67	47,30	1,23	14,75	1,00
Huelva	Nuevo	ABCD	0,0824	0,9176	0,5839	0,4161	17,80	0,22	23,03	0,22	14,87	1,22
Huelva	Existente	EFG	0,0824	0,9176	0,5683	0,4317	58,57	0,60	39,25	1,13	14,80	1,00
Malaga	Nuevo	ABCD	0,1024	0,8976	0,2538	0,7462	16,14	0,29	17,93	1,42	13,42	1,22
Malaga	Existente	EFG	0,1024	0,8976	0,3532	0,6468	44,65	0,68	32,29	1,23	13,85	1,00
Murcia	Nuevo	ABCD	0,1023	0,8977	0,3321	0,6679	24,18	0,33	14,49	1,08	14,03	1,22
Murcia	Existente	EFG	0,1023	0,8977	0,5037	0,4963	72,65	0,68	26,68	1,12	14,82	1,00
Sevilla	Nuevo	ABCD	0,0624	0,9376	0,5831	0,4169	23,19	0,41	29,23	1,40	14,87	1,22
Sevilla	Existente	EFG	0,0624	0,9376	0,4748	0,5252	58,36	0,69	48,42	1,23	14,39	1,00
Tarragona	Nuevo	ABCD	0,0872	0,9128	0,4635	0,5365	28,38	0,37	20,06	1,40	14,53	1,22
Tarragona	Existente	EFG	0,0872	0,9128	0,3460	0,6540	69,55	0,72	33,09	1,23	13,99	1,00
Valencia	Nuevo	ABCD	0,0636	0,9364	0,2562	0,7438	24,94	0,30	14,16	1,05	13,68	1,22
Valencia	Existente	EFG	0,0636	0,9364	0,2606	0,7394	68,30	0,75	24,70	1,06	13,70	1,00
A Coruña	Nuevo	ABCD	0,0905	0,9095	0,1548	0,8452	32,57	0,57	0,00	0,00	13,74	1,22
A Coruña	Existente	EFG	0,0905	0,9095	0,4424	0,5576	103,76	1,00	0,00	0,00	15,12	1,04

Figure 23. Structure of the sheet organizing streams and coefficients through regions

Although the coefficients calculations will be explained in other chapters, it has been already described some of them used in the precious sheet. Those are exactly the same used for this sheet, so there is no need to explain them again. Furthermore, they can be seen in the formulas explained before. The new formula used to obtain the final demand per provinces is:

$$\begin{aligned} Resource\ demand &= C_{new\ buildings} \cdot C_{denormalized,new} \cdot Demand_{resource\ weighted\ new} \\ &+ C_{old\ buildings} \cdot C_{denormalized,old} \cdot Demand_{resource\ weighted\ old} \end{aligned}$$

(XVIII)

With this, the minimum consumptions for the three streams are achieved and can be exported to the consumptions section.

5.2.3. Nivel 1, 2, 3, 4, 5 and 6

These sheets divide the consumptions of the three streams for the levels explained before. At this point, where the segmentation is already performed and the coefficients declared and known, the sheet differentiates between the basic consumption case and the optimal. The consumptions consist in:

- *Electricity Basic case*

  Includes the consumptions for:

  $$Washing\ machine + TV + Illumination + Refrigerator$$

  (XIX)

  Taking into account the efficiency, supposed equal to 99%

- *Electricity Optimal case*

  Includes the consumptions for:

  $$Basic\ case + Computer + Air\ conditioning$$

  (XX)

  For the optimal case, all the amenities for the basic case are included but also the use of a computer and the air conditioning consumption, which will depend on the energetic level and the region in which the household is located due to climate.

- *Gas Basic case*

  The consumptions are:

  $$Heating + ACS + Cooking$$

  (XXI)

  In the case of gas, the efficiency considered is 97%

- *Gas Optimal case*

  In addition to the basic case, the optimal is equal to equation XXI:

$$Heating + ACS + Cooking$$

  Although it seems to be the same that the basic case, the optimal case is considering heating for the entire household, not only the living room. For the hot water (ACS) is the same, in this situation it is considered that the demand is greater as the effective surface of the household (m^2) is greater.

- *Water consumption*

  Although it will be explained in the sheet dedicated exclusively to water consumption, it includes the liters (L) used for shower, washing machines, toilet and to wash the dishes.

Finally, the aspect of the sheet is:

Nivel 1
Anual

Miembros	Agua L	Electricidad Basico kWh	Electricidad Optimo kWh	Gas Basico kWh	Gas Optimo kWh
1	39.055,00	750,59	1.800,39	650,14	1.062,75
2	78.110,00	829,45	1.951,53	677,02	1.166,99
3	117.165,00	963,59	2.233,77	703,90	1.322,80
4	156.220,00	1042,45	2.384,91	730,78	1.427,05
5	195.275,00	1138,38	2.577,21	757,65	1.557,07

Table 8. Consumptions of the three streams shown in the sheets "Nivel"

5.3. Coefficients and Population

The Coefficients and Population section has no more than two sheets. However, these sheets have crucial meaning for the rest of the excel file and the study itself.

The first sheet, which will be described below with more detail, gets together all the coefficients used for the segmentation criteria and they are all related with energy efficiency in buildings. Also, they follow the normative stipulated by the Spanish government of the Real Decreto 235/2013, in accordance with the EU Directive 2010/31.

Second, the sheet named "Poblacion" defines the surface of the household that will be applied for the basic or optimal case, and then collects the data from all the peninsular regions concerning distribution of habitants per household. For example, with the data of this sheet it is known what percentage of the households in Murcia have three habitants.

5.3.1. Coeficientes

As it has just been said before, the calculation of the coefficients used in this sheet, which are related to energy efficiency in buildings, follow the Real Decreto 235/2013.

The calculations are different depending on if the building analyzed is new, old or even if it is a detached house or a block of flats. The coefficients change too if the consumption taken into account is heating, air conditioning or hot water (ACS).

Because of this, it was needed to build a table in the sheet which gathered all of the factors that looked like the figure succeeding:

Provincia	Zona	Stream	Existentes											
			Unifamiliares						Bloques					
			I0/IR	I0/IS	C1	C2	R	R'	I0/IR	I0/IS	C1	C2	R	R'
A Coruña	C1	Calefaccion	0,27	1,00	0,00	1,00	1,50	1,20	0,27	1,00	0,00	1,00	1,50	1,10
A Coruña	C1	Refrigeracion	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
A Coruña	C1	ACS	0,63	1,09	0,00	1,50	1,20	1,10	0,63	1,00	0,00	1,00	1,20	1,10
Albacete	D3	Calefaccion	0,27	1,00	0,00	1,00	1,50	1,20	0,27	1,00	0,00	1,00	1,50	1,10
Albacete	D3	Refrigeracion	1,37	0,54	1,75	0,00	1,40	1,30	1,37	0,54	1,75	0,00	1,40	1,30
Albacete	D3	ACS	0,63	1,09	0,00	1,50	1,20	1,10	0,63	1,00	0,00	1,00	1,20	1,10
Alicante	B4	Calefaccion	1,43	0,54	1,75	0,00	1,50	1,30	0,93	0,82	1,00	0,00	1,50	1,10
Alicante	B4	Refrigeracion	0,37	1,23	0,00	1,50	1,40	1,30	0,37	1,23	0,00	1,50	1,40	1,30
Alicante	B4	ACS	0,63	1,00	0,00	1,00	1,20	1,10	0,63	1,00	0,00	1,00	1,20	1,10
Almeria	A4	Calefaccion	0,93	0,43	1,00	0,00	1,50	1,40	0,60	0,82	0,50	0,00	1,50	1,10
Almeria	A4	Refrigeracion	0,37	1,23	0,00	1,50	1,40	1,30	0,37	1,23	0,00	1,50	1,40	1,30
Almeria	A4	ACS	0,63	1,00	0,00	1,00	1,20	1,10	0,63	1,00	0,00	1,00	1,20	1,10
Araba	D1	Calefaccion	0,27	1,17	0,00	1,50	1,50	1,20	0,27	1,09	0,00	1,50	1,50	1,10
Araba	D1	Refrigeracion	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Araba	D1	ACS	0,63	1,09	0,00	1,50	1,20	1,10	0,63	1,00	0,00	1,00	1,20	1,10
Asturias	D1	Calefaccion	0,27	1,17	0,00	1,50	1,50	1,20	0,27	1,00	0,00	1,00	1,50	1,10
Asturias	D1	Refrigeracion	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Asturias	D1	ACS	0,63	1,09	0,00	1,50	1,20	1,10	0,63	1,00	0,00	1,00	1,20	1,10
Avila	E1	Calefaccion	0,27	1,17	0,00	1,50	1,50	1,20	0,27	1,09	0,00	1,50	1,50	1,10
Avila	E1	Refrigeracion	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Figure 24. Energetic coefficients for the households analyzed

As it can be seen in Figure 24, for each type of household there exist six different coefficients, always regarding at efficiency and according to the normative. They are explained next:

- *I0/IR*

  Also called *Índice de Eficiencia Energética*, along with I0/IS, is a coefficient that denormalizes the demand and allows achieving the final number for the household consumption. It is only applied if the building is new (after 2006). It is calculated as:

$$I0/IR = \frac{1 + (C_1 - 0{,}6) \cdot 2 \cdot (R - 1)}{R}$$

(XXII)

- *I0/IS*

  The concept for this one is the same than for the previous one, the difference lies in the fact that it is used for old buildings (before 2006) instead of new ones. It is calculated as follows:

$$I0/IS = \frac{1 + (C_2 - 0{,}5) \cdot 2 \cdot (R' - 1)}{R'}$$

(XXIII)

- *C_1, C_2, R, R'*

  Standard coefficients extracted from data available in the documents mentioned by IDAE. C_1 and C_2 are related with indexes of energy rating of the building and R, R' are ratios used to get the values of I0/IS and I0/IR.

The coefficients were calculated with the help of the data collected in the documents about the description of new and old buildings elaborated by the Intituto para la Diversificación y Ahorro de la Energía (IDAE). The documents [20] [21], were decisive for the design of the sheet described in this chapter.

Moreover, the sheet includes the efficiency of the streams of electricity and gas and, although they were already mentioned, they can be appreciated in the table:

	Gas	Electricidad
Eficiencia	0,97	0,99
Perdidas	1,03	1,01

Table 9. Efficiency of gas and electricity streams

5.3.2. Poblacion

What is important about "Poblacion" is that it gathers the values that distinguish between the basic case and the optimal case for future consumptions calculations. The basic case only considers a space of 20 m^2, not depending on how many people actually lives in the household. Thus, there are only 20 m^2 that need the energy streams studied. On the other hand, for the optimal case, it is included the variable space of the household depending directly to the number of habitants it has. Therefore, the values can be seen:

	Miembros				
	1	2	3	4	5
Casa m² - Optimo	36	39	44	47	51
Salon m² - Basico	20	20	20	20	20

Table 10. Values of the space applied to the household

In addition to the space needed for both of the cases elaborated in the project, the sheet still adds value to the calculations by collecting the distribution of population for all the Spanish regions object of the study. The appearance will be shown after the paragraph but it has to be said that the data of the sheet is linked to the distribution of the population organized in the sheet called "PoblacionViviendas", which belongs to the section of Database. So, although the addition of the table might be redundant, the author considered that it could help getting the data if you would like to modify something in a way much easier.

	Miembros				
Provincia	1	2	3	4	5
A Coruña	25,3%	22,3%	16,4%	11,7%	1,5%
Albacete	23,6%	21,2%	15,7%	18,9%	3,0%
Alicante	25,7%	22,8%	15,3%	14,7%	2,6%
Almeria	21,5%	19,9%	16,5%	18,2%	4,4%
Araba	30,8%	24,8%	14,6%	12,8%	1,9%
Asturias	29,6%	23,4%	16,2%	9,5%	1,3%
Avila	28,8%	24,6%	15,2%	15,4%	2,5%
Badajoz	24,2%	20,3%	16,3%	18,8%	3,5%
Barcelona	24,9%	21,7%	15,1%	14,5%	3,0%
Burgos	29,7%	22,0%	15,4%	14,4%	2,2%
Caceres	27,5%	24,0%	15,4%	15,2%	2,6%
Cadiz	21,0%	17,2%	18,2%	20,0%	3,8%
Cantabria	27,4%	20,0%	16,1%	13,0%	2,1%
Castellon	25,4%	22,2%	17,5%	14,8%	2,5%

Figure 25. Percentage of distribution of population among the regions

5.4. Consumptions

It was mandatory to include a section in the tool dedicated to the definition and declaration of the different consumptions of the resources (such as water, heating, TV...) to achieve the final demand of the streams looked for. They are strongly related with the sheets of the section "Database", as many values are taken from that part of the project. However, the sheets here include the segmentation by level and region when applied, and some of them have a distinct methodology to reach the desired values.

An extra difference between the basic scenario and the optimal scenario is also incorporated. The basic scenario does not count with computer and air conditioning in the household, whereas the optimal does. Therefore, the consumptions for both of them can be found in the section.

The sheets are described next with more detail, also with the method of calculation.

5.4.1. Agua

"Agua" has the main objective to determine the consumptions of water for a household. The hypothesis adopted for the consumption of water is that the households have all the same minimum demand of the resource, not depending by the location or climate zone but only depending on the number of habitants that it has, which will increase the consumption as more people will use the bathroom, take showers and so on.

Moreover, four types of forms of water consumption were identified in the study, which are: washing machine, shower, toilet and washing the dishes. The numbers have already dealt with a small waste of water, as it is comprehensible that when washing the dishes for example the efficiency will never be 100% because of the amount of water that is wasted in the process.

Therefore, the final quantity of water needed in a household and the annual consumption can be seen in the following tables:

	Lavadora	Ducha	Cisterna	Lavar platos
Consumo L	40	50	6	23
Agua Caliente L	0	25	0	0
Frecuencia	0,25	1	4	1

Table 11. Liters of water needed in a household depending on type of use

Anual

Miembros	Consumo
1	39.055
2	78.110
3	117.165
4	156.220
5	195.275

Table 12. Annual consumption of water in a household

The annual rates for the water needs are estimated as:

$$Annual\ water\ need = (washing\ machine \cdot frequency_{daily} + shower \cdot frequency_{daily} + toilet \cdot frecuency_{daily} + dishes \cdot frequency_{daily}) \cdot 365\ {}^{days}/_{year}$$

(XXIV)

5.4.2. ACS

This sheet, "ACS", has its name received because of the acronym in Spanish for domestic hot water (DHW). It collects the demands of the domestic hot water for the two levels of segmentation mentioned in many cases in the document, energetic levels and per regions. It divides the consumptions between the basic case, with less square meters per household, and the optimal case, where those square meters are increased depending on the number of people living in the household.

The consumptions for ACS are gathered in energy units (kWh), as in the section "Database", although it is explained in other different section, shows the demands in kWh/m². Thus, by multiplying the m², depending on the case analyzed, the final kWh will be achieved.

Finally, the rates per level and region can be appreciated in the next table and figure, which sum up the look of the sheet:

Miembros	m^2	kWh					
		Nivel 1	Nivel 2	Nivel 3	Nivel 4	Nivel 5	Nivel 6
1	36	622,44	633,85	666,20	513,43	536,19	569,62
2	39	674,31	686,67	721,72	556,21	580,87	617,09
3	44	760,76	774,70	814,25	627,52	655,34	696,21
4	47	812,62	827,52	869,76	670,31	700,02	743,67
5	51	881,78	897,95	943,78	727,35	759,60	806,97

Table 13. Optimal case for the annual rate consumption of ACS per level

Provincia	kWh									
	1 Miembro - Basica	1 Miembro - Optima	2 Miembros - Basica	2 Miembros - Optima	3 Miembros - Basica	3 Miembros - Optima	4 Miembros - Basica	4 Miembros - Optima	5 Miembros - Basica	5 Miembro - Optima
A Coruña	316,43	569,57	316,43	617,04	316,43	696,14	316,43	743,61	316,43	806,89
Albacete	277,98	500,37	277,98	542,07	277,98	611,57	277,98	653,26	277,98	708,86
Alicante	278,95	502,11	278,95	543,95	278,95	613,68	278,95	655,53	278,95	711,32
Almeria	297,35	535,24	297,35	579,84	297,35	654,18	297,35	698,78	297,35	758,25
Araba	295,89	532,59	295,89	576,98	295,89	650,95	295,89	695,33	295,89	754,51
Asturias	292,95	527,31	292,95	571,25	292,95	644,49	292,95	688,43	292,95	747,02
Avila	330,33	594,59	330,33	644,13	330,33	726,72	330,33	776,26	330,33	842,33
Badajoz	305,74	550,34	305,74	596,20	305,74	672,64	305,74	718,50	305,74	779,65
Barcelona	276,23	497,22	276,23	538,65	276,23	607,71	276,23	649,14	276,23	704,39
Burgos	311,86	561,35	311,86	608,13	311,86	686,09	311,86	732,87	311,86	795,24
Caceres	312,24	562,04	312,24	608,87	312,24	686,93	312,24	733,77	312,24	796,22
Cadiz	292,00	525,60	292,00	569,40	292,00	642,40	292,00	686,19	292,00	744,59
Cantabria	306,63	551,93	306,63	597,92	306,63	674,58	306,63	720,57	306,63	781,90
Castellon	283,72	510,70	283,72	553,25	283,72	624,18	283,72	666,74	283,72	723,48

Figure 26. Rates of ACS consumption per region

It has to be stated that the rate calculation is the following, taking into account the different efficiency coefficients already explained on previous equations:

$$ACS = m^2 \cdot ACS\ demand \cdot C_{denormalized}$$

(XXV)

5.4.3. Calefaccion

It is referred to the heating consumption of the households and the structure of the sheet is pretty similar to the one found in the prior sheet explained, "ACS".

