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MASTER IN THE ELECTRIC POWER INDUSTRY

BASIC ENERGY CONSUMPTIONS FOR THE ENERGY POVERTY STUDIES IN SPAIN

Author: Ignacio García-Atance
Supervisor: D. Pablo Frías
Co-Supervisor: D. Lorenzo Simons

Madrid
June 2017

Master's Thesis Presentation Authorization

THE STUDENT:

Ignacio García-Atance García

....

THE SUPERVISOR

D. Pablo Frías

Signed: .... Date: 26/ 06/ 2017

THE CO-SUPERVISOR

D. Lorenzo Simons

Signed: .... Date: 26/ 06/ 2017

Authorization of the Master's Thesis Coordinator

Dr. Luis Olmos Camacho

Signed: .... Date: 26/ 06/ 2017

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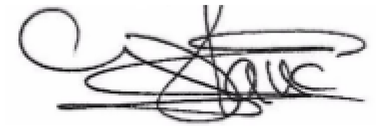

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Basic energy consumptions for the energy poverty studies in Spain
Author: Ignacio García-Atance García
Director: Dr. Pablo Frías
Co-Director: Lorenzo Simons

ABSTRACT:

The project context is the energy poverty. This theme is very actual and has a lot of social repercussion nowadays as electricity and gas price volatility has affected too many humble people in Europe. People, governments and utilities are becoming more and more aware of the magnitude of the penetration of energy poverty in the society and the efforts to reduce it have never been as many as now.

The energy services are essential for a country, for its development and the welfare of its population. For example, electricity consumption is strongly related with the GDP growth of a country.

The main energetic vectors that concern the energy poverty are the access and consumption of electricity, gas and heat water. These energy vectors are essential to have a decent household habitability. Despite so, it is estimated that 1.2billion people still do not have to electricity. These people are distributed mainly over Africa and Asia and with a higher proportion in rural areas.

Two important figures to have in mind are that 17% of global population do not have electricity and 38% of global population do not have cooking facilities.

There are two essential parts concerning the energy poverty, the energy access and the energy consumption, i.e. people not having the opportunity to consume electricity, gas or heat water because the grid is not developed to meet them, and the people who despite having the connection cannot consume because they are not able to pay for the cost of the consumption.

In the case of Spain, geographical target of this study, the energy access is universal and is considered as a solved issue and the energy poverty was thought to be linked with the economic crisis despite it existed before too.

The reality of the energy poverty has motivated and maintained the community doing studies around the topic despite the difficulties due to the little resource availability. To promote an effective and useful debate about the different possible solutions, to identify and imply the different agents and actors including the public administrations, the media, the energy utilities and the political parties among others.

The objective of the study is to calculate the basic energy consumptions in Spain under different scenarios. These consumptions will be used to develop and analyse projects and strategies to mitigate the energy poverty.

To achieve so, there are many variables that have to be determined and studies for different scenarios to study the energy needs to meet a worthy habitability in order to keep the household heated during the winter and cooled during the summer, to have energy to cook and do the normal living.

So, the project's main objective is the development of a tool to compute different energy poverty scenarios and quantify in monetary terms the subsidies that would be needed to cover the problem break down into autonomous communities, provinces and rural and urban area.

There must be a distinction between the water, electricity and gas expenses taking into account the different demands and consumes of the different regions in Spain.

The program has been developed in Excel due to the simplicity of the programming and the capacity to be easily extended during and after the project.

In the excel tool there are many freedom degrees in order to let the user create cases regarding its needs. For this purpose, there have been added especially modifiable quantities marked in pink in the general data sheet. These variables are:

Water consumption: the frequency and quantities of water consumption can be modified in order to create different water consumption profiles.

Cooking frequency: the number of cooks per week can be modified to adapt it to the case of study desired.

Television and computer: the frequency and hours can be modified to create different consumption profiles.

Fixed cost of water: due to the fact that it was too complex to take into account each water supply company, the different bills have been simplified with a variable term plus a fix term as it was explained before. The fixed term depends on the company and thus has been let free to change as a variable of the case.

Electricity contracted power: contracted electricity power. Normally with a contracted power of 3.3kW of electric capacity is enough to cover the peak demand, but the term has been let variable to generate different cases.

Electricity price: the electricity price is very volatile depending on the weather, costs of fuel etc. It is interesting to see how its different prices may affect energy poverty and quantify it.

Social bonus: the social bonus is already acting and thus, it has been let free to be able to quantify the energy poverty with and without its effect.

Size of the household: the size of the household is modifiable; for the base case the size has been extracted from the minimum habitability cellule, but it has been let free to generate different cases. The size of the household is directly related to the heat and air conditioning consumptions.

Heating coefficient: gives the percentage of the heated surface of the household in the optimal case. For the base case, it is only considered to have 20m2 of heated surface.

Air conditioned surface: gives the possibility to modify the air-conditioned surface to create new scenarios or compute its effect.

Percentage of energy poverty to cover: gives the possibility to adjust the percentage of the households that is under energy poverty whose energy expenses are going to be take into account to be covered.

Gas penetration coefficient: this coefficient affects the hypothesis of the gas penetration. Let it in 0 the penetration of the gas is only in the urban areas, but if it is higher than 0 there exist buildings with gas in the rural areas. This tool allows the creation of new scenarios and is interesting to see how the gas penetration affects energy poverty.

Energy efficiency factor: this factor can take values from 0 to 5. If 1, then the efficiency is the one extracted from the studies and used in the base case. If 0, all the buildings are considered old and thus, with bad efficiency characteristics. The higher the value, the higher the proportion of new buildings with better efficiency characteristics.

It is essential to mention another useful tool used to show the results in a summarized way. The map of Spain with the different provinces also developed in Excel allows to show the values of anything, for example, demands, water cost, electricity costs, etc. in a simple way.

[Source: Blog "Análisis y decision." http://analisisydecision.es/nuevo-y-muy-mejorado-mapa-de-espana-por-provincias-con-excel/]

Given the base case consumption profile and hypothesis, and having the actual image of Spain in terms of distribution of population in rural and urban areas, the gas penetration, the population of the different cities and provinces and the reference demands, the expenses that the State should dispose in order to cover the total of the energy vulnerability should be the ones shown in the table below.

	BASIC				
€	Urban			Rural	
AUTONOMOUS COMMUNITY	Elect	Gas	Water	Elect	Water
Navarra	158631	145494	149699	330301	118798
Ceuta	192548	132534	159886	6613	2667
Andalucía	2637132	1797257	3239316	2385711	1384007
Aragón	334481	292319	358920	1075059	461534
Asturias	348811	296506	390593	490234	223350
Cantabria	244336	188553	274089	124042	61434
Castilla y León	732317	706630	667723	2547474	854978
Castilla-La Mancha	435003	372378	426959	1386760	530971
Cataluña	2108116	1632127	2859995	3209067	1749347
Extremadura	265129	204498	287261	825165	392754
Galicia	699062	556937	635039	2010955	733887
La Rioja	111641	95257	107322	163857	63853
Melilla	20463	12810	17016	59	26
Islas Baleares	349455	235180	501187	330777	234808
País Vasco	680169	591217	646766	454025	163644
Canarias	650746	357814	793791	413751	288477
Comunidad de Madr	2166989	1832604	2241945	383487	162153
Región de Murcia	520416	355699	831071	266659	208010
Comunidad Valencia	712994	499377	914428	336721	206772
TOTAL	13368437	10305191	15503008	16740717	7841470
TOTAL ANNUAL	160421250	123662297	186036096	200888603	94097644
	TOTAL URBAN			TOTAL RURAL	
		ubano	470119643	rural	294986247
	TOTAL BASIC				
	765105891				

Total expenses to cover completely the vulnerable consumers expenses by Autonomous Communities

Given the absence of direct policies to combat energy poverty by the central government beyond this incomplete social bond, it is at the regional and municipal levels that we find the most relevant initiatives. We highlight the case of the Generalitat of Catalonia that, for just over a year and a half, is working with the central government in relation to a regulation on energy poverty. This work aimed to establish a winter truce between November and March, both included, so that the energy supply (water, electricity and gas) would not be interrupted to families in vulnerable situation.

The Social Inclusion Plan of the Government of Andalusia includes an Extraordinary Program for vital minimum supplies and social emergency benefits. The program is endowed with 6.5 million euros and will be carried out through transfers to municipalities. Specific costs are considered to cover basic energy supplies, electricity costs and expenses related to water supply.