Furthermore, procedures to obtain the final annual consumption is also quite the same than the previous. Data is imported from the "Database" section concerning buildings and then it is weighted and denormalized with the help of coefficients. It does not add value to attach an image of the sheet, as is the same as in Figure 26, or a table with the consumptions. On the other hand, what is really valuable is to clarify how the rates are obtained:

$$Heating = m^2 \cdot Heating\ demand \cdot C_{denormalized}$$

(XXVI)

5.4.4. Cocina

Regarding at the energy the household need for cooking facilities, the sheet called "Cocina" is built. The segmentation used in here was the same than for previous work, and no other than making the classification depending on the people living in the household. Once the organization is made it is only needed to determine the consumptions per use and the frequency of uses the kitchen will have along an entire day.

The values are:

	Miembros				
	1	2	3	4	5
Frecuencia por semana	5	6	7	8	9
Energia consumida por uso	0,5	0,5	0,5	0,5	0,5
kWh	0,3571	0,4286	0,5000	0,5714	0,6429

Table 14. Consumption rates for cooking

Anual

Miembros	kWh
1	130,36
2	156,43
3	182,50
4	208,57
5	234,64

Table 15. Annual consumption for cooking needs

Then, the annual rates are:

$$Cooking = energy\ per\ use \cdot frequency_{daily} \cdot 365\ {}^{days}/_{year}$$

(XXVII)

5.4.5. Lavadora

This sheet is destined to obtain the consumptions of the usage of a washing machine. It has already been stated the water consumption of the electrical appliance but not its electric supply need.

Therefore, the final calculation of the energy is:

$$Washing\ machine = energy\ per\ use \cdot frequency_{daily} \cdot 365\ {}^{days}/_{year}$$

(XXVIII)

Being the values used and the final rates the following:

	Miembros				
	1	2	3	4	5
Cargas al dia	0,25	0,50	0,75	1,00	1,25
Energia consumida por carga	0,3	0,3	0,3	0,3	0,3
kWh	0,0750	0,1500	0,2250	0,3000	0,3750

Table 16. Consumption rates for the washing machine

Miembros	kWh
1	27,38
2	54,75
3	82,13
4	109,50
5	136,88

Table 17. Annual consumption rates for the washing machine

5.4.6. Television

Sheet very similar to the previous ones, with the objective to calculate the energy need for a television, a basic good for a household considered in the study.

The difference with other sheets, and at the same time the similarity with the sheet that sums up the consumption of the computer, lies in the detail that a TV is also consuming electrical energy when is turned off. This effect is called stand by power and, besides it is a minor power, it could make a huge impact in households in the situation of poverty, as the electrical bill would be higher. It could appear insignificant but, as just said, to fulfill the objectives of the study, it should not be forgiven.

The stand by power was fixed in 2,7 watts and the data used for the elaboration of the sheet is introduced next:

	Miembros				
	1	2	3	4	5
Horas	4	4	5	5	5
Potencia kW	0,06	0,06	0,06	0,06	0,06
Potencia de stand by kW	0,0027	0,0027	0,0027	0,0027	0,0027
kWh	0,29	0,29	0,35	0,35	0,35

Table 18. Consumption rates for the TV

Miembros	kWh
1	107,31
2	107,31
3	128,22
4	128,22
5	128,22

Table 19. Annual consumption rates for the TV

In addition, the equation followed to achieve these results is:

$$TV = (hours\ of\ use \cdot power_{ON} + (24 - hours\ of\ use) \cdot power_{STAND\ BY}) \cdot 365\ {}^{days}/_{year}$$

(XXIX)

5.4.7. Iluminacion

Another factor to consider when approaching the electrical needs is the illumination of the house. The detail of this part of the analysis is not focused on the type of light bulbs that it uses, low efficiency bulbs or high efficiency (LED). It would be interesting the addition of the concept for future studies, but it is out of scope in this particular case. Hence, the approximation used is based on the average consumption, in the field of illumination of course, for a household in Spain, what is 38 kWh per year. As it is known the surface to illuminate and the average population distribution in Spain (from the section "Database") to get the results is not a huge deal at this point. So, the formula used to calculate the final value in kWh is:

$$Illumination_{n\ habitants} = \frac{\left(\frac{\%\ population_n \cdot \%\ consumption_n}{\sum_{n=1}^{5} \%\ population_n \cdot \%\ consumption_n}\right) \cdot 38\ kWh}{\%\ population_n}$$

(XXX)

The rates obtained are:

	Miembros				
	1	2	3	4	5
m^2	36	39	44	47	51
Distribucion de poblacion	31,37%	26,36%	19,55%	18,93%	3,80%
Distribucion de consumo	16,59%	17,97%	20,28%	21,66%	23,50%
	0,0520	0,0474	0,0396	0,0410	0,0089
kWh	10,4655	9,5262	7,9711	8,2435	1,7937

Table 20. Consumption rates for illumination

Miembros	kWh
1	33,36
2	36,14
3	40,77
4	43,55
5	47,26

Table 21. Annual consumption rates for illumination

5.4.8. Refrigerador

An incorporation of a refrigerator for the study is elementary, as it has to be found in every household to maintain the standards of a minimum living condition in a developed country like Spain and during the era we are living in. Because they are not the same the energy rates for a fridge if it is freezing food and drinks for a single person than for multiple people, the method applied to estimate the mentioned rates is the one used before for illumination. Given the distribution of population and then the distribution of the consumption, with the help of the known average value for a typical refrigerator (655 kWh per year), we are capable of obtaining the year consumption rates.

$$Refrigerator_{n\ habitants} = \frac{\left(\frac{\%\ population_n \cdot \%\ consumption_n}{\sum_{n=1}^{5} \%\ population_n \cdot \%\ consumption_n}\right) \cdot 655\ kWh}{\%\ population_n}$$

(XXXI)

Then, the values are:

	Miembros				
	1	2	3	4	5
m^2	36	39	44	47	51
Distribucion de poblacion	31,37%	26,36%	19,55%	18,93%	3,80%
Distribucion de consumo	16,59%	17,97%	20,28%	21,66%	23,50%
	0,0520	0,0474	0,0396	0,0410	0,0089
kWh	180,3927	164,2014	137,3962	142,0920	30,9178

Table 22. Consumption rates for the refrigerator

Miembros	kWh
1	575,04
2	622,96
3	702,83
4	750,75
5	814,64

Table 23. Annual consumption rates for the refrigerator

5.4.9. Computer

The computer is considered a non-basic item for keeping the comfortable living conditions in Spain. Is because of this that the consumption is only included for the optimal cases of electricity.

As it happened with the case of the television, the computer requires electricity when it is off too. Thus, the calculation applied in the case is almost the same used as for television, but it is required to know the power of the apparatus at full performance, when it is in stand by mode and the hours that it will be used. The power was estimated to be 80 watts, whereas the stand by mode was estimated in 5 watts. With a usage of 5 hours per day, the final results appear in the succeeding tables:

	Miembros				
	1	2	3	4	5
Horas	5	5	6	6	6
Potencia kW	0,08	0,08	0,08	0,08	0,08
Potencia de stand by kW	0,005	0,005	0,005	0,005	0,005
kWh	0,50	0,50	0,57	0,57	0,57

Table 24. Consumption rates for the computer

Miembros	kWh
1	180,68
2	180,68
3	208,05
4	208,05
5	208,05

Table 25. Annual consumption rates for the computer

As in the case of TV, the formula used is similar to its respective equation:

$$Computer = (hours\ of\ use \cdot power_{ON} + (24 - hours\ of\ use) \cdot power_{STAND\ BY}) \cdot 365\ {}^{days}/_{year}$$

(XXXII)

5.4.10. Refrigeracion

Refrigeracion, sheet named in reference to the air conditioning systems, is a point of vital importance for the final difference between regions. Though it is discussed in the section of results, the refrigeration demand for the households increases significantly the price per year that such a household pays at the end. The discrimination criteria follows the climate characteristics of the Spanish territory, this means that the household that will pay the most in electricity terms are the ones located in warm areas with air conditioning systems. However, this is only applied when regarding at the optimal case, because another hypothesis adopted for this part is that the air conditioning system is not essential for a house that might be in danger of energy poverty, as happens with the computer.

Calculations are performed at both of the levels considered in the study, and also for the basic case and optimal case. Moreover, the coefficients of the buildings and the weights of themselves have to be noticed. However, as just explained, the optimal case was only included. For this, refrigeration is dissimilar from heating, a basic need.

$$Refrigeration = m^2 \cdot Refrigeration\ demand \cdot C_{denormalized}$$

(XXXIII)

And the data obtained are:

Miembros	m^2	kWh					
		Nivel 1	Nivel 2	Nivel 3	Nivel 4	Nivel 5	Nivel 6
1	36	858,63	478,50	55,46	1477,51	723,47	115,32
2	39	930,18	518,38	60,08	1600,63	783,76	124,93
3	44	1049,43	584,84	67,78	1805,84	884,24	140,94
4	47	1120,99	624,71	72,40	1928,97	944,53	150,55
5	51	1216,39	677,88	78,57	2093,14	1024,92	163,37

Table 26. Optimal case for the annual rate consumption of Refrigeration per level

Provincia	kWh									
	1 Miembro - Basica	1 Miembro - Optima	2 Miembros - Basica	2 Miembros - Optima	3 Miembros - Basica	3 Miembros - Optima	4 Miembros - Basica	4 Miembros - Optima	5 Miembros - Basica	5 Miembro - Optima
A Coruña	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Albacete	182,21	327,98	182,21	355,31	182,21	400,86	182,21	428,20	182,21	464,64
Alicante	794,06	1429,32	794,06	1548,42	794,06	1746,94	794,06	1866,05	794,06	2024,86
Almeria	936,43	1685,58	936,43	1826,04	936,43	2060,15	936,43	2200,61	936,43	2387,90
Araba	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Asturias	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Avila	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Badajoz	874,88	1574,78	874,88	1706,01	874,88	1924,73	874,88	2055,96	874,88	2230,94
Barcelona	168,11	302,59	168,11	327,81	168,11	369,83	168,11	395,05	168,11	428,67
Burgos	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Caceres	966,48	1739,67	966,48	1884,64	966,48	2126,26	966,48	2271,23	966,48	2464,53

Figure 27. Rates of Refrigeration consumption per region

It can be seen, in Figure 27, that there exists region such as A Coruña or Araba whose demand of refrigeration is 0, due to climate characteristics. The fact influences directly the final prices for the region, as the author explained in the paragraph above, so there will be regions that will pay many more euros per year if the optimal case is the solution adopted to analyze the problem of poverty.

5.5. Database

The purpose in having a section called "Database" contained in the excel book is to put together all the data collected from articles, books or reports that influenced the calculations described.

A positive aspect of the tool and the section in particular is that even a small change in the data would mean the update of all the other related sheets, so it is quite easy to achieve different results by changing the data.

It includes values related to prices of water per region, classification into the energetic levels, organization of regions throughout climate conditions, or even de demand of water, heating and air conditioning by the buildings also depending on the region.

Finally, as the bulk majority of the sheets only contain data, they will be briefly explained, but if there is some point important for the further development of the tool, will be explained with detail.

5.5.1. PreciosAgua

The first page of the last section of the tool regards the prizes of the water for the different regions of Spain. In the case of water, the stream does not have a special tariff that is applied for vulnerable consumers (as there is not defined yet in terms of who is vulnerable concerning water consumption) as happens in the case of electricity, or a standard tariff applied to everyone like for gas. Therefore, water must be treated differently and the prize has to be differentiated among the regions. It will also help later the analysis of the sensibility. With this the author means that analyzing the impact of the change in prizes of the water will be very simple and the final amount that a person living in Valencia would pay for minimum water demand, for example, will be easy to compare with the amount that a person living in any other place would pay. Additionally, in the project the prize per region is approximated by the prize of the major city in the region. This is done because if not, there would be a vast quantity of prizes, and calculating the mean of all the values would be an inefficient approximation.

It was also necessary to calculate the prize of water to apply to the energetic levels, which was estimated as the mean of the regions conforming the desired level. Hence, the prizes obtained for those levels are:

Nivel	Precio
1	2,16
2	1,65
3	1,34
4	2,16
5	1,65
6	1,34

Table 27. Prizes of water in €/m3 applied to the energetic levels

In addition, the figure below shows how the sheet looks for the regions:

Provincia	Suministro (€/m3)	Saneamiento (€/m3)	Total (€/m3)
Murcia	2,0	0,9	2,9
Barcelona	1,9	1,0	2,9
Alicante	1,6	1,0	2,6
Cadiz	1,0	1,5	2,5
Huelva	1,2	1,2	2,4
Tarragona	1,3	1,0	2,3
Sevilla	1,1	1,2	2,3
Lleida	1,2	1,0	2,2
Valencia	1,2	1,0	2,2
Granada	1,1	0,8	1,9

Figure 28. Appearance of water prizes included in the sheet, divided in prize per supply and sanitation

It can be seen that the final prize is the sum of two terms: first the prize per supply and second the prize per sanitation. The complete table that appears in the excel document is ordered in descending order from highest to lowest final prize.

5.5.2. DistribucionSalarios

In order to elaborate the sheet containing the results for the 10% indicator concerning poverty, it was required to get data related to the distribution of salaries among the Spanish population. Thus, the INE was consulted [14]. The objective of building a sheet containing the distribution of salaries is to know what percentage of population is below a certain salary. With this, once know what is the final annual prize that a household would pay for basic and optimal conditions, in contrast with the distribution of salaries, the indicator is obtained. The values were achieved from the SMI, or Standard Minimum Income, which in Spain for the data of 2015 was equal to 9.080,40 €. Two additional values to know the distribution of population that have to be clear are the active men and women in terms of employment. By knowing these, it is relatively easy to build a table with the final quantity of people that is receiving a salary below a certain amount. The look of the sheet is shown below:

Trabajadores en función de su ganancia anual con respecto al SMI por periodo
Unidades: Porcentaje

	Hombres		Mujeres		Total	€/año
	%	trabajadores	%	trabajadores	2015	2015
De 0 a 1 SMI	7,4%	914.292	18,2%	1.919.044	2.833.337	9.080,40 €
De 1 a 2 SMI	28,1%	3.471.839	36,9%	3.890.810	7.362.649	18.160,80 €
De 2 a 3 SMI	30,1%	3.718.945	22,8%	2.404.078	6.123.023	27.241,20 €
De 3 a 4 SMI	15,3%	1.890.361	11,5%	1.212.583	3.102.944	36.321,60 €
De 4 a 5 SMI	9,3%	1.149.043	5,7%	601.019	1.750.062	45.402,00 €
De 5 a 6 SMI	4,0%	494.212	2,2%	231.972	726.184	54.482,40 €
De 6 a 7 SMI	2,3%	284.172	1,3%	137.075	421.247	63.562,80 €
De 7 a 8 SMI	1,6%	197.685	0,8%	84.354	282.038	72.643,20 €
Más de 8 SMI	1,8%	222.395	0,7%	73.809	296.205	81.723,60 €

Cantidad hombres asalariados	12.355.300
Cantidad mujeres asalariadas	10.544.200
TOTAL	22.899.500
SMI	9.080,40 €

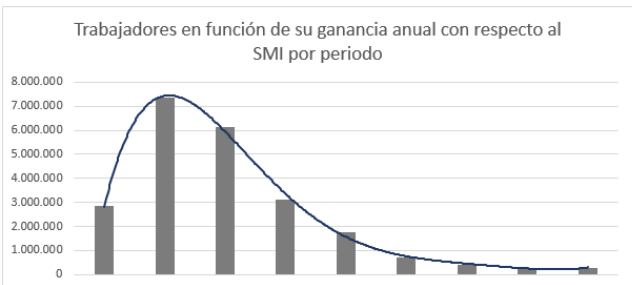

Figure 29. Distribution of salaries and data used to build the sheet

Figure 29 is formed by two tables and a graph. The table on the left contains the numbers related to salaries in Spain and the distribution of population for those salaries. Then, the table on the right of the figure includes the figures of the people who is working at the moment in the country and the Standard Minimum Income, which has been explained and it is fixed by the government every year. Lastly, the graph illustrates the table so a better view of the distribution is got.

5.5.3. DemandaNuevoUnifamiliar

In the sheet the values of consumptions for ACS (Domestic Hot Water), heating and refrigeration can be found for new households which are detached houses. The segmentation is throughout regions among the Spanish peninsula and the values are extracted from the report by IDAE [20].

The way the sheet looks in the excel tool is appreciated next:

Provincia	Demanda calefaccion (kWh/m2)	Demanda refrigeracion (kWh/m2)	Demanda ACS (kWh/m2)
A Coruña	46,6	0,0	17,8
Albacete	72,2	13,9	17,9
Alicante	23,0	24,2	16,8
Almeria	19,8	27,7	16,6
Araba	97,0	0,0	18,5
Asturias	73,1	0,0	18,1
Avila	101,0	0,0	18,7
Badajoz	41,6	25,1	17,2
Barcelona	43,4	12,1	17,4
Burgos	113,1	0,0	18,8
Caceres	48,4	27,8	17,3
Cadiz	17,2	21,4	16,7

Figure 30. Appearance of the data included in the sheet "DemandaNuevoUnifamiliar"

The units of all the numbers included are kWh/m^2, so the increase in the surface of the household would mean also an increase in the overall consumption.

5.5.4. DemandaNuevoBloque

"DemandaNuevoBloque" is quite similar to the previous sheet, but the difference remains in that the households in the sheet belong to a block of flats. It is typical to have lower values regarding at consumptions. Due to insulation and other factors concerning heat transfer and psychrometrics the demand, as just said, is minor.

The appearance of the values is the same as in Figure 30 and the source is the same report.

5.5.5. DemandaExistUnifamiliar

The concept behind the present excel sheet is the same as for the previous two, being no other than contributing building the database for the later consumption estimation. However, the sheet distinguishes the old households but only the ones built before 2006, with features of old buildings worse prepared in terms of insulation.

Also, the appearance of the data is the same as in Figure 30, the values are in kWh/m^2 for further use and the resources are ACS, heating and air conditioning. On the other hand, the report in which the values were extracted from is the IDAE report Escala de calificación energética. Edificios existentes [21], elaborated by Instituto para la Diversificación y Ahorro de la Energía.

5.5.6. DemandaExistBloque

Regarding at household consumption, "DemandaExistBloque" is the last sheet defining it. Furthermore, the structure is the same as

"DemandaExistUnifamiliar" but the values correspond to old household of blocks of flats.

Appearance is the same as in Figure 30 and the source of information is the report by IDAE too.

5.5.7. CantidadHogaresNuevosExistentes

During the elaboration of the tool, it was necessary to construct a sheet that had all the parameters and values regarding at distribution of buildings among the territory of the country. It is remarkable then, to explain how decisive is the sheet described here.

From the data available in INE (Instituto Nacional de Estadística) [14], it was possible to determine how the households were distributed depending on the region they belonged. Thanks to that, the classification made between the buildings was:

- *Detached houses*
  - *Old*

    Houses built before 2006.
  - *New*

    Houses built after 2006.
- *Block of flats*
  - *Old*

    Houses built before 2006.
  - *New*

    Houses built after 2006.

Moreover, the semblance of the sheet, slightly different from the rest, is the following:

Miles de hogares

Provincia	Unifamiliar			Bloques		
	Total	Posterior a 2006	Anterior a 2006	Total	Posterior a 2006	Anterior a 2006
A Coruña	187,3	6,3	181	262,5	34,4	228,1
Albacete	48	4	44	102,2	13,2	89
Alicante	238,9	16,4	222,5	511,4	38	473,4
Almeria	128,4	16,3	112,1	127,6	27,5	100,1
Araba	17,5	3	14,5	122,6	21,6	101
Asturias	81,6	7,4	74,2	375,5	34,6	340,9
Avila	27,5	2	25,5	40,1	2,8	37,3
Badajoz	138,9	13,7	125,2	126,1	8,1	118

Figure 31. Appearance of the values included in the distribution of buildings sheet

The units of the values in Figure 31 are in thousands of households.

In Spain, the majority of buildings are old. In fact, there is a period when Spanish stakeholders invested much money on new buildings, approximately around 2005, but with the economic crisis and the amount of empty and unsold buildings that can be found in the country, the sector is experiencing a huge slow down. For this, the percentage of new building among overall is small, and the consumptions will be slightly greater then.

5.5.8. PoblacionViviendas

Especially similar to the sheet already explained that includes the distribution of new and old houses, it was required to obtain the distribution of population for those households. In other words, the database needed a sheet including the number of households in which there are one person living, two, three, four or five at most. The data are also accessible in the INE webpage [14].

In addition, it includes the percentage over the total, and the units shown in the next figure are thousands of households:

Miles de hogares

Provincia	Unipersonal	Pareja sin hijos	Pareja 1 hijo	Pareja 2 hijos	Pareja 3 o más hijos	RESTO
A Coruña	113,8	100,3	73,8	52,5	6,7	102,7
	25,3%	22,3%	16,4%	11,7%	1,5%	22,8%
Albacete	35,5	31,9	23,6	28,5	4,5	26,5
	23,6%	21,2%	15,7%	18,9%	3,0%	17,6%
Alicante	193	171,2	114,8	110,5	19,7	141,2
	25,7%	22,8%	15,3%	14,7%	2,6%	18,8%
Almeria	55,1	51	42,2	46,5	11,3	50
	21,5%	19,9%	16,5%	18,2%	4,4%	19,5%
Araba	43,1	34,7	20,4	17,9	2,7	21,2
	30,8%	24,8%	14,6%	12,8%	1,9%	15,1%
Asturias	135,4	107,1	73,9	43,3	6,1	91,5

Javier:
(monoparentales, nucleo familiar con otras personas, personas que no forman nucleo familiar, 2 o mas nucleos familiares)

Figure 32. Appearance of the data describing the distribution of population in Spain

It can be appreciated in the Figure 32 a column called "Resto", or rest in English, that includes households out of the classification of the project, such as households in which two families live together or flats occupied by student colleagues for example.

5.5.9. ZonaClimatica

In this sheet the regions are classified according to the normative HE and depending on the climate of the mentioned region. The normative was approved on March the 17th of 2006 and it is compiled in the Real Decreto 314/2006 [22]. The authority in charge of the development of the normative was the Ministerio de Fomento of Spain and it updated the normative applied in the past years to the directive approved by the EU concerning new constructions, the Directive 2010/31/UE.

Ensuing the lines of the Real Decreto, and in particular the DB H1, the classification of the areas was made in agreement with the tables included in the document about summer and winter areas. This certification is granted depending on the temperatures reached during the month of warm weather and the months of cold weather. Furthermore, it will directly determine the consumptions of heating and air conditioning, as it might be thought. The classification of the Spanish territory is the following:

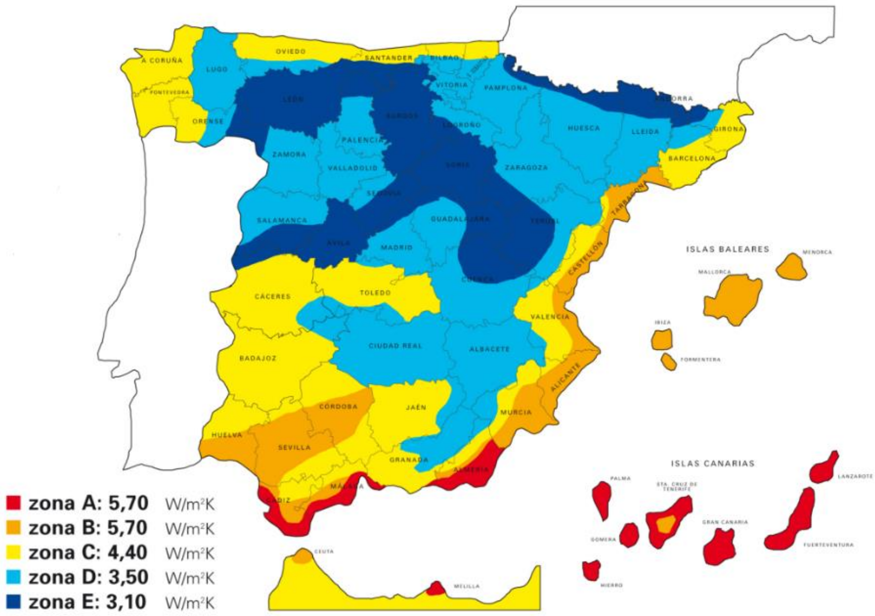

Figure 33. Winter classification DB H1. Source: CTE Arquitectura

In the case of the summer criteria, the concept is the same but naming the zones per number and not per letter. Then, a letter and a number are assigned to every region of the country. The possible combinations are 20, but once having the results for the provinces, they are only classified in 12 values, which are appreciated now:

Type	Area
Hot	A3
Hot	A4
Hot	B3
Hot	B4
Mixed	C1
Mixed	C2
Mixed	C3
Mixed	C4
Mixed	D3
Cold	D1
Cold	D2
Cold	E1

Table 28. Classification of the territory according to weather

The classification made into types was a key step for the further organization into levels, because of the fact already stated that the areas with higher demand of resources (heating as most important) will be the ones belonging to the cold classification.

The final look of the sheet is the next one, and it includes a table in which the areas are identified and another one with the classification criteria following the DB H1:

Provincia	Zona Climatica	Categori clima
A Coruña	C1	Mixta
Albacete	D3	Mixta
Alicante	B4	Calor
Almeria	A4	Calor
Araba	D1	Frio
Asturias	D1	Frio
Avila	E1	Frio
Badajoz	C4	Mixta
Barcelona	C2	Mixta
Burgos	E1	Frio
Caceres	C4	Mixta
Cadiz	A3	Calor
Cantabria	C1	Mixta

Zona de verano	Zona de Invierno			
	1	2	3	4
A			Calor	Calor
B			Calor	Calor
C	Mixta	Mixta	Mixta	Mixta
D	Frio	Frio	Mixta	
E	Frio			

Figure 34. Appearance of the sheet classifying the regions per type depending on climate

5.5.10. ClasificacionNiveles

Finally, the last sheet containing valuable data for the design of the rest of sheets is "ClasificacionNiveles". It sums up all the data containing the classification of climate areas and then adds the values of the consumptions of the buildings included in the previous sheets.

The sheet was made for a better view of the values and an easier call with the command *vlookup,* used all along the tool.

The look of the page is:

Miles de hogares

Provincia	Zona Climatica	Categoria Clima	Calefacci Unifamiliar Nuevos	Calefacci Unifamiliar Existentes	Calefacci Bloques Nuevos	Calefacci Bloques Existentes	Refrigeracio Unifamiliar Nuevos	Refrigeracio Unifamiliar Existentes	Refrifgeracio Bloques Nuevos	Refrigeracio Bloques Existentes	ACS Unifamiliar Nuevos	ACS Unifamiliar Existentes	ACS Bloques Nuevos	ACS Bloques Existentes
A Coruña	C1	Mixta	46,6	117,2	30,0	93,1	0,0	0,0	0,0	0,0	17,8	17,8	13,0	13,0
Albacete	D3	Mixta	72,2	172,3	49,1	135,9	13,9	17,9	9,7	17,1	17,9	13,0	13,1	13,1
Alicante	B4	Calor	23,0	76,9	13,2	49,2	24,2	40,9	16,7	29,4	16,8	16,8	12,3	12,3
Almeria	A4	Calor	19,8	44,7	10,8	36,5	27,7	46,8	19,1	33,7	16,6	16,6	12,1	12,1
Araba	D1	Frio	97,0	203,9	65,4	163,6	0,0	0,0	0,0	0,0	18,5	18,5	13,5	13,5
Asturias	D1	Frio	73,1	152,4	48,3	122,8	0,0	0,0	0,0	0,0	18,1	18,1	13,3	13,3
Avila	E1	Frio	101,0	221,5	69,5	187,5	0,0	0,0	0,0	0,0	18,7	18,7	13,7	13,7
Badajoz	C4	Mixta	41,6	123,1	27,4	85,4	25,1	42,4	17,1	30,2	17,2	17,2	12,6	12,6

Figure 35. Appearance of the data in the sheet "ClasificacionNiveles", putting together the values of climate and demands

5.5.11. TablaDinamicaZona

The only purpose of the sheet is to have a Dynamic Table to help the identification of the energetic levels and consumptions. It also allows the user to change the climate zone or even the type of building it is desired to see.

6. Results

This part gathers the numbers obtained after building the model and focuses on the analysis for the region level. It also discusses the situation of the country nowadays contrasting the poverty indicator that the model calculates. Lastly, there is a chapter considering the social bond and the impact on population, as well as new measures that could be introduced in case that the social bond is not enough to help Spanish society.

First of all, it has to be explained that, after performing the calculations and obtaining the values for consumptions in the region, it was necessary to perform a sanity check in order to see if those values obtained were reliable or, on the other hand, there was some hypothesis adopted which would be needed to change.

Therefore, it is needed to remember the values for domestic consumption of energy in all the country and then compare them with the figures achieved with the excel tool. The succeeding table contents the values of Table 1 which have interest for the sanity check and the results:

			Electricity and gas				Electricity only	
	Domestic annual consumption	Water	Electricity basic	Electricity optimal	Gas basic	Gas optimal	Electricity basic	Electricity optimal
Water (hm^3)	2.269,97	1.556,70	-	-	-	-	-	-
Electricity (GWh)	69.647,50	-	15.022,91	30.800,83	-	-	63.890,62	127.537,25
Gas (GWh)	53.510,00	-	-	-	49.875,29	98.730,98	-	-

Table 29. Sanity check for the annual consumptions by case

The way applied to obtain the consumptions from the results is to calculate the mean of the streams for every region and then multiply this average for the number of households existing in Spain, which is 17.057.800. Because of this, at least the basic cases of the houses demanding as little as possible, should be less than the real consumption of the country. That is exactly what happens with the results, the water consumption is 1.556,70 hm^3, less than the current demand, and for the electricity there are two cases. First, if the houses were equipped with heating by gas, and all the houses had heating systems, what is not real, the consumptions are OK below the real data. Second, for the case of using only electricity for heating purposes, and also taking into account that all the buildings in the country have a heating system, the electricity consumption is below the current one, what is great. The results only disagree for the optimum case of gas, what is normal because the hypothesis is considering that the 17 million houses in Spain consume gas every year, and it is far from reality as many of them have only electricity or even do not have heating system. It happens the same for the case of only electricity and optimal, but the reason is the same as before, it is unreal to have the entire amount of households demanding electricity for heating and air conditioning purposes.

Therefore, the data achieved and contrasted with the sanity check values can be considered reliable.

During the next sections, the results for the regions will be discussed and evaluated.

6.1. Basic scenario

The basic case is the one in which there is no consideration of the installation of air conditioning systems in the households and its surface, for heating demand purposes for example, is considered to be only 20 m^2, what a living room would be.

Results obtained for the three energy vectors are the following ones:

Region	Water	Electricity and gas		Electricity only
	L	Electricity kWh	Gas kWh	Electricity kWh
A Coruña	87.685,28	870,30	2.474,68	3.294,98
Albacete	96.566,64	892,57	3.295,04	4.121,05
Alicante	91.053,54	878,37	1.274,52	2.127,14
Almeria	99.712,47	900,83	920,88	1.803,11
Araba	85.079,41	862,99	4.007,71	4.789,74
Asturias	82.743,64	857,72	3.036,93	3.833,30
Avila	89.259,03	873,63	5.012,01	5.784,38
Badajoz	96.954,35	893,86	2.345,42	3.191,89
Barcelona	91.999,81	880,87	2.029,30	2.869,17
Burgos	87.966,74	870,95	5.015,43	5.785,06
Caceres	90.126,92	875,89	2.425,08	3.251,98
Cadiz	101.707,71	906,82	999,09	1.885,73
Cantabria	88.575,99	872,99	2.441,32	3.264,99
Castellon	91.942,41	881,25	1.470,96	2.322,49
Ciudad Real	97.467,06	895,08	3.101,25	3.933,68
Cordoba	97.668,89	895,72	1.451,23	2.317,63
Cuenca	91.187,51	878,55	4.341,32	5.132,16
Girona	91.314,79	878,12	2.929,30	3.748,24
Granada	94.665,78	887,45	2.805,11	3.635,89
Guadalajara	94.901,31	888,72	3.170,50	3.995,17
Guipuzkoa	92.519,13	881,83	2.803,62	3.628,81
Huelva	98.053,52	897,15	1.153,63	2.027,48
Huesca	89.189,43	873,95	3.686,28	4.485,77
Jaen	98.759,55	898,32	2.165,11	3.019,68
La Rioja	88.106,89	871,27	3.185,18	3.992,11
Leon	85.471,28	864,25	4.960,46	5.724,50
Lleida	88.955,61	873,26	3.001,39	3.814,02
Lugo	85.080,05	864,24	4.410,72	5.185,86
Madrid	92.046,00	881,25	2.925,18	3.747,34
Malaga	94.358,83	886,93	1.035,60	1.901,60
Murcia	101.816,11	905,98	1.415,23	2.292,62
Navarra	92.082,59	881,17	3.779,59	4.584,40
Ourense	84.538,19	862,36	2.961,70	3.764,23
Palencia	88.047,48	871,15	4.460,86	5.241,89
Pontevedra	88.047,48	871,15	4.460,86	5.241,89
Salamanca	87.710,48	870,22	4.506,67	5.285,84

Segovia	92.053,00	880,84	4.553,32	5.342,17
Sevilla	100.562,64	903,44	1.263,67	2.141,58
Soria	88.212,56	870,90	4.848,94	5.621,88
Tarragona	92.073,63	880,93	1.429,19	2.281,25
Teruel	91.015,13	878,38	4.299,61	5.091,13
Toledo	100.071,47	901,64	2.819,70	3.664,38
Valencia	92.809,63	883,65	1.450,45	2.304,79
Valladolid	89.107,75	873,61	3.759,00	4.556,67
Vizkaia	88.844,72	873,41	2.586,95	3.408,09
Zamora	84.749,95	862,56	4.435,04	5.208,00
Zaragoza	89.519,60	874,80	2.750,66	3.569,89
MEAN	91.752,81	880,45	2.971,40	3.791,82

Table 30. Results of the consumptions of the regions for the basic case

The regions where the consumption is higher than the rest are, in terms of water and electricity, Murcia, Cadiz and Sevilla; regarding at gas: Burgos, Avila and Leon. Furthermore the distribution of gas consumption has to be noticed, it is shown in the Spanish map [23]:

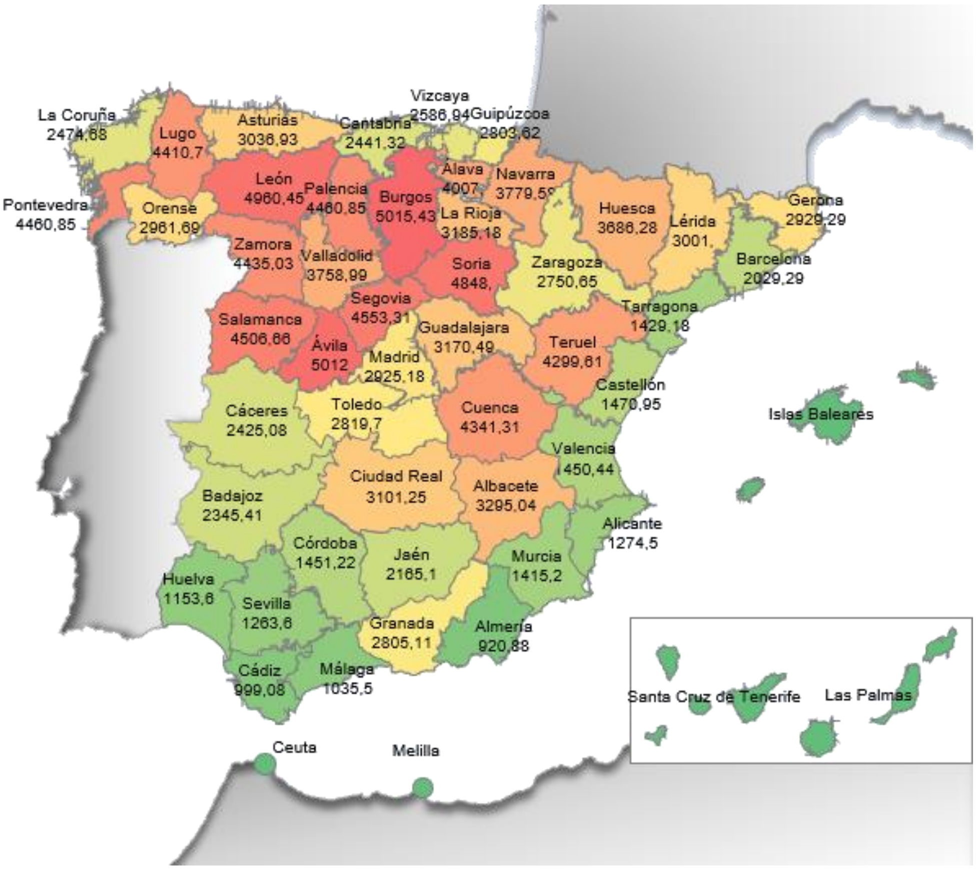

Figure 36. Distribution of gas consumption in the different regions

In the Figure 36, the parts of the territory that are seen with shades of red are the ones where the gas consumptions are higher. It is checked that the regions with higher annual demand are those in where the weather is much worse during the year. In particular, Ávila and Burgos face the worst conditions, and because of the distribution of building and population, they are the regions that have to pay more at the end of the year. This map lead us to the idea that maybe it should be appropriate to introduce new measures for the households located in areas in red in terms of gas helps. With this the author means that it might be great to elaborate a social bonus for gas that would be applied in the areas that pay more for gas services, to decrease the inequality because of weather conditions. Of course, this idea would be also good to be applied for the water stream, as there is neither a definition of vulnerable consumer.

In addition, what it interesting at this point is to compare the minimum consumption of a household with the average real consumption in Spain. With this, it will be known the percentage of overconsumption that a typical household has. The numbers obtained with the tool are compared in the next figures:

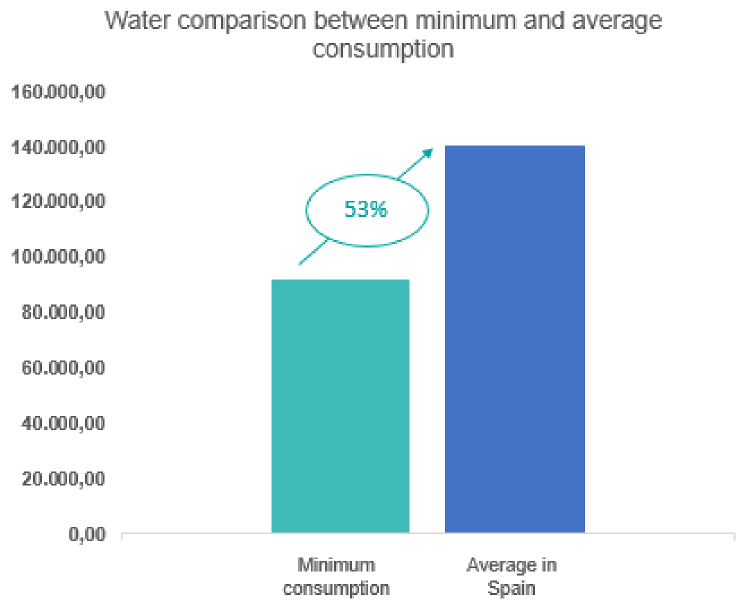

Figure 37. Water consumption comparison between the minimum consumption and the average in Spain

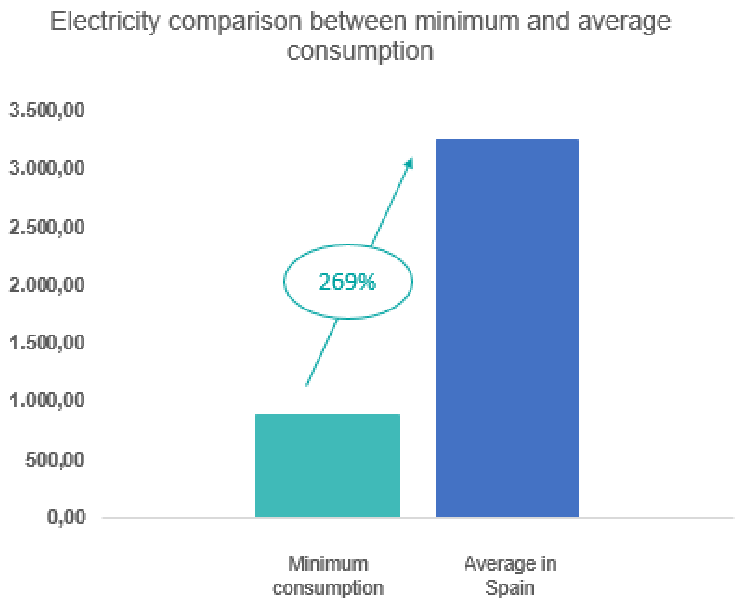

Figure 38. Electricity consumption comparison between the minimum consumption and the average in Spain

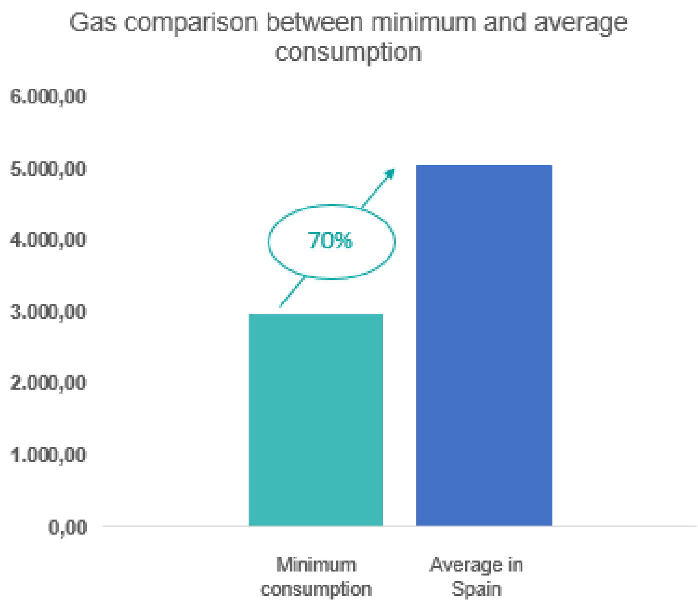

Figure 39. Gas consumption comparison between the minimum consumption and the average in Spain

First of all, the values of the average consumption in Spain was extracted from two different sources, the INE and the web [24]. These sources gathered the real consumptions of the country. Now, it is incredible, after regarding at the figures above, that the average consumption currently in Spain is always higher than the minimum necessary to fulfill the basic necessities. This means that the households are wasting unnecessary energy. The case of electricity is the most notable, the households are demanding a 269% more than the minimum. On the other hand, gas represents a 70% more and water a 53% more than the basic. This should be kept in mind for authorities and responsible organizations in order to raise awareness of the waste of energy.

However, to reach valuable conclusions it is more interesting to obtain the final prizes that the households would pay depending on the region. It is important to state that the final bill that the households would pay for is calculated assuming that it is formed by the sum of water, electricity and gas. The next map shows the final prize that the households should have to pay for the minimum supply:

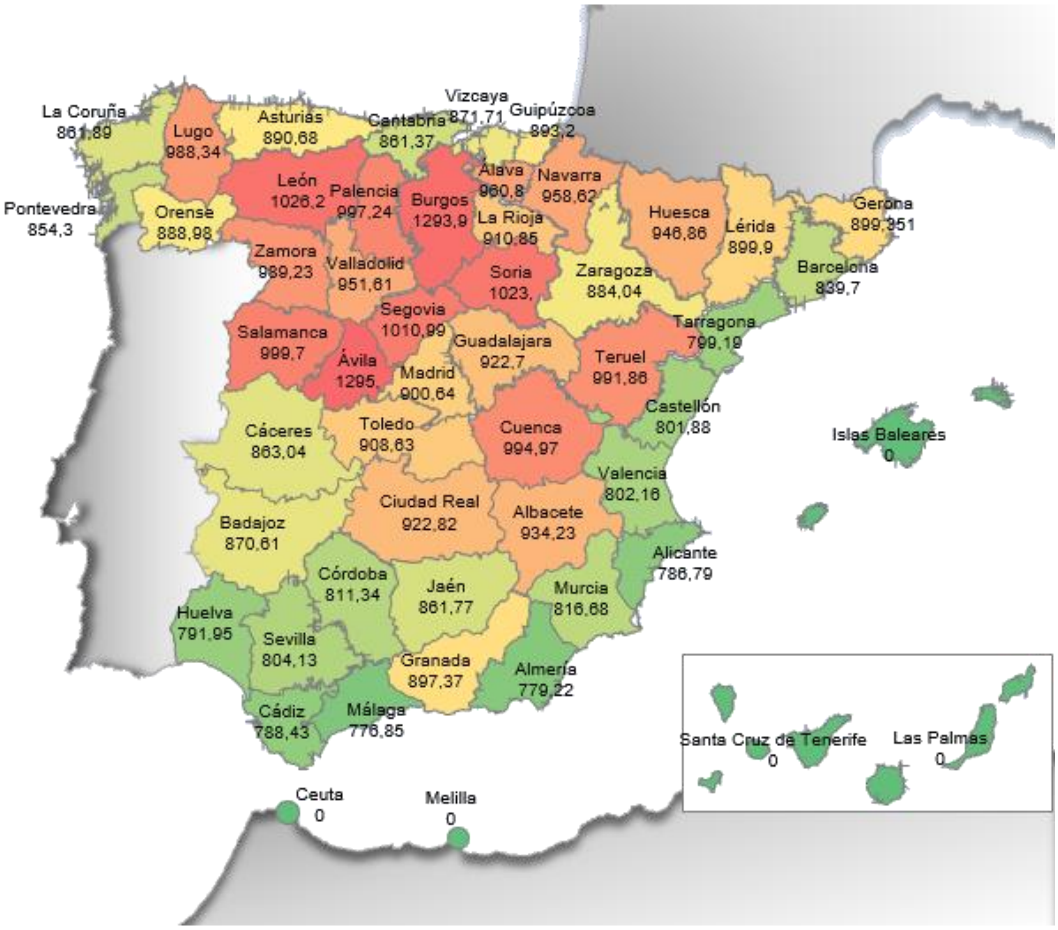

Figure 40. Annual prizes per region considering the sum of water, electricity and gas

And, if the basic case is only based in electricity consumption, avoiding gas:

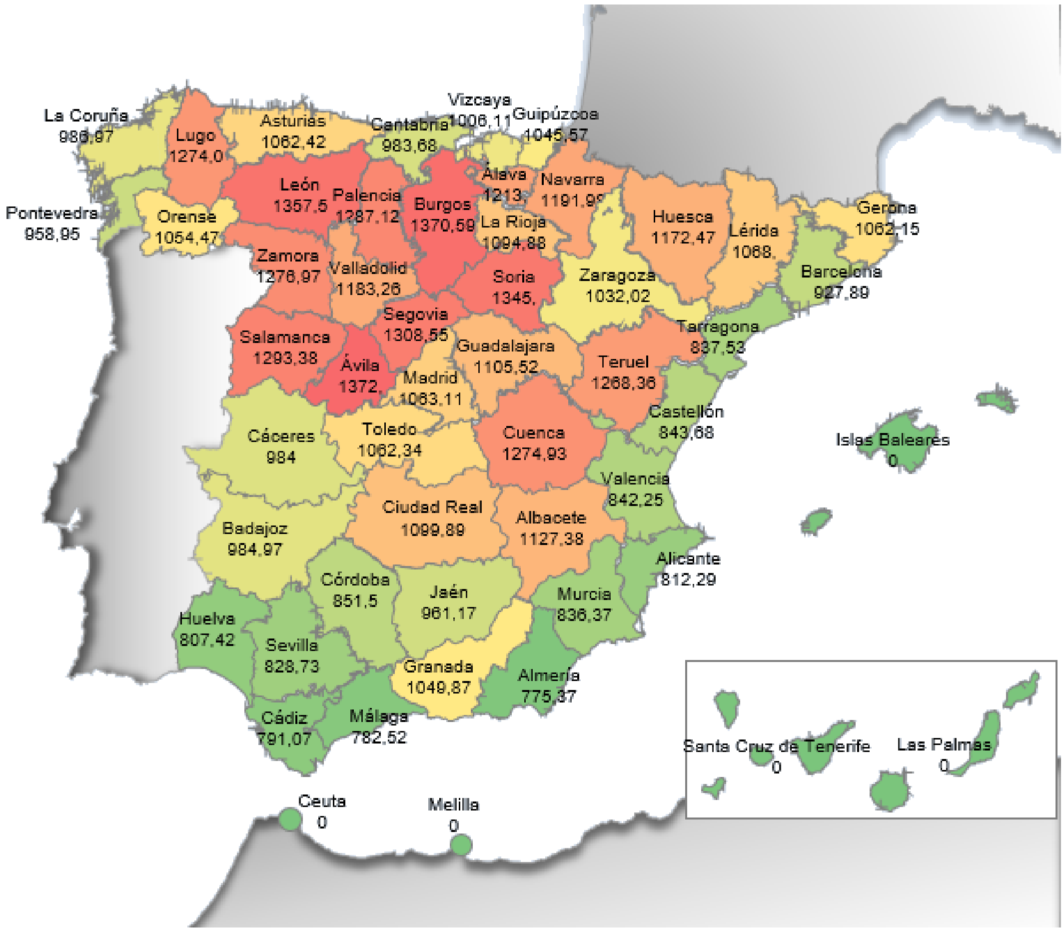

Figure 41. Annual prizes per region considering only water and electricity

The places are influenced the most by the prize of the gas. The north of Spain in general faces more expensive prizes at the end of the year than the ones located at the south. On the other hand, the average prize that a household afford per year is equal to 911,21 €, and if there is only electricity equipment is of 1.018,81, €. It must be stated that the distribution taking into account only electricity is exactly the same as for the other case with gas, with the only respective increase in the prize due to higher cost of electricity.

6.1.1. 10% poverty indicator for the basic case

The poverty indicator of the 10% shows us, as explained in the chapter of the description of the tool, the percentage of population which experiences difficulties to pay for other necessary goods because of the high cost of energy. It will be shown next the percentage of population whose energy cost at the end of the year suppose more than a 10% of the salary. The table gathers the results for the two cases, one considering gas and the other only electricity:

Region	Water, electricity and gas	Water and electricity
A Coruña	11,74%	13,45%
Albacete	12,73%	15,36%
Alicante	10,72%	11,07%
Almeria	10,62%	10,57%
Araba	13,09%	16,53%
Asturias	12,14%	14,48%
Avila	17,66%	18,70%
Badajoz	11,86%	13,42%
Barcelona	11,44%	12,64%
Burgos	17,63%	18,68%
Caceres	11,76%	13,41%
Cadiz	10,74%	10,78%
Cantabria	11,74%	13,40%
Castellon	10,93%	11,50%
Ciudad Real	12,57%	14,99%
Cordoba	11,06%	11,60%
Cuenca	13,56%	17,37%
Girona	12,25%	14,47%
Granada	12,23%	14,31%
Guadalajara	12,57%	15,06%
Guipuzkoa	12,17%	14,25%
Huelva	10,79%	11,00%
Huesca	12,90%	15,98%
Jaen	11,74%	13,10%
La Rioja	12,41%	14,92%
Leon	13,98%	18,50%
Lleida	12,26%	14,56%

Lugo	13,47%	17,36%
Madrid	12,27%	14,49%
Malaga	10,59%	10,66%
Murcia	11,13%	11,40%
Navarra	13,06%	16,24%
Ourense	12,11%	14,37%
Palencia	13,59%	17,54%
Pontevedra	11,64%	13,07%
Salamanca	13,62%	17,62%
Segovia	13,78%	17,83%
Sevilla	10,96%	11,29%
Soria	13,95%	18,34%
Tarragona	10,89%	11,41%
Teruel	13,52%	17,28%
Toledo	12,38%	14,48%
Valencia	10,93%	11,48%
Valladolid	12,97%	16,12%
Vizkaia	11,88%	13,71%
Zamora	13,48%	17,40%
Zaragoza	12,05%	14,06%
MEAN	12,42%	14,47%

Table 31. Percentage of population whose energy bill is more than a 10% of the salary, depending on region

The mean for the Spanish territory is of 12,42%, what means that approximately two million households have to pay more than a 10% of the salary in energy costs, with consuming the minimum possible. This figure is truly important and illustrates the difficulty of the population to afford the standard living conditions. Because of this, it has to be said that there exist a need to develop a social bond that helps those families and which is well elaborated, keeping in mind that the indicator of the 10% is awful in Spain. The worst part is located in Castilla y León and Castilla-La Mancha.