On the other hand, the budget in the Basque Country includes a budget of 200,000 euros to cover the needs of families who cannot cope with energy bills, although the mechanisms for allocating this item have not yet been defined. It is important to note that this is in addition to social emergency aid, which includes energy bills by law.

Finally, the Xunta de Galicia has just launched the second call for its social electric ticket with a budget of 1.5 million euros. The aid, which is requested for half-year, is 180 euros for families with one or two children (under 18 years) and 300 euros for large families.

As it can be seen, the actual measures are insufficient. It has to be taken into account that the numbers shown in the previous table are the sum of the expenses for all the vulnerable consumers, and not only the ones suffering energy poverty. In addition, it has to be mentioned that finally not all the people under energy poverty would ask for the aid due to lack of information etc.

Analysing in further detail the two existing measures regarding direct payments to cover energy invoices:

The Basque Country only destinies 200.000€ to fight the energy poverty. The amount calculated for the vulnerable consumers is 19.2 million euros per year for all the electricity and gas consumptions but taking into account all the vulnerable consumers. Despite this number is overestimated because not all the vulnerable consumers will suffer from energy poverty and neither all of them will ask for the aid, the amount designated is considered lower than the real amount needed.

The Xunta de Galicia designates 1.5million euros to fight the energy poverty in the electricity and gas concepts. The calculated amount to cover the energy vulnerable consumers in Galicia is around 20 million euros per year. As in the above case, this includes all the expenses in electricity and gas taking into account all the vulnerable population of Galicia. The amount is small compared to the needs because estimating with the energy poverty percentage the amount needed is around 10 million euros.

Finally, it is important to point out that the payment of the unpaid invoice does not solve the root problem, it merely alleviates a situation of vulnerability which, with few exceptions, is not only a temporary problem of the home, but a chronic situation in time. For this reason, it is thought that this type of measures must be accompanied by other measures of greater depth that allow to mitigate Energy poverty. However, it must be realized that certain situations of social urgency require funds to be allocated to measures that, although mitigating, are those that can be implemented more quickly and those that allow an emergency to be dealt with immediately.

Basic energy consumptions for the energy poverty studies in Spain

Alumno:
Ignacio García-Atance
+34 634 504 934
Igarcia.atance@gmail.com

Director:
Dr. Pablo Frías
Co-Director:
Lorenzo Simons

UNIVERSIDAD PONTIFICIA COMILLAS
Escuela Técnica Superior de Ingeniería (ICAI)
Official Master´s Degree in the Electric Power Industry

THESIS

Basic energy consumptions for the energy poverty studies in Spain

Author: García-Atance García, Ignacio
Director: Dr. Pablo Frías
Co-Director: Lorenzo Simons

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THESIS

1. INTRODUCTION

This project is developed in collaboration with the IIT, Instituto de Investigación Tecnológica. The tutor of the project has been Dr. Pablo Frías and Lorenzo Simons.

The project has been developed as the master thesis of the Official Masrter's Degree in the Electricity Power Industry, in the second year of a double master program MII+MEPI at the University of Comillas, ICAI, Instituto Católico de Artes e Industria.

The project context is the energy poverty. This theme is very actual and has a lot of social repercussion nowadays as electricity and gas price volatility has affected too many humble people in Europe. People, governments and utilities are becoming more and more aware of the magnitude of the penetration of energy poverty in the society and the efforts to reduce it have never been as many as now.

1.1 INTRODUCTION TO THE ENERGY POVERTY

Energy poverty is nowadays getting more and more recognition as a problem with its own entity. The public administrations are recognizing the problem and focusing efforts to eradicate it at the local and municipal levels especially with no remarkable enough actions taken at the country level.

The energy services are essential for a country, for its development and the welfare of its population. For example, electricity consumption is strongly related with the GDP growth of a country.

The main energetic vectors that concern the energy poverty are the access and consumption of electricity, gas and heat water. These energy vectors are essential to have a decent household habitability. Despite so, it is estimated that 1.2billion people still do not have to electricity. These people are distributed mainly over Africa and Asia and with a higher proportion in rural areas.

Two important figures to have in mind are that 17% of global population do not have electricity and 38% of global population do not have cooking facilities.

There are two essential parts concerning the energy poverty, the energy access and the energy consumption, i.e. people not having the opportunity to consume electricity, gas or heat water because the grid is not developed to meet them, and the people who despite having the connection cannot consume because they are not able to pay for the cost of the consumption.

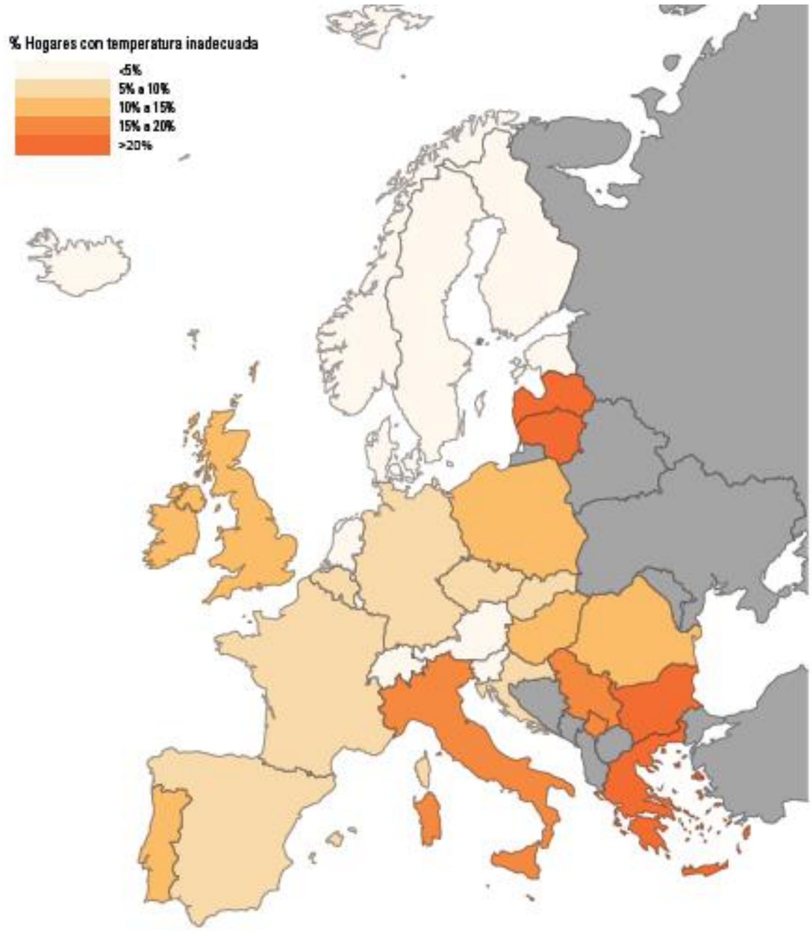

Figure 1: Percentage of households unable to maintain an adequate temperature

[Source: Pobreza energética en España. Análisis económico y propuestas de actuación. (Economics for Energy, Vigo, 2014)]

This figure shows the current situation of Europe regarding one feature of the energy poverty, the capacity to maintain an adequate temperature in the household to be able to do the normal activities. It is alarming that there are countries like Italy where around 20% of the households are under this hazard.

In the case of Spain, geographical target of this study, the energy access is universal and is considered as a solved issue and the energy poverty was thought to be linked with the economic crisis despite it existed before too.