Finally, considering the minimum consumptions in Spain, it is concluded that the prizes for energy streams are too high, even applying the special electricity tariff. It would be a great advance if the governments decided what is a vulnerable consumer in terms of gas and water and then apply measures to decrease the values of the poverty indicator, 12,42% in the case of water, electricity and gas and 14,47% for water and electricity only is not an acceptable value for a country like Spain and it must be diminished.

6.2. Optimal scenario

This scenario is more complex than the basic one, and, as a result, the prizes and consumptions are different for the regions, being the prizes higher and the kWh and L consumed, having a distinct distribution. The structure of the chapter is the same one as for the basic scenario, the consumptions will be explained and analyzed (taking into account if the impact of the air conditioning systems and computer influence the overall results) and it will be evaluated the scenario in Spain.

Notice that the hypothesis of consumptions in this case change and the refrigeration systems are now considered, depending on the weather conditions, the values change. Also, the use of a computer is measured, and the m^2 of the household are related with the number of people living in it. Because of this, the surface in which the heating, refrigeration and ACS are considered changes. The results for the average consumption of the regions is exhibited:

		Electricity and gas		Electricity only
Region	Water L	Electricity kWh	Gas kWh	Electricity kWh
A Coruña	87.685,28	1.063,39	4.841,62	5.807,20
Albacete	96.566,64	1.468,37	6.629,43	7.963,88
Alicante	91.053,54	2.709,48	2.424,74	5.085,24
Almeria	99.712,47	3.068,20	1.728,36	4.761,65
Araba	85.079,41	1.055,03	8.012,82	8.905,98
Asturias	82.743,64	1.049,55	5.916,12	6.846,15
Avila	89.259,03	1.066,71	10.012,78	10.877,22
Badajoz	96.954,35	2.919,23	4.670,44	7.495,31

Barcelona	91.999,81	1.422,22	3.973,93	5.315,87
Burgos	87.966,74	1.064,03	9.995,73	10.857,82
Caceres	90.126,92	3.057,70	4.763,77	7.725,23
Cadiz	101.707,71	2.526,58	1.898,97	4.387,19
Cantabria	88.575,99	1.066,46	4.785,19	5.754,98
Castellon	91.942,41	2.173,56	2.832,07	4.948,42
Ciudad Real	97.467,06	2.218,53	6.242,58	8.335,00
Cordoba	97.668,89	3.493,29	2.822,72	6.258,98
Cuenca	91.187,51	1.335,91	8.686,48	9.846,90
Girona	91.314,79	1.376,57	5.802,36	7.061,71
Granada	94.665,78	2.261,64	5.593,07	7.741,73
Guadalajara	94.901,31	1.439,95	6.351,62	7.663,25
Guipuzkoa	92.519,13	1.075,69	5.562,68	6.525,99
Huelva	98.053,52	2.819,67	2.207,68	4.982,75
Huesca	89.189,43	1.435,26	7.319,92	8.607,31
Jaen	98.759,55	3.455,70	4.312,39	7.680,98
La Rioja	88.106,89	1.316,26	6.287,22	7.476,47
Leon	85.471,28	1.056,52	9.825,48	10.683,50
Lleida	88.955,61	2.151,61	5.924,59	7.956,51
Lugo	85.080,05	1.056,91	8.717,76	9.598,55
Madrid	92.046,00	1.574,05	5.809,21	7.265,90
Malaga	94.358,83	2.672,36	1.948,70	4.581,68
Murcia	101.816,11	2.301,17	2.769,45	5.014,67
Navarra	92.082,59	1.075,09	7.557,69	8.480,11
Ourense	84.538,19	1.343,50	5.788,88	7.015,43
Palencia	88.047,48	1.064,23	8.873,15	9.758,12
Pontevedra	88.047,48	1.064,23	8.873,15	9.758,12
Salamanca	87.710,48	1.186,67	8.958,28	9.963,98
Segovia	92.053,00	1.277,23	9.138,51	10.231,12
Sevilla	100.562,64	3.565,39	2.447,48	5.963,43
Soria	88.212,56	1.063,60	9.658,86	10.527,34
Tarragona	92.073,63	2.713,13	2.746,12	5.403,77
Teruel	91.015,13	1.204,09	8.600,54	9.630,88
Toledo	100.071,47	3.127,68	5.689,57	8.702,31
Valencia	92.809,63	2.133,25	2.795,41	4.872,19
Valladolid	89.107,75	1.264,86	7.465,88	8.579,92
Vizkaia	88.844,72	1.066,85	5.082,56	6.046,73
Zamora	84.749,95	1.304,36	8.753,73	9.881,25
Zaragoza	89.519,60	1.647,60	5.421,73	6.959,81
MEAN	91.752,81	1.805,39	5.883,43	7.569,97

Table 32. Results of the consumptions of the regions for the optimal case

In this case, the places with higher demand of electricity supply are located in the south area of the country, being the regions with higher demands: Sevilla, Córdoba, Jaén or Toledo. In terms of gas consumption, Burgos and Ávila are still at the top of the list.

In is curious to regard at the electricity consumption for the optimal case, as it completely changes. The introduction of the air conditioning systems makes the situation of electricity demands in households to look like the resulting figure:

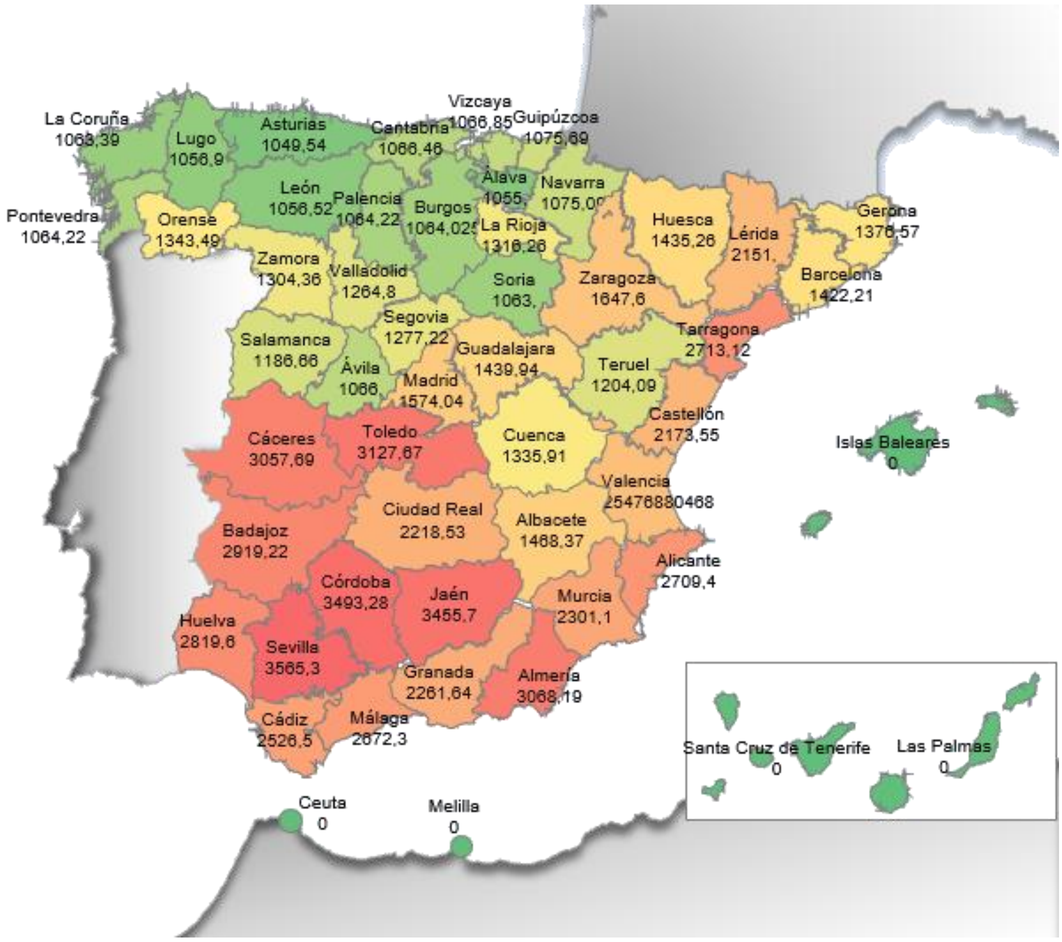

Figure 42. Distribution of electricity consumption in the different regions

So, as said before, in this scenario the regions that face the highest prizes of electricity, due to a higher consumption of air conditioning in the major part and computer too, are located on the south region of Spain. For this, during the months of warm weather, there will be many more families affording high bills in Andalucía, Murcia or Extremadura.

However, in order to get an even better view of the scenario, it is required to talk about prizes and costs that households afford at the end of the year, and then check how the indicator of the 10% increases. It is known that it will be increased because the consumptions are greater than for the basic case, so, with the same income entering in the household, same prizes for energy, and higher consumption, there will be more families in danger of poverty.

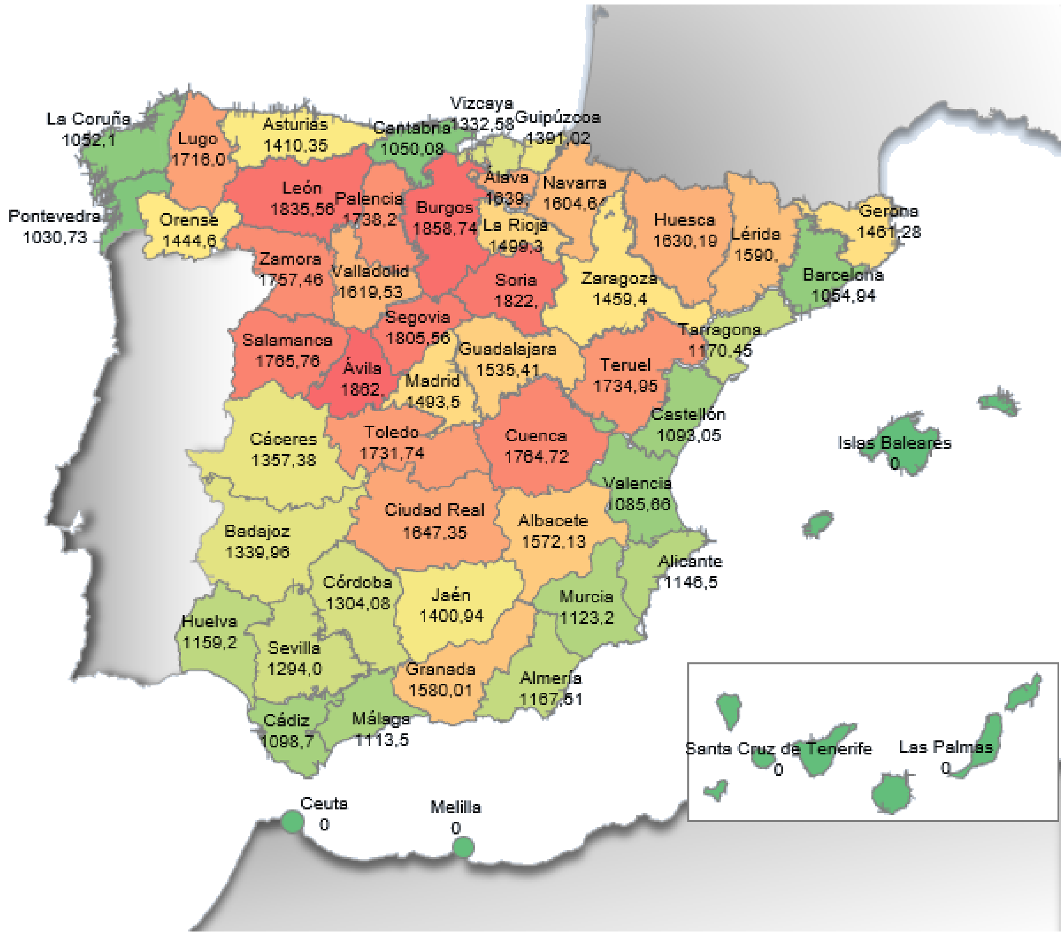

Figure 43. Annual prizes per region considering the sum of water, electricity and gas for the optimal case

As a conclusion for the Figure 43, the gas demand is also defining the higher costs of energy. It can be seen that the prizes increase by an amount of approximately 400-600 € per region, but the areas that have to make the greater effort are also located in Castilla y León and Castilla-La Mancha but also the east of the peninsula has been altered with greater expenses. Now the highest quantity corresponds with 1.862,92,07 € in the case of Ávila, 1.858,65,90 € in Burgos and 1.835,56 € in León. Because of this, it can be said that the optimal scenario does not change the view of the country mainly, the areas in which the energy poverty is greater correspond with the ones calculated for the basic case and located in the center and north of the peninsula but there are more affected however.

In addition, although the distribution will be the same as in Figure 43, it is valuable to get the figures for the case of household which only have electricity installed as heating system. The values obtained are shown in the following map of Spain:

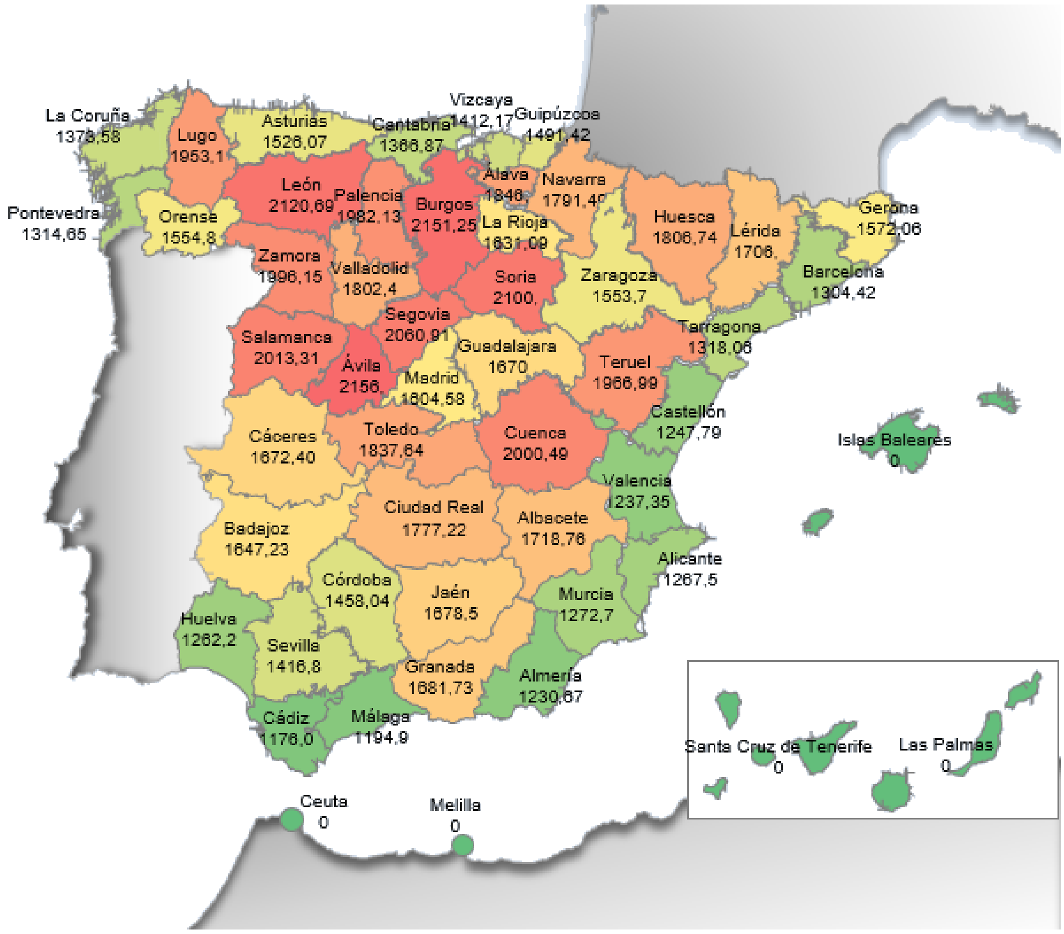

Figure 44. Annual prizes per region considering the sum of water and electricity for the optimal case

6.2.1. 10% poverty indicator for the optimal case

The poverty indicator of the 10%, given the optimal case, will increase and tell us that more population suffers of energy poverty. This is because the energy cost will be higher and the salary distribution will not. It makes sense to think that a greater expense will directly mean greater poverty if the income is the same. Thus, the poverty indicator in this chapter is shown next, including the cases of heating with gas and electricity or only electricity too:

Region	Water, electricity and gas	Water and electricity
A Coruña	14,34%	18,72%
Albacete	21,42%	23,42%
Alicante	15,62%	17,27%
Almeria	15,91%	16,77%
Araba	22,35%	25,16%
Asturias	19,22%	20,79%
Avila	25,38%	29,38%
Badajoz	18,26%	22,45%
Barcelona	14,37%	17,77%
Burgos	25,33%	29,31%
Caceres	18,50%	22,79%
Cadiz	14,97%	16,02%
Cantabria	14,31%	18,63%
Castellon	14,89%	17,00%
Ciudad Real	22,45%	24,22%
Cordoba	17,77%	19,87%
Cuenca	24,05%	27,26%
Girona	19,91%	21,42%
Granada	21,53%	22,92%
Guadalajara	20,92%	22,76%
Guipuzkoa	18,95%	20,32%
Huelva	15,80%	17,20%
Huesca	22,21%	24,62%
Jaen	19,09%	22,87%

La Rioja	20,43%	22,23%
Leon	25,01%	28,90%
Lleida	21,67%	23,25%
Lugo	23,38%	26,61%
Madrid	20,35%	21,86%
Malaga	15,17%	16,28%
Murcia	15,30%	17,34%
Navarra	21,86%	24,41%
Ourense	19,68%	21,19%
Palencia	23,69%	27,01%
Pontevedra	14,04%	17,91%
Salamanca	24,06%	27,43%
Segovia	24,60%	28,08%
Sevilla	17,63%	19,31%
Soria	24,84%	28,62%
Tarragona	15,95%	17,96%
Teruel	23,64%	26,80%
Toledo	23,60%	25,04%
Valencia	14,79%	16,86%
Valladolid	22,07%	24,56%
Vizkaia	18,16%	19,24%
Zamora	23,95%	27,20%
Zaragoza	19,89%	21,17%
MEAN	19,82%	22,30%

Table 33. Percentage of population whose energy bill is more than a 10% of the salary, depending on region and for the optimal case

The regions of Ávila, Burgos and León have also in this case the worst poverty indicators. It has to be noticed too that, given the optimal case and the greater consumptions, the poverty indicator of the 10% increases the mean from 12,42% to 19,82% in the case of gas heating systems and from 14,47% to 22,30% if it is considered only electricity demand. Because of this indicator, it is concluded that the problem is larger than imagined and there are too many households in danger of energy poverty.