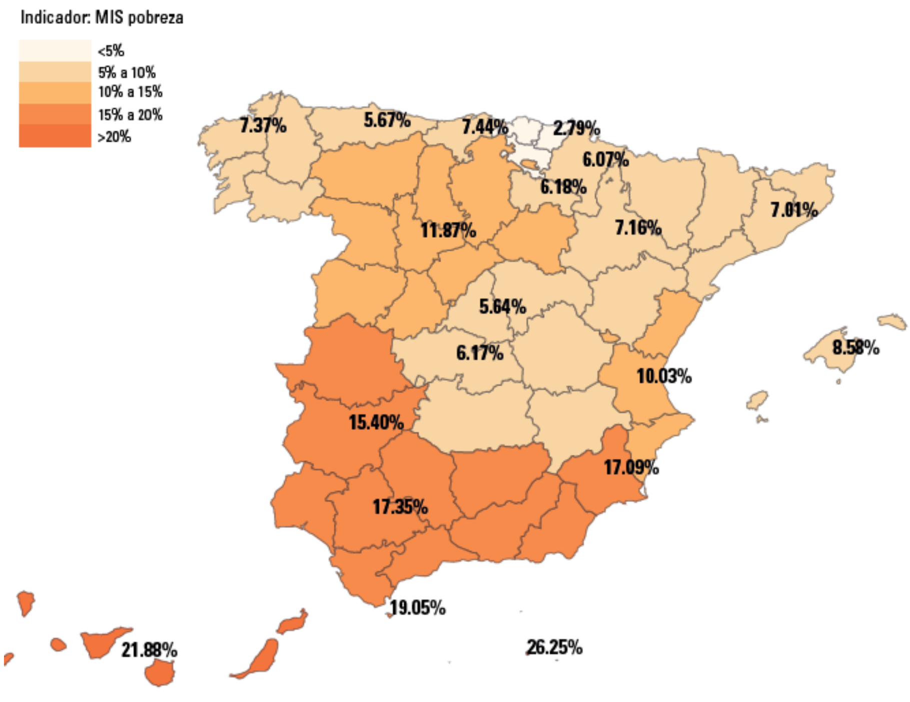

Figure 2: Energy poverty in Spain according MIS indicator

[Source: Pobreza energética en España. Análisis económico y propuestas de actuación. (Economics for Energy, Vigo, 2014)]

In this figure, it can be seen that the current situation of Spain is alarming and that the energy poverty is a problem that affects around 10% of the population. It also shows that it is not equally distributed, being more serious in the South.

Energy poverty is defined as the direct consequence of the energy vulnerability; this other concept is defined as the probability of a household of not receiving the necessary amount of energy services.

This new focus explains the energy poverty as a temporal condition caused by general structural and relevant factors besides the traditional ones like household income, energy prices, energy efficiency etc.

The motivation of this project relies on the actuality of the energy poverty in Spain and its recognition by the society, by the government and the companies belonging to the electric and gas sector.

The energy poverty is a vast topic and therefore many studies have been carried out, but it is considered that there are very few studies that give an easy-handling quantitative focus, i.e. a tool able to provide results of the quantification of the effects of the energy poverty and its solutions in a way that non-experts can understand and use.

The developments of these kind of tools is essential in the correct decision making that is being done towards the eradication of the energy poverty.

1.2 Motivation of the project

The reality of the energy poverty has motivated and maintained the community doing studies around the topic despite the difficulties due to the little resource availability. To promote an effective and useful debate about the different possible solutions, to identify and imply the different agents and actors including the public administrations, the media, the energy utilities and the political parties among others.

The sum of efforts from numerous organizations, collectives from all kind, professionals, institutions, and media summing their sand grain to generate new studies, boosting networks, developing projects, proposals, formation procedures, informative material etc. Have elaborated a net each time bigger and interconnected of information that has enabled to give efficient results born from a collective effort.

The political parties have presented almost in their totality their proposals to fight against the energy poverty both in the general elections of December 2015 such as in the autonomous elections in May 2015. Today there are many administrations that are executing measures or initiating to plan them, and the government will probably have the obligation to undertake measures co-ordinately with the rest of administrations.

The effects of conditions associated with energy poverty on human health have been studied and documented extensively for decades. According to a World Health Organization (WHO) study published in 1987 on the impacts of cold inside the homes concluded that there are no risks for sedentary and healthy people in a temperature range between 18 and24ºC.
And recognized a greater vulnerability of certain groups such as the very old and very young, the sick and the disabled, for which a temperature of not less than 20 ºC was recommended (WHO, 1987).

The increase in winter mortality rates is possibly the most well-known health effect of energy poverty. It is known that living in a house with temperatures below recommended levels is related to an increased risk of respiratory and cardiovascular diseases, a cause of the seasonal increase in mortality during the winter months among the elderly. This is what is known as additional winter mortality. Although only a fraction of the additional deaths produced in winter are strictly attributable to energy poverty, their correlation with the energy efficiency of residential buildings and house temperatures appears to be well established (The Eurowinter Group 1997, Wilkinson et al., 2001 World Health Organization, 2011).

1.3 Objectives

The project has one main objective and several secondary objectives that are necessary for the consecution of the main one or complement it.