Lastly, given the results of the indicator for the optimal case, it is considered more necessary to eradicate the poverty taking into account the basic case with electricity, water and gas demands. The reason is mainly because the indicator is smaller, the costs to cover would be minor too and the impact of the measure to apply for the households in danger of poverty would be huge. Thus, the next chapter covers measures to apply and the evaluation of the current scenario with the social bonus.

6.3. Regulatory framework

The regulatory framework chapter tries to evaluate the impact of the poverty in terms of money and then analyze the measure applied in the new social bond. The chapter will only discuss the basic scenario of consumptions divided into water, electricity and gas, to minimize the costs that the state should afford.

The chapter will be divided into two different parts. First, the necessary money that the Ministerio should invest in order to remove the situation of poverty in the households depending on the region will be discussed. Later, the established social bond consumptions will be analyzed to check if the figures written by the government are enough or, on the other hand, they should be changed.

Therefore, the first approach to calculate the investment necessary to eradicate the energy poverty based on the indicator of the 10% will now be explained. Regarding at the costs that the household have to face, showed in Figure 40, and knowing the percentage of population per region that is having problems to pay for the streams, it is known then the amount of households in danger of poverty per region. Also, the salary that the household should have so that the energy costs correspond with a 10% of this salary is data that the tool returns. Then, taking into account that the average income for those households is approximated to the IPREM (Indicador Público de Renta de Efectos Múltiples) [25] what is an indicator used by the Spanish government to give grant of aid, subsidies or unemployment benefit and it was born from the SMI, already explained. The IPREM is equal to 7.519,59 € in 2017, so the quantity that the public authorities should cover to mitigate the indicator is the difference between ten times the cost of energy (salary that should have the household) and this minimum salary. Finally, multiplying the number of households by the difference, the money for the invest is achieved. The calculation corresponds with the equation below:

$$Total\ investment = n°households \cdot (\frac{cost\ of\ energy}{10\%} - average\ salary)$$

(XXXIV)

Furthermore, the tool also contains the costs of the streams per region, so the hypothesis adopted to divide the investments into streams is to apply the percentages of distribution between the streams to the final amount of the investment. This is interesting because, as stated in the document, the Spanish government only gives money with the social bond for electricity costs, so then the figure will be compared with the current investment to evaluate if it is enough or it should be increased or decreased.

The data achieved for the regions, also containing the full amount is exhibited in the table below:

Region	Investment		
	Water	Electricity	Gas
A Coruña	14.966.867,05 €	16.948.419,20 €	12.897.338,19 €
Albacete	9.274.562,16 €	10.144.677,72 €	9.352.699,71 €
Alicante	8.468.999,19 €	9.461.198,93 €	4.819.323,80 €
Almeria	2.341.718,89 €	2.531.730,12 €	1.092.534,72 €
Araba	9.600.731,59 €	10.983.065,22 €	11.901.386,89 €
Asturias	19.393.964,60 €	22.406.740,57 €	19.789.095,97 €
Avila	12.583.030,72 €	14.155.595,96 €	29.447.853,87 €
Badajoz	10.737.562,02 €	11.729.406,00 €	8.515.676,89 €
Barcelona	60.550.853,26 €	67.398.653,84 €	44.820.607,20 €

Burgos	26.823.502,64 €	30.339.779,30 €	63.229.819,45 €
Caceres	6.195.012,08 €	6.945.609,42 €	5.200.039,66 €
Cadiz	5.677.552,69 €	6.095.877,50 €	2.720.759,84 €
Cantabria	8.092.922,85 €	9.133.759,98 €	6.878.443,28 €
Castellon	3.809.033,65 €	4.241.788,51 €	2.330.194,61 €
Ciudad Real	11.296.616,53 €	12.315.861,22 €	10.850.322,35 €
Cordoba	6.095.711,44 €	6.641.053,28 €	3.596.642,92 €
Cuenca	6.405.627,08 €	7.151.801,42 €	8.187.451,70 €
Girona	13.571.413,69 €	15.139.412,22 €	12.904.772,81 €
Granada	17.750.394,22 €	19.553.876,33 €	16.093.752,25 €
Guadalajara	5.801.940,89 €	6.387.689,97 €	5.735.564,94 €
Guipuzkoa	13.130.531,83 €	14.583.555,38 €	12.030.131,98 €
Huelva	2.561.148,50 €	2.786.842,07 €	1.337.925,18 €
Huesca	5.431.728,93 €	6.113.697,27 €	6.182.571,22 €
Jaen	9.434.388,43 €	10.235.701,12 €	7.036.882,42 €
La Rioja	6.539.551,97 €	7.392.580,77 €	6.715.080,35 €
Leon	17.544.830,99 €	20.041.586,39 €	25.687.741,42 €
Lleida	8.438.238,81 €	9.506.059,82 €	8.263.839,94 €
Lugo	9.429.872,97 €	10.793.975,49 €	12.597.044,12 €
Madrid	119.895.763,98 €	133.447.506,85 €	113.469.150,81 €
Malaga	5.186.751,55 €	5.721.146,90 €	2.620.421,52 €
Murcia	11.690.900,20 €	12.540.783,51 €	6.667.114,66 €
Navarra	17.080.631,41 €	19.006.986,14 €	19.522.965,96 €
Ourense	5.524.744,92 €	6.336.399,44 €	5.484.321,48 €
Palencia	5.417.194,98 €	6.125.352,82 €	7.189.105,51 €
Pontevedra	11.305.076,77 €	12.566.560,21 €	8.865.948,89 €
Salamanca	11.623.620,58 €	13.160.341,19 €	15.578.016,27 €
Segovia	5.559.235,37 €	6.186.169,97 €	7.345.829,13 €
Sevilla	12.318.127,70 €	13.278.584,68 €	6.655.515,61 €
Soria	3.388.919,44 €	3.828.200,44 €	4.802.510,33 €
Tarragona	4.802.473,82 €	5.343.731,01 €	2.889.780,30 €
Teruel	4.403.479,24 €	4.920.365,77 €	5.590.807,10 €
Toledo	13.749.627,77 €	14.844.823,54 €	12.181.743,77 €
Valencia	16.811.109,91 €	18.659.894,43 €	10.160.020,05 €
Valladolid	14.232.193,86 €	16.023.230,41 €	16.448.367,81 €
Vizkaia	17.915.030,63 €	20.194.997,10 €	15.816.314,03 €
Zamora	5.929.787,10 €	6.793.993,28 €	7.969.684,44 €
Zaragoza	16.972.071,27 €	19.078.136,63 €	15.580.081,62 €
TOTAL	**635.755.050,15 €**	**709.217.199,35 €**	**645.053.196,96 €**
GRAND TOTAL	**1.990.025.446,46 €**		

Table 34. Results obtained for the investment needed to mitigate the 10% poverty indicator

The places where the greater investment is needed correspond with the regions that have more households affected. In other words, although the costs needed vary among the regions, it is the number of households affected what decides the higher investment. The share each stream has over the grand total is:

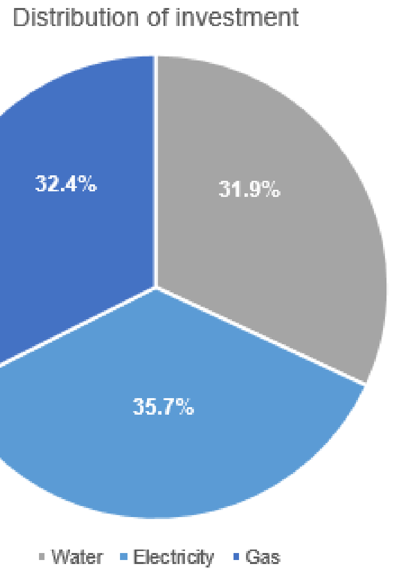

Figure 45. Distribution of the investment among the streams

The majority is related to electricity, what gives us the idea that, even if the social bond by the government may be insufficient, it is great that it is focused on this type of stream, as it is where the help is needed the most. Each stream has approximately the same weight, so this figure leads the reader to the idea that more measures are needed, it is not correct to focus only on electricity aids because there exists a real necessity to cover expenses for water and gas.

Now the measured that entered into force with the Real Decreto 897/2017 including the definition of vulnerable consumer (only for electricity) and the social bond will be discussed and evaluated.

6.3.1. Real Decreto 897/2017 and social bond

First, it must be known how the social bond is applied and who has the right to get benefits from it. The new structure introduced has led population to a circumstance of confusion, as there are many definitions that are not very clear and the way the measure is applied is also quite diffuse. Vulnerable consumers who can apply for the social measure are distinguished between the family members of the household and the income that such household has. Moreover, the type of electricity bill that it must have is the PVPC bill. The conditions to apply for the bond depend on the IPREM (Indicador Público de Renta de Efectos Múltiples). In the year 2017, the IPREM of Spain (divided in 14 pay offs) was 7.519,59 € per year. The conditions are:

- *Household formed by one person or two, no children*

  The salary has to be equal or less than 1,5 times the IPREM

$$Salary = 1{,}5 \cdot IPREM = 11.279{,}38\ €$$

(XXXV)

- *Household with one child*

  The salary has to be equal or less than 2 times the IPREM

$$Salary = 2 \cdot IPREM = 15.039{,}18\ €$$

(XXXVI)

- *Household with two children*

  The salary has to be equal or less than 2,5 times the IPREM

$$Salary = 2{,}5 \cdot IPREM = 18.798{,}97\ €$$

(XXXVII)

- *Household with three or more children and pensioners*

  They can apply with no salary constraint

These conditions change if the household is classified as severe vulnerable consumer. For the first three categories the minimum salary that the household should have is obtained by dividing the previous ones by two and for numerous families it has to be at least 2 times the IPREM (15.039,18 €). In the case of pensioners, they should earn the IPREM or less.

There is an additional category named severe vulnerable consumer at risk of social exclusion, what consists in severe consumers that beyond the conditions listed, they receive a special aid from the autonomous community that covers 50% of the electricity bill.

The aid that the government gives to the households on the electricity bill depends on the category that it has between the explained above. The type of aid is illustrated in the next figure:

Figure 46. Percentage of the bill afforded by the government depending on type of consumer

Also, the Real Decreto establishes, in the Annex I, that the household must have a maximum limit of electricity consumption, and then the discount will be applied to that maximum amount. The table included in the annex containing the amounts is shown next:

Categorías	Límites máximos al consumo (kWh)
Unidad familiar sin menores /demandante individual.	1.200
Unidad familiar con un menor.	1.680
Unidad familiar con dos menores.	2.040
Unidad familiar familias numerosas	3.600
Unidad familiar /demandante individual - pensionistas (cuantía mínima)	1.680

Figure 47. Extract from the RD 897/2017 containing the maximum consumptions established per year in electricity

Once gathered the valuable data of the social bond, the excel tool is used to quantify the amount that the Spanish government will spend if the households that can have the social measure, apply for the measure and receive the aid. It must be said that the study will not consider the group of pensioners, and they will be included in the group of individual family units. This will not influence the final result in an enormous way, it only will slightly diminish the value of the investment. However, it will be greater than the real one, because the household are experiencing many difficulties to access to the bond due to the complex information and many families that could apply are not, thinking that they do not fulfill the conditions.

The procedure to obtain the money the government has decided to spend on vulnerable households will be now explained. However, first it has to be said that at this point, the excel tool proved its potential and freedom to get valuable data. The choices that can be made, and the conclusions that can be achieved by using the tool are truly great. From the maximum consumptions established by the State, in Figure 47, and applying the PVPC, the final prize the households would face is got, also divided depending on people living in it. Then, also with the help of the tool, and taking into account the IPREM and the constraints for the different aids of 25% and 40%, the number of households that can apply for the bonus is obtained. Lastly, and knowing the amount of euros the government is assigning, given the mentioned maximum consumptions, returned by the tool, the final quantity per region is obtained. It is important to know how many euros can be given at the end of the year, so the figures are exhibited:

Members	Case 25%	Case 40%
1	46,17 €	73,87 €
2	46,17 €	73,87 €
3	64,63 €	103,42 €
4	78,48 €	125,58 €
5	138,50 €	221,60 €

Table 35. Maximum aid possible per year, depending on number of people

Then budget the Spanish government is allocating given the hypothesis and constraints explained before is:

Region	Case 25%	Case 40%
A Coruña	2.525.043,00 €	3.127.987,23 €
Albacete	1.183.506,04 €	1.285.634,04 €
Alicante	5.356.022,91 €	5.917.795,70 €
Almeria	2.377.572,58 €	2.294.537,14 €
Araba	892.185,90 €	1.062.165,85 €
Asturias	2.465.952,95 €	3.118.193,64 €
Avila	490.247,67 €	554.966,96 €
Badajoz	2.228.373,16 €	2.328.205,67 €
Barcelona	16.207.211,68 €	17.137.749,40 €
Burgos	1.015.808,04 €	1.178.897,86 €
Caceres	1.204.050,81 €	1.346.915,17 €
Cadiz	4.053.606,28 €	4.134.279,70 €
Cantabria	1.535.743,37 €	1.769.038,00 €
Castellon	1.637.227,28 €	1.850.690,23 €
Ciudad Real	1.776.122,55 €	1.745.149,96 €
Cordoba	2.593.723,69 €	2.660.390,06 €
Cuenca	529.254,78 €	628.612,93 €
Girona	2.275.395,27 €	2.293.453,38 €
Granada	3.382.301,10 €	3.224.739,48 €
Guadalajara	843.677,61 €	867.736,99 €
Guipuzkoa	2.081.570,21 €	2.291.199,94 €
Huelva	1.600.464,19 €	1.660.610,00 €
Huesca	555.673,72 €	658.419,61 €
Jaen	2.094.543,41 €	2.217.952,07 €
La Rioja	917.207,16 €	998.394,12 €
Leon	1.253.517,83 €	1.479.603,97 €
Lleida	1.283.736,82 €	1.384.572,83 €
Lugo	773.321,63 €	915.450,73 €
Madrid	19.339.579,70 €	20.237.373,33 €
Malaga	5.218.193,75 €	5.323.192,38 €
Murcia	5.531.604,85 €	5.003.117,46 €
Navarra	1.978.356,57 €	2.078.388,57 €
Ourense	758.099,85 €	916.637,63 €
Palencia	464.235,58 €	527.313,37 €
Pontevedra	2.346.528,07 €	2.675.283,60 €
Salamanca	923.273,72 €	1.098.008,87 €
Segovia	493.492,08 €	533.660,34 €
Sevilla	6.562.842,68 €	6.366.818,23 €
Soria	291.941,79 €	306.550,45 €
Tarragona	2.520.625,09 €	2.552.240,31 €
Teruel	396.246,28 €	445.096,44 €
Toledo	2.367.148,04 €	2.328.531,70 €

Valencia	7.847.985,56 €	8.381.800,86 €
Valladolid	1.510.151,33 €	1.703.163,48 €
Vizkaia	2.938.576,92 €	3.520.499,82 €
Zamora	485.238,85 €	574.406,42 €
Zaragoza	2.624.148,70 €	3.060.950,67 €
TOTAL	129.731.331,11 €	137.766.376,59 €
GRAND TOTAL	**267.497.707,70 €**	

Table 36. Budget of the Spanish government for electricity aids

Notice that the case of severe consumer in risk of social exclusion is not included. This is because they are a minority and very particular cases. Furthermore, they also depend on every city hall, so the estimation for the Spanish territory is complicated. But, although they are not included, the figures are supported by different sources, like EuropaPress [26]. As the measure is very recent, there are not official figures yet of the cost, but it can be said that the approximation of the methodology applied is good, as the first numbers of the cost are around 235 million euros, and the values are reliable.

Once achieved the results of the real cost of the social bond, what adds value is to compare the current investment with the investment needed to solve the situation, calculated before, and then evaluate the regulatory framework. The data are explained in the next table and figure:

Current investment			Needed investment		
Water	Electricity	Gas	Water	Electricity	Gas
0,00 €	267.497.707,70 €	0,00 €	635.755.050,15 €	709.217.199,35 €	645.053.196,96 €

Table 37. Current and needed investment to correct the poverty situation

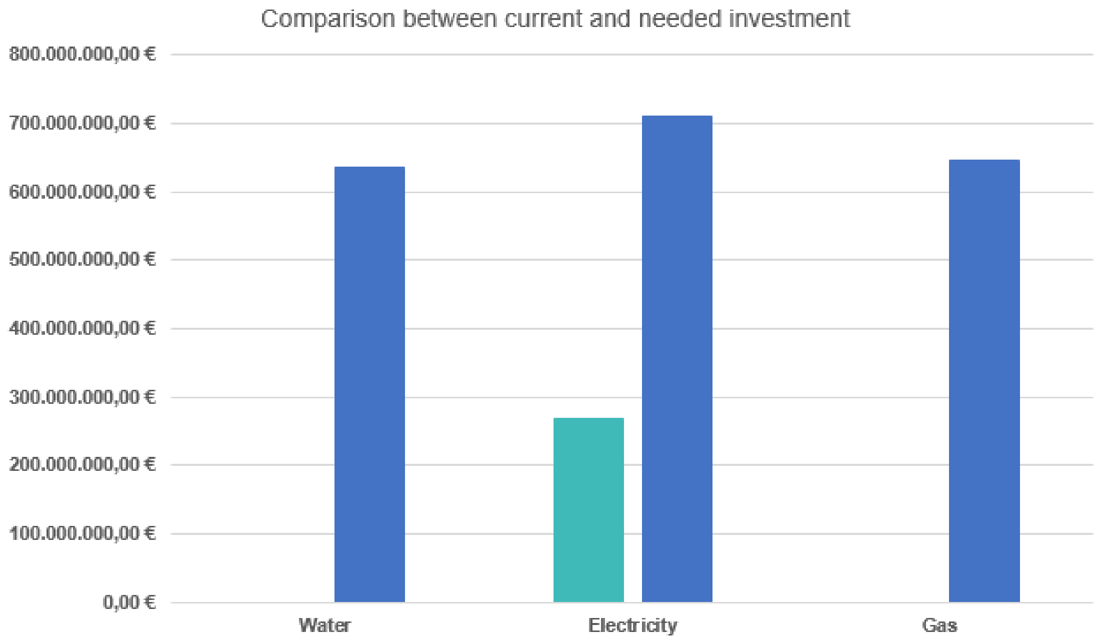

Figure 48. Current and needed investment by the government comparison

It must be remarked that the current investment that the government is giving in form of aid for the electricity bill supposes 37,72% of the needed investment. This number highlights the insufficient amount of money that the state is allocating. Furthermore, there is no type of aid for the water and gas streams. The regulatory framework analysis, because of these data, concludes that the social bond is more than insufficient for the households in danger of energy poverty and it should be redesigned.

Also, the analysis performed here does not evaluate the case in which the heating systems are based on electricity. One of the numerous problems that the bond implies is that it discriminates the households whose heating system is electric because its maximum consumption will be greater than the others that use gas, but the limits are the same for both of them. Thus, the household equipped with gas will receive the same amount of aid than the other even when the electricity costs more. To some extent, the bond is encouraging the use of gas, but the Ministerio has not developed a social bond for that kind of stream consumption, so the structure does not make much sense.

Moreover, regarding at the results, it would be also interesting to develop the measure realizing that the households vary the consumption depending on their location. As seen before, the bill for the minimum consumption the region of Ávila has to pay for is greater than the bill of the region of Córdoba. However, all of the households have the same limits established and the discount is also identical.

Finally, the tool and the project go beyond the scope of the social bond. The proposal for the new investment to solve the energy poverty based on the 10% indicator includes and divides the cost of the three streams, water, gas and electricity. Therefore, the approach gives the numbers that should be invested to solve the energy poverty including the vulnerable consumers in their complete definition. Then, just regarding at the numbers, the government should increase the investment and introduce as soon as possible measures to solve the situation also concerning water and gas consumptions.

7. Conclusions

After the development of the excel tool, and the evaluation of the results obtained, it can be ensured that the energy poverty is a huge challenge that the Spanish government should be treat with respect and efficiency. Numbers speak for themselves, with the current social aid system it is true that the government is trying to help solving the situation, but it is not enough. The current approximated investment of 267 million euros is nothing compared with the money needed. What it is not possible to happen is that in a country like Spain, what is considered itself as a welfare state and always tries to be an example for the rest of the world in terms of social security and sanitary system, more than 7.000 people die each year because of the energy poverty. In addition to this data, there exist more than 1,5 million households in Spain whose minimum energetic expense suppose more than the 10% of the household income. There are many expenses that the household has to cover, and these costs increase when there are children forming the family unit, as they need book for school and similar. Then, the new Real Decreto 897/2017 is more than insufficient, it is a 37,7% of the total amount estimated that needs to be allocated, as it is equal to 709 million euros. Furthermore, this is only in terms of electricity. The project has concluded that special aids are needed too for the other basic streams (gas and water). Counting on the total euros that are needed to cover the costs required, the actual share is the next:

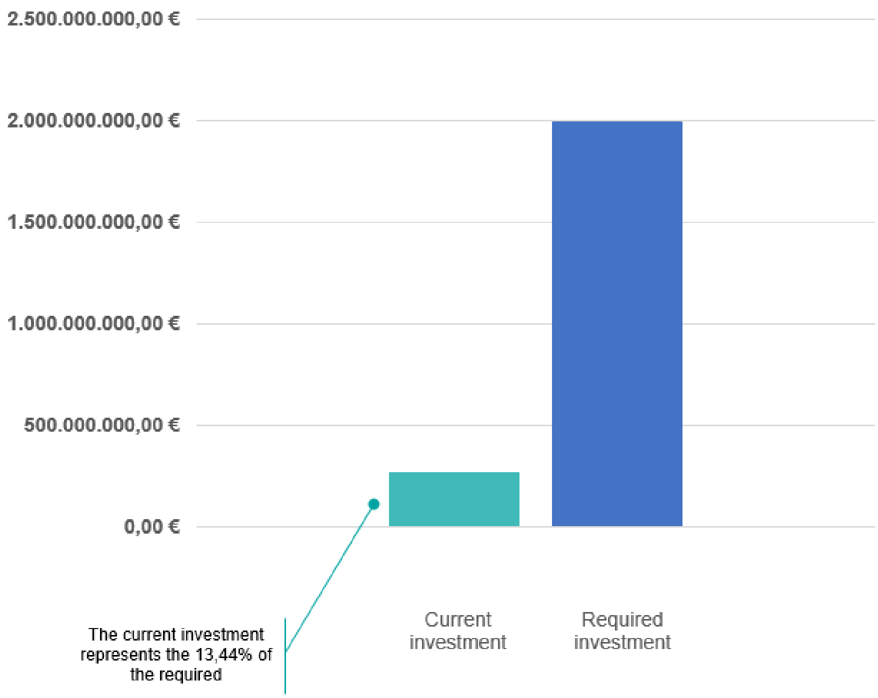

Figure 49. Current and required investments overall comparison

In addition, the costs to cover can be divided into the three streams, to see how much is needed for each case:

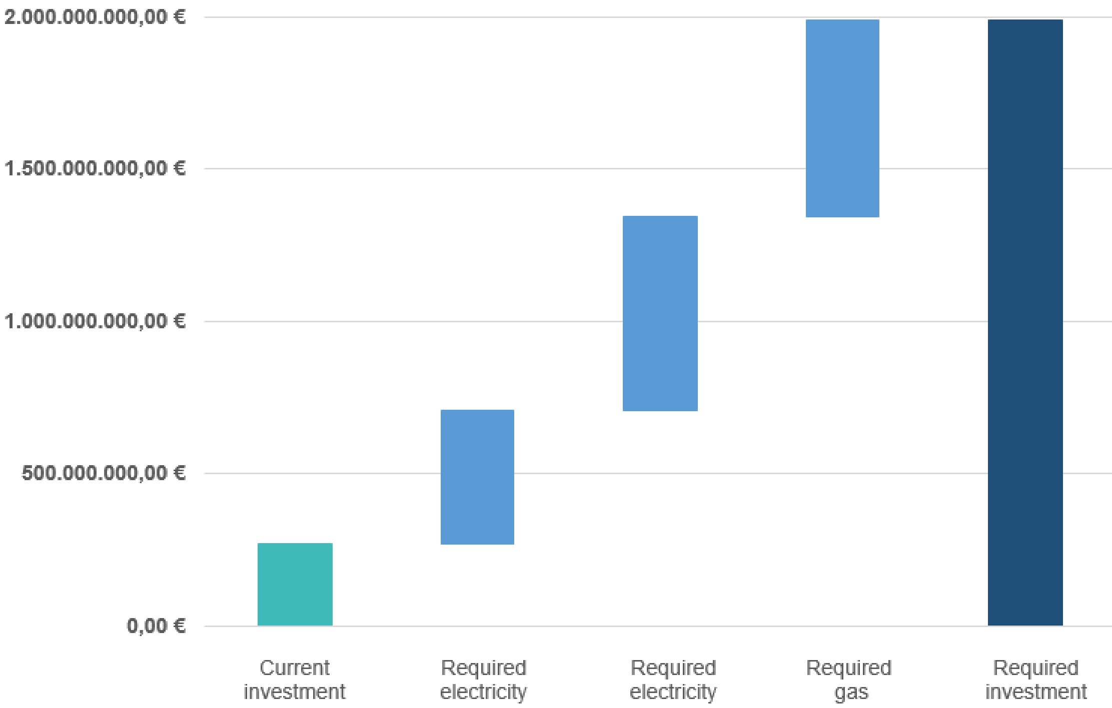

Figure 50. Segmentation of expenses to cover compared with the actual budget

As it is appreciated, in the case of Spain there is much to do yet. The main conclusion is that the investment has to increase and that the necessities also rely on water and gas, so new measures should be elaborated for the other two basic streams too.

On the other hand, and concerning the most affected households per region, the locations in which the aid should be greater are in Castilla y León and Castilla-La Mancha. The climate conditions are the factors that affect the most the consumptions. Places that need more heating to maintain the household at an adequate temperature are the ones that have to pay more, as it is obvious, because of greater gas or electricity consumption. Then, another issue to take into account about the bond is that if it is considering the minimum consumptions for the households, the aid should be different depending on the region. Places like Ávila or Burgos are receiving the same amount of money than places like Alicante or Huelva for example. Furthermore, the prize of water also changes the final monetary outputs, but the final difference between the regions is not as greater as for heating consumption, so, if that is a factor considered to change and standardize, it should be treated after more important problems.

Furthermore, the cases analyzed vary the results obtained with the excel tool. The addition of distinct constraints for the optimal case make the prizes increase in all the territory. Also, the heating systems based on electricity make the annual energy bill more expensive. This is important in terms of the social bond too. There exists a discrimination for the households that base their heating in electricity because the consumption will be greater than the others but the aid is the same. The establishment of maximum annual consumptions are the same for all types of households, and the is something that should be though about again. Average prizes for the basic case including gas are of 911,21 € and for only electricity are of 1.018,81 €. In the case of the optimal case, these values increase to 1.366,97 € and 1.538,53 € respectively. With these costs of energy, the indicator of the 10% gets the values of: 12,42%, 14,47%, 19,82% and 22,30%. Then, the optimal case is almost dismissed. It is very unreal to cover the optimal needs of the society when the basic indicator is of 12,42%. Because of this factor, it was much better to focus on the basic value first, approximately more than 1,5 million households cannot cover the costs.

It has been concluded also that the households in Spain waste a lot of energy in terms of resources when comparing with the minimum values that are necessary for a comfortable standard living condition. In the case of water, the average in the country reaches the value of 140.459,3 liters, what is 53% more than the minimum. In the case of electricity and gas, these values rise to 269% and 70% respectively. The case of electricity could be biased and represent a bit more of what is real, because the average of the country includes also households with electric heating systems that consume more than usual. However, it would be still greater than the minimum so the authorities could raise awareness of a fair use of the streams in order to decrease prizes due to the use of cheaper raw materials.

The excel tool has demonstrated its true potential. By following the structure explained in the chapter of methodology, and building a reliable database containing the demands for all the buildings of the Spanish regions included in the study, the possibilities that the tool offers are numerous. At first, it makes possible to convert into monetary units the consumptions of the households depending on region and habitants, what is a very deep level of segmentation that has many possibilities of analysis. Then, it returns the poverty indicator with the help of drop-down lists, what facilitates the use. Also, the data located in the database sheets is editable, and changes will be synchronized with the rest of the excel book. In conclusion, the tool is powerful and gives the user many possibilities.

Also related with the excel tool, it has to be said too that the macros facilitate the achievement of the valuable data. In the opinion of the author, it was much better to include commands associated with macros to get the desired results. With this, the user can perform different sensibility analysis. Also, the macros are left unprotected, so if further analysis is required, no problems at all will be found concerning the edition of the code.

Finally, it must be said that the initial objectives of the project have been successfully fulfilled and the author will of awareness with the huge problem of energy poverty in Spain has been fully expressed in the document.

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ANNEXES

9. Annexes

Annex 1. Demands for old buildings

Localidad	Demanda calefacción referencia unifamiliares kWh/m²	Demanda calefacción referencia bloques kWh/m²	Demanda refrigeración referencia unifamiliares kWh/m²	Demanda refrigeración referencia bloques kWh/m²	Demanda ACS referencia unifamiliares kWh/m²	Demanda ACS referencia bloques kWh/m²
Albacete	172,3	135,9	23,5	17,1	17,9	13,1
Alicante	76,9	49,2	40,9	29,4	16,8	12,3
Almería	44,7	36,5	46,8	33,7	16,6	12,1
Ávila	221,5	187,5			18,7	13,7
Badajoz	123,1	85,4	42,4	30,2	17,2	12,6
Barcelona	117,1	87,4	21,3	14,6	17,4	12,8
Bilbao	132,0	106,1			17,8	13,0
Burgos	234,2	193,6			18,8	13,8
Cáceres	109,7	92,5	46,9	33,5	17,3	12,7
Cádiz	50,7	33,7	36,1	25,7	16,7	12,3
Castellón	91,1	64,3	32,7	23,1	17,1	12,5
Ceuta	75,2	60,6	14,2	10,1	17,2	12,6
Ciudad Real	144,3	116,2	31,9	23,3	17,8	13,0
Córdoba	78,8	64,2	54,4	39,5	16,9	12,4
Cuenca	193,4	156,2	14,6	10,2	18,2	13,3
Girona	135,4	110,5	17,2	11,7	17,7	13,0
Granada	127,5	106,6	29,9	22,0	17,6	12,9
Guadalajara	146,9	132,2	19,2	13,8	17,9	13,1
Huelva	70,4	43,0	44,6	32,2	16,7	12,3
Huesca	171,5	137,9	20,7	14,5	17,9	13,1
Jaén	104,8	83,5	53,7	39,4	16,7	12,3
La Coruña	117,2	93,1			17,8	13,0
Las Palmas de Gran Canaria			27,7	19,6	16,2	11,8
León	223,8	179,1			18,6	13,6
Lérida	145,6	117,9	30,9	21,9	17,7	13,0
Logroño	166,0	132,2	15,9	10,8	17,9	13,2
Lugo	195,6	154,8			18,5	13,5
Madrid	149,8	121,2	26,5	19,1	17,7	13,0

Localidad	Demanda calefacción referencia unifamiliares kWh/m²	Demanda calefacción referencia bloques kWh/m²	Demanda refrigeración referencia unifamiliares kWh/m²	Demanda refrigeración referencia bloques kWh/m²	Demanda ACS referencia unifamiliares kWh/m²	Demanda ACS referencia bloques kWh/m²
Málaga	50,6	41,4	39,4	28,4	16,7	12,3
Melilla	45,0	31,6	35,3	25,1	16,7	12,2
Murcia	85,3	59,8	31,3	22,0	17,1	12,5
Ourense	136,2	105,4	16,0	10,5	17,7	13,0
Oviedo	152,4	122,8			18,1	13,3
Palencia	210,3	160,7			18,4	13,5
Palma de Mallorca	74,6	51,0	39,4	28,1	16,9	12,4
Pamplona	185,1	152,5			18,2	13,3
Pontevedra	109,6	86,1			17,5	12,9
Salamanca	220,4	161,0	8,0	4,9	18,4	13,5
San Sebastián	140,3	118,8			18,0	13,2
Santa Cruz de Tenerife			38,3	27,5	16,1	11,8
Santander	120,0	96,2			17,8	13,0
Segovia	188,1	162,0	11,0	7,6	18,3	13,5
Sevilla	64,4	52,9	56,4	41,2	16,7	12,3
Soria	232,6	187,1			18,7	13,7
Tarragona	82,3	62,8	41,0	28,9	17,0	12,4
Teruel	183,2	163,8	8,1	5,2	18,4	13,5
Toledo	132,1	106,2	45,9	33,4	17,4	12,8
Valencia	79,1	64,5	31,5	22,3	17,1	12,5
Valladolid	181,7	155,1	12,2	8,3	18,2	13,3
Vitoria	203,9	163,6			18,5	13,5
Zamora	213,3	148,4	13,8	9,7	18,1	13,3
Zaragoza	136,4	116,0	28,6	20,1	17,6	12,9