The main objective of the study is the development of a tool that enables the calculation of the basic energy consumptions in Spain under different scenarios. As a secondary step, these consumptions will be used to develop and analyse projects and strategies to mitigate the energy poverty.

To achieve so, there are many variables that have to be determined and studies for different scenarios to study the energy needs to meet a worthy habitability in order to keep the household heated during the winter and cooled during the summer, to have energy to cook and do the normal living.

These variables will be studied for both electricity and gas energetic vectors and water consumption.

Some of the affecting variables that will be taken as explanatory variables are:

Energy efficiency of the household: The energetic efficiency of a household is directly linked with the amount of energy needed to warm-up and cool down the spaces and to keep a certain desired temperature and thus, directly linked with the energetic poverty.

Average winter/summer temperatures of the area: The outside temperature is directly linked with the temperature gradient that has to be maintained between the household and the environment, the bigger the gradient, the bigger the amount of energy to be used.

Average age of the population: The age of the population is useful to determine their approximated activity profiles and their habits.

Average number of people living in each household: Families having children will have different consumption patterns and higher energy consumptions.

Population consumption profiles: Average energy consumption profiles.

Average number of household appliances and types: Households having air conditioner, electric cooking, and electric water heating may have different consumption profiles.

Gas penetration: The availability to consume gas by pipe or by gas bottles, or the need of electric heating and cooking.

Geographic area: These variables may differ from one location to another, so different specific areas will be taken into account.

The development of a tool using an excel sheet is also scheduled as an objective; this tool will be used in further studies to provide particular information concerning different actions that may be taken to prevent and eradicate the energy poverty in Spain.

To sum up, the main objectives are:

-Summarize the variables that are explanatories for the energy poverty.

-Define scenarios that may be find in Spain.

-Calculate the values associated to the variables for the different scenarios.

-Develop a tool using this information.

-Calculate some basic scenarios to prove the tool.

-Extract conclusions.

2. Review of the energy poverty studies

This chapter gives a quick view of the status of the energy poverty topic and situates the project in its context.

2.1 Previous studies

There exist many other opportunities to develop in parallel. Among them, the improvement of the habitability conditions of the Spanish households, to take advantage the maximum the processes of energetic rehabilitation of the buildings and the urban renovation boosted by the European policies, to rethink the necessity of the energetic transition from the energy poverty perspective, to attend the European and international obligations in the field of climate change and energy efficiency, to generate now and innovative social support networks that do not exist until now or to incentivize the comprehension of the interdepartmental dependency among administrations etc.

Even though there exist many ways to fight the energy poverty, this Project focuses on the fastest but not the most effective in the long term. It studies the direct payment of part of the energy bill in a concept of social bonus to cover the basic energy needs of energetic services.

2.2 Other approaches

As the energy poverty issue is nowadays very common there are many studies that tries to give figures about its penetration and impact.

There are studies at the world and European level as well as studies for the different countries, but the numbers are difficult to be determined with precision. Normally the studies are based on surveys and data from the population of the country and from the different utilities or retail companies.

For this study, there are two studies about the energy poverty that have had special relevance as many numbers and data used in the calculations have been extracted from them:

- "POBREZA, VULNERABILIDAD Y DESIGUALDAD ENERGETICA. Nuevos enfoques de análisis. España 2006-2016", (Asociación de Ciencias Ambientales, 2016), gives a deep study of the actual situation of the energy poverty in Spin. It also contains the contextual and theoretical framework for the development of energy poverty studies. It stablishes the conditions under which there are situations of energy poverty or energy vulnerability and data from surveys to quantify the penetration in Spain.
- "ACER Market Monitoring Report 2015 - CONSUMER PROTECTION AND EMPOWERMENT, ACER 2016", (ACER, 2015), that contains a European level vision of the energy poverty and the vulnerable consumers and they need. Also gives general information of the different measures that are being carried out by the different members to mitigate it.
- "Pobreza energética en España. Análisis económico y propuestas de actuación. ", (Economics for Energy, Vigo, 2014) is a study focused on the economic view of the

measures currently being taken in Europe to fight against the energy poverty. General figures and data has been collected from this study.

There are many other studies not directly related to the energy poverty but these are the main ones that have been used to compute different figures of the Spanish case.

These documents cover different areas like efficiency, habits, distribution of the population, etc.