Values of demands for old buildings, blocks and detached houses

Source: IDAE. Instituto para la Diversificación y Ahorro de la Energía [21]

Annex 2. Demands for new buildings

Localidad	Demanda calefacción kWh/m²	Demanda refrigeración kWh/m²	Demanda ACS kWh/m²	Emisiones calefacción $kgCO_2/m^2$	Emisiones refrigeración $kgCO_2/m^2$	Consumo E. Primaria calefacción kWh/m²	Consumo E. Primaria refrigeración kWh/m²
Albacete	72.2	13.9	17.9	23.1	3.5	104.7	14.2
Alicante	23.0	24.2	16.8	7.4	6.1	33.4	24.7
Almería	19.8	27.7	16.6	6.3	6.9	28.7	28.3
Ávila	101.0	0.0	18.7	32.3	0.0	146.5	0.0
Badajoz	41.6	25.1	17.2	13.3	6.3	60.3	25.6
Barcelona	43.4	12.1	17.4	13.9	3.0	62.9	12.3
Bilbao	61.9	0.0	17.8	19.8	0.0	89.8	0.0
Burgos	113.1	0.0	18.8	36.2	0.0	164.0	0.0
Cáceres	48.4	27.8	17.3	15.5	7.0	70.2	28.4
Cádiz	17.2	21.4	16.7	5.5	5.4	24.9	21.8
Castellón	35.5	19.4	17.1	11.4	4.9	51.5	19.8
Ceuta	31.2	8.4	17.2	11.9	3.2	48.4	11.0
Ciudad Real	66.4	18.9	17.8	21.2	4.7	96.3	19.3
Córdoba	38.3	32.2	16.9	12.3	8.1	55.5	32.8
Cuenca	89.3	8.3	18.2	28.6	2.1	129.5	8.5
Gerona	63.7	9.8	17.7	20.4	2.5	92.4	10.0
Granada	55.9	17.7	17.6	17.9	4.4	81.1	18.1
Guadalajara	74.8	11.4	17.9	23.9	2.9	108.5	11.6
Huelva	21.5	26.4	16.7	6.9	6.6	31.2	26.9
Huesca	74.6	11.7	17.9	23.9	2.9	108.2	11.9
Jaén	39.9	31.8	16.7	12.8	8.0	57.9	32.4
La Coruña	46.6	0.0	17.8	14.9	0.0	67.6	0.0
Las Palmas de G. C.	9.3	16.4	16.2	3.5	6.2	14.4	21.5
León	95.7	0.0	18.6	30.6	0.0	138.8	0.0
Lérida	62.3	18.3	17.7	19.9	4.6	90.3	18.7
Logroño	70.8	9.0	17.9	22.7	2.3	102.7	9.2
Lugo	89.5	0.0	18.5	28.6	0.0	129.8	0.0
Madrid	64.4	15.7	17.7	20.6	3.9	93.4	16.0
Málaga	24.2	23.3	16.7	7.7	5.8	35.1	23.8
Melilla	17.5	20.9	16.7	6.7	7.9	27.1	27.4
Murcia	33.0	18.5	17.1	10.6	4.6	47.9	18.9
Orense	66.1	9.1	17.7	21.2	2.3	95.8	9.3
Oviedo	73.1	0.0	18.1	23.4	0.0	106.0	0.0
Palencia	90.0	0.0	18.4	28.8	0.0	130.5	0.0
P. de Mallorca	25.1	23.3	16.9	9.5	8.9	38.9	30.5
Pamplona	85.3	0.0	18.2	27.3	0.0	123.7	0.0

Localidad	Demanda calefacción kWh/m²	Demanda refrigeración kWh/m²	Demanda ACS kWh/m²	Emisiones calefacción $kgCO_2/m^2$	Emisiones refrigeración $kgCO_2/m^2$	Consumo E. Primaria calefacción kWh/m²	Consumo E. Primaria refrigeración kWh/m²
Pontevedra	41.2	0.0	17.5	13.2	0.0	59.7	0.0
Salamanca	91.1	4.5	18.4	29.2	1.1	132.1	4.6
San Sebastián	71.4	0.0	18.0	22.8	0.0	103.5	0.0
Santander	51.3	0.0	17.8	16.4	0.0	74.4	0.0
S. C. de Tenerife	9.3	22.7	16.1	3.5	8.6	14.4	29.7
Segovia	96.4	6.2	18.3	30.8	1.6	139.8	6.3
Sevilla	27.9	33.4	16.7	8.9	8.4	40.5	34.1
Soria	105.4	0.0	18.7	33.7	0.0	152.8	0.0
Tarragona	36.0	24.3	17.0	11.5	6.1	52.2	24.8
Teruel	94.4	4.6	18.4	30.2	1.2	136.9	4.7
Toledo	58.4	27.2	17.4	18.7	6.8	84.7	27.7
Valencia	35.5	18.7	17.1	11.4	4.7	51.5	19.1
Valladolid	89.7	6.9	18.2	28.7	1.7	130.1	7.0
Vitoria	97.0	0.0	18.5	31.0	0.0	140.7	0.0
Zamora	83.1	7.8	18.1	26.6	2.0	120.5	8.0
Zaragoza	60.6	16.9	17.6	19.4	4.2	87.9	17.2

Values of demands for new buildings, detached houses

Source: IDAE. Instituto para la Diversificación y Ahorro de la Energía [20]

Localidad	Demanda calefacción kWh/m²	Demanda refrigeración kWh/m²	Demanda ACS kWh/m²	Emisiones calefacción $kgCO_2/m^2$	Emisiones refrigeración $kgCO_2/m^2$	Consumo E. Primaria calefacción kWh/m²	Consumo E. Primaria refrigeración kWh/m²
Albacete	49.1	9.7	13.1	15.7	2.4	71.2	9.9
Alicante	13.2	16.7	12.3	4.2	4.2	19.1	17.0
Almería	10.8	19.1	12.1	3.5	4.8	15.7	19.5
Ávila	69.5	0.0	13.7	22.2	0.0	100.8	0.0
Badajoz	27.4	17.1	12.6	8.8	4.3	39.7	17.4
Barcelona	28.3	8.0	12.8	9.1	2.0	41.0	8.2
Bilbao	40.0	0.0	13.0	12.8	0.0	58.0	0.0
Burgos	77.1	0.0	13.8	24.7	0.0	111.8	0.0
Cáceres	32.1	19.0	12.7	10.3	4.8	46.5	19.4
Cádiz	9.0	14.6	12.3	2.9	3.7	13.1	14.9
Castellón	21.4	13.1	12.5	6.8	3.3	31.0	13.4
Ceuta	18.3	5.7	12.6	7.0	2.2	28.4	7.5
Ciudad Real	45.0	13.2	13.0	14.4	3.3	65.3	13.5
Córdoba	23.5	22.4	12.4	7.5	5.6	34.1	22.8
Cuenca	60.9	5.6	13.3	19.5	1.4	88.3	5.7

Localidad	Demanda calefacción kWh/m²	Demanda refrigeración kWh/m²	Demanda ACS kWh/m²	Emisiones calefacción $kgCO_2/m^2$	Emisiones refrigeración $kgCO_2/m^2$	Consumo E. Primaria calefacción kWh/m²	Consumo E. Primaria refrigeración kWh/m²
Gerona	42.4	6.4	13.0	13.6	1.6	61.5	6.5
Granada	37.4	12.5	12.9	12.0	3.1	54.2	12.8
Guadalajara	50.4	7.8	13.1	16.1	2.0	73.1	8.0
Huelva	12.6	18.3	12.3	4.0	4.6	18.3	18.7
Huesca	50.6	7.9	13.1	16.2	2.0	73.4	8.1
Jaén	26.2	22.3	12.3	8.4	5.6	38.0	22.7
La Coruña	30.0	0.0	13.0	9.6	0.0	43.5	0.0
Las Palmas de G. C.	3.5	11.1	11.8	1.3	4.2	5.4	14.5
León	65.5	0.0	13.6	21.0	0.0	95.0	0.0
Lérida	42.0	12.4	13.0	13.4	3.1	60.9	12.6
Logroño	47.4	5.9	13.2	15.2	1.5	68.7	6.0
Lugo	60.2	0.0	13.5	19.3	0.0	87.3	0.0
Madrid	43.2	10.8	13.0	13.8	2.7	62.6	11.0
Málaga	13.4	16.1	12.3	4.3	4.0	19.4	16.4
Melilla	9.3	14.2	12.2	3.5	5.4	14.4	18.6
Murcia	19.8	12.5	12.5	6.3	3.1	28.7	12.8
Orense	43.2	5.7	13.0	13.8	1.4	62.6	5.8
Oviedo	48.3	0.0	13.3	15.5	0.0	70.0	0.0
Palencia	61.2	0.0	13.5	19.6	0.0	88.7	0.0
P. de Mallorca	14.4	15.9	12.4	5.5	6.0	22.3	20.8
Pamplona	57.5	0.0	13.3	18.4	0.0	83.4	0.0
Pontevedra	26.5	0.0	12.9	8.5	0.0	38.4	0.0
Salamanca	62.3	2.7	13.5	19.9	0.7	90.3	2.8
San Sebastián	46.9	0.0	13.2	15.0	0.0	68.0	0.0
Santander	33.0	0.0	13.0	10.6	0.0	47.9	0.0
S. C. de Tenerife	3.5	15.6	11.8	1.3	5.9	5.4	20.4
Segovia	65.7	4.2	13.5	21.0	1.1	95.3	4.3
Sevilla	16.6	23.4	12.3	5.3	5.9	24.1	23.9
Soria	72.1	0.0	13.7	23.1	0.0	104.5	0.0
Tarragona	21.8	16.4	12.4	7.0	4.1	31.6	16.7
Teruel	64.5	2.8	13.5	20.6	0.7	93.5	2.9
Toledo	39.0	18.9	12.8	12.5	4.7	56.6	19.3
Valencia	21.3	12.6	12.5	6.8	3.2	30.9	12.9
Valladolid	60.6	4.5	13.3	19.4	1.1	87.9	4.6
Vitoria	65.4	0.0	13.5	20.9	0.0	94.8	0.0
Zamora	56.3	5.3	13.3	18.0	1.3	81.6	5.4
Zaragoza	40.6	11.4	12.9	13.0	2.9	58.9	11.6

Values of demands for new buildings, block of flats

Source: IDAE. Instituto para la Diversificación y Ahorro de la Energía [20]

Annex 3. Classification of regions per climate conditions

Tabla B.1.- Zonas climáticas de la Península Ibérica

Zonas climáticas Península Ibérica																		
Capital	**Z.C.**	**Altitud**	**A4**	**A3**	**A2**	**A1**	**B4**	**B3**	**B2**	**B1**	**C4**	**C3**	**C2**	**C1**	**D3**	**D2**	**D1**	**E1**
Albacete	D3	677										h < 450			h < 950			h ≥ 950
Alicante/Alacant	B4	7					h < 250					h < 700			h ≥ 700			
Almería	A4	0	h < 100				h < 250	h < 400				h < 800			h ≥ 800			
Ávila	E1	1054														h < 550	h < 850	h ≥ 850
Badajoz	C4	168									h < 400	h < 450			h ≥ 450			
Barcelona	C2	1											h < 250			h < 450	h < 750	h ≥ 750
Bilbao/Bilbo	C1	214												h < 250			h ≥ 250	
Burgos	E1	861															h < 600	h ≥ 600
Cáceres	C4	385									h < 600				h < 1050			h ≥ 1050
Cádiz	A3	0		h < 150				h < 450				h < 600	h < 850			h ≥ 850		
Castellón/Castelló	B3	18						h < 50				h < 500			h < 600	h < 1000		h ≥ 1000
Ceuta	B3	0						h < 50										
Ciudad Real	D3	630									h < 450	h < 500			h ≥ 500			
Córdoba	B4	113					h < 150				h < 550				h ≥ 550			
Coruña, La/ A Coruña	C1	0												h < 200			h ≥ 200	
Cuenca	D2	975													h < 800	h < 1050		h ≥ 1050
Gerona/Girona	D2	143											h < 100			h < 600		h ≥ 600
Granada	C3	754	h < 50				h < 350				h < 600	h < 800			h < 1300			h ≥ 1300
Guadalajara	D3	708													h < 950	h < 1000		h ≥ 1000
Huelva	A4	50	h < 50				h < 150	h < 350				h < 800			h ≥ 800			
Huesca	D2	432										h < 200			h < 400	h < 700		h ≥ 700
Jaén	C4	436					h < 350				h < 750				h < 1250			h ≥ 1250
León	E1	346																h < 1250
Lérida/Lleida	D3	131										h < 100			h < 600			h ≥ 600
Logroño	D2	379											h < 200			h < 700		h ≥ 700
Lugo	D1	412															h < 500	h ≥ 500
Madrid	D3	589										h < 500			h < 950	h < 1000		h ≥ 1000
Málaga	A3	0						h < 300				h < 700			h ≥ 700			
Melilla	A3	130																
Murcia	B3	25						h < 100				h < 550			h ≥ 550			
Orense/Ourense	D2	327										h < 150	h < 300			h < 800		h ≥ 800
Oviedo	D1	214												h < 50			h < 550	h ≥ 550
Palencia	D1	722															h < 800	h ≥ 800
Palma de Mallorca	B3	1						h < 250				h ≥ 250						
Pamplona/Iruña	D1	456											h < 100			h < 300	h < 600	h ≥ 600
Pontevedra	C1	77												h < 350			h ≥ 350	
Salamanca	D2	770														h < 800		h ≥ 800
San Sebastián/Donostia	D1	5															h < 400	h ≥ 400
Santander	C1	1												h < 150			h < 650	h ≥ 650
Segovia	D2	1013														h < 1000		h ≥ 1000
Sevilla	B4	9					h < 200				h ≥ 200							
Soria	E1	984														h < 750	h < 800	h ≥ 800
Tarragona	B3	1						h < 50				h < 500			h ≥ 500			
Teruel	D2	995										h < 450	h < 500			h < 1000		h ≥ 1000
Toledo	C4	445									h < 500				h ≥ 500			
Valencia/València	B3	8						h < 50				h < 500				h < 950		h ≥ 950
Valladolid	D2	704														h < 800		h ≥ 800
Vitoria/Gasteiz	D1	512															h < 500	h ≥ 500
Zamora	D2	617														h < 800		h ≥ 800
Zaragoza	D3	207										h < 200			h < 650			h ≥ 650
Capital	**Z.C.**	**Altitud**	**A4**	**A3**	**A2**	**A1**	**B4**	**B3**	**B2**	**B1**	**C4**	**C3**	**C2**	**C1**	**D3**	**D2**	**D1**	**E1**

Classification of the regions following the normative depending on climate conditions

Source: Section HE 1 of the building regulations [36]

Annex 4. Social bond maximum consumptions and constraints

Categorías	Límites máximos al consumo (kWh)
Unidad familiar sin menores /demandante individual.	1.200
Unidad familiar con un menor.	1.680
Unidad familiar con dos menores.	2.040
Unidad familiar familias numerosas	3.600
Unidad familiar /demandante individual - pensionistas (cuantía mínima)	1.680

Limits established for consumptions

Source: Real Decreto 897/2017 [5]

CAPÍTULO II

Consumidor vulnerable

Artículo 3. *Definición de consumidor vulnerable.*

1. A los efectos de este real decreto y demás normativa de aplicación, tendrá la consideración de consumidor vulnerable el titular de un punto de suministro de electricidad en su vivienda habitual que, siendo persona física, esté acogido al precio voluntario para el pequeño consumidor (PVPC) y cumpla los restantes requisitos del presente artículo.
2. Para que un consumidor de energía eléctrica pueda ser considerado consumidor vulnerable, deberá cumplir alguno de los requisitos siguientes:

a) Que su renta o, caso de formar parte de una unidad familiar, la renta conjunta anual de la unidad familiar a que pertenezca sea igual o inferior:

– a 1,5 veces el Indicador Público de Renta de Efectos Múltiples (IPREM) de 14 pagas, en el caso de que no forme parte de una unidad familiar o no haya ningún menor en la unidad familiar;
– a 2 veces el índice IPREM de 14 pagas, en el caso de que haya un menor en la unidad familiar;
– a 2,5 veces el índice IPREM de 14 pagas, en el caso de que haya dos menores en la unidad familiar.

A estos efectos, se considera unidad familiar a la constituida conforme a lo dispuesto en la Ley 35/2006, de 28 de noviembre, del Impuesto sobre la Renta de las Personas Físicas y de modificación parcial de las leyes de los Impuestos sobre Sociedades, sobre la Renta de no Residentes y sobre el Patrimonio.

b) Estar en posesión del título de familia numerosa.

c) Que el propio consumidor y, en el caso de formar parte de una unidad familiar, todos los miembros de la misma que tengan ingresos, sean pensionistas del Sistema de la Seguridad Social por jubilación o incapacidad permanente, percibiendo la cuantía mínima vigente en cada momento para dichas clases de pensión, y no perciban otros ingresos.

Constraints to fulfill to apply for the social bond

Source: Real Decreto 897/2017 [5]