The main ones are:

- "Censos de Población y Viviendas 2011 Edificios y viviendas.", (Instituto Nacional de Estadística, 2013), contained information about the different types of buildings and their antiquity.
- "Escala de calificación energética para edificios existentes.", (Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento", 2011) contains particular information about the efficiency and consumption in existing buildings.
- "Escala de calificación energética para edificios de nueva construcción.", (Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento, 2011) contains general information about the efficiency and consumption in new buildings.
- "Estimaciones de la población rural y urbana a nivel municipal." (Univeridad Politécnica de Valencia, 2015) that studies the proportion of population living in rural areas and in cities, and allowing to break down the study to extract more useful information and give more precise results.

There have been many other sources of various information used like official documents like BOEs or RDs as well as particular studies concerning the energy poverty or socio-economic aspects of the population, spatially:

- "Pobreza energética; Definiciones, el contexto Catalán y Español." (Diputación de Barcelona, 2016) that contains Catalonian measures against energy poverty.
- Real Decreto 1434/2002, de 27 de diciembre, that contains regulation regarding gas distribution and tariffs.
- Real Decreto 216/2014, de 28 de marzo, that contains information regarding comercialisation of electricity and PVPC information.

An important source from information that needs to be mentioned is the CIS, Centro de Investigaciones Sociológicas, in whose surveys there is a lot of general information concerning the habits of the population and its configuration of living.

Finally, for the purpose of analysing the current measures being taken there have been some essential sources too like the following ones:

- "Pobreza energética en España. Análisis económico y propuestas de actuación. ", (Economics for Energy, Vigo, 2014) is a study focused on the economic view of the measures currently being taken in Europe to fight against the energy poverty. General figures and data has been collected from this study.

- VIII Informe del Observatorio de la Realidad Social, (Cáritas Española, 2013) that contains a general view of the situation of energy poverty in Spain and the actions being took by Cáritas in collaboration with the different Autonomous Communities.

- Podemos 2017 webpage in which we can find their proposals to fight against energy poverty and that are nowadays very commented into the electricity sector.

2.3 General information

The used indicators point that an important part of the Spanish households live under conditions associated to energy poverty. Thus, the energy poverty is still being a reality that affects a high number of the Spanish households and in more detail:

- 11% of the Spanish households, equivalent to 5.1million people declared unable to maintain their household in an adequate temperature during the cold months.

- 8% of the Spanish households, equivalent to 4.2 million people declared to have had delays in the payment of their domestic energy bills.

- 15% of the Spanish households, equivalent to 6.2 million people, destined more than 10% of their income to pay their domestic energy bills.

- 10% of the Spanish households, equivalent to 4.9 million inhabitants were under a situation of difficulties according to the application of the official energy poverty indicator of the United Kingdom to the Spanish situation. This means that once discounted the expenses in the household and energy, the households were below the economic poverty margin and simultaneously their energy expenses were over the median of the median of the equivalent per person energy expense for Spain.

- 21% of the Spanish households, equivalent to 2.1million people, where under difficulties according to the application to the Spanish situation of the minimum income standard focused indicator. According to this methodology, the income of the households discounting the energy expenses and the house are under the minimum rent (discounted these same applications).

The four most affected regions are Andalucía, Castilla-La Mancha, Extremadura and Murcia. On the other hand, the less affected regions are País Vasco, Asturias and Madrid. On top of that, there exist a higher proportion of affected households in the rural area tan in the urban area.

There exist structural factors that explain that a part of the Spanish population is in conditions of energy vulnerability, such as the energy inefficiency of the housing stock or the persistence of layers of poverty and material deprivation, but the factors can also be operating on shorter temporary scales. These include variables such as economic growth, unemployment and occupation, which are macro factors of energy vulnerability that determine the general context in which short-term energy poverty figures move.

In absolute terms, in 2014 there were:

- 5.1 million people who could not afford to keep their home at an adequate temperature;
- One million people living in households that had been late in paying housing receipts in the last 12 months;
- 3.2 million people living in households that had had more than one delay in the payment of housing receipts in the last 12 months;
- 7.8 million people living with leaks, dampness on walls, floors, ceilings or foundations, or rotting on floors, window frames or doors

The trend in indicators is consistent: a rise in the percentage of households with 'disproportionate' expenditure until 2012, followed by a slight decrease in 2013 and 2014. The result of this evolution shows that, in 2014:

- 45% of households (equivalent to 20.7 million people) spent more than 5% of their income on energy;
- 15% of households (equivalent to 6.6 million people) spent more than 10% of their income on energy;
- 6% of households (equivalent to 2.6 million people) spent more than 15% of their income on energy;
- 3% of households (equivalent to 1.2 million people) spent more than 20% of their income on energy.
- 7% of households (equivalent to 4.7 million people) would be in energy poverty according to the indicator MIS1 (minimum income threshold of 417 € / month in 2014 for the first person in the household).
- 10% of households (equivalent to 4.9 million people) would be in energy poverty according to indicator LIHC

By population density, the results are different depending on the energy poverty estimation approach. Expenditure indicators indicate a higher incidence in rural or sparsely populated areas, perhaps related to the typology of housing (more spacious and difficult to heat than in cities). However, indicators based on household perceptions and statements do not indicate such a clear trend beyond the greater degree of involvement of suburban or intermediate areas, in addition to a greater presence of damp and rot in rural areas.

These data have been collected from the study mentioned before, “POBREZA, VULNERABILIDAD Y DESIGUALDAD ENERGETICA. Nuevos enfoques de análisis. España 2006-2016”, (Asociación de Ciencias Ambientales, 2016).

2.4 AVAILABLE RESOURCES

To develop the study and the tool there have been a necessity of information to cover many hypothesis and to be able to calculate different proportions of populations and their living habits, consumptions etc.

The sources of information have been very diverse as it has been shown before.

From the energy poverty studies mentioned before there have been extracted the different energy poverty metering for the different autonomous communities. This information has been useful to adjust the quantity of households under energy vulnerability in each region in the study.

Tabla 7. Principales indicadores de pobreza energética por comunidades autónomas (porcentaje de hogares con gastos desproporcionados del 5%, 10%, 15% y 20%, LIHC, MISI, MIS2 y MIS3, incapacidad para mantener su vivienda con una temperatura adecuada, con retrasos en el pago de recibos (calefacción, electricidad, gas, agua, etc.) y presencia de goteras, humedades o podredumbre en su vivienda, España 2014.
Fuente: Datos elaborados por ACA a partir la EPF y la ECV, INE.
Nota: colores cálidos (rojos) indican que el valor del indicador para la Comunidad Autónoma está por encima de la media nacional; colores fríos (azules) indican lo contrario.

2014	5%	10%	15%	20%	LIHC	MISI	MIS2	MIS3	ECV T°	ECV Ret	ECV got
Castilla – La Mancha	67,5%	36,4%	19,1%	9,0%	19,9%	8,2%	27,3%	41,3%	14,2%	8,1%	16,7%
Andalucía	44,3%	15,3%	5,8%	3,0%	9,2%	9,8%	28,9%	41,3%	15,8%	11,2%	23,4%
Extremadura	53,7%	19,5%	6,5%	2,5%	11,4%	7,4%	26,2%	40,6%	8,3%	3,8%	29,2%
Murcia, Región de	45,6%	15,5%	5,4%	2,1%	11,9%	9,7%	26,1%	37,2%	18,5%	11,1%	14,2%
Aragón	49,2%	19,2%	8,3%	3,6%	9,6%	4,6%	13,6%	23,2%	4,7%	4,7%	7,5%
Balears, Illes	46,4%	14,6%	5,9%	2,1%	9,9%	7,0%	21,9%	29,8%	6,6%	13,0%	26,7%
Canarias	27,2%	7,1%	2,6%	1,2%	4,6%	9,6%	29,8%	43,9%	0,2%	11,5%	35,3%
Cantabria	52,2%	15,8%	6,1%	2,2%	11,8%	5,9%	21,4%	30,7%	8,3%	4,5%	12,0%
Castilla y León	56,6%	23,1%	10,4%	4,4%	11,9%	4,6%	17,0%	27,3%	5,8%	2,4%	11,9%
Galicia	49,4%	16,8%	6,9%	2,3%	8,4%	5,8%	18,7%	30,7%	16,0%	6,9%	34,2%
Rioja, La	54,6%	21,7%	8,6%	4,3%	10,8%	4,5%	15,5%	24,3%	9,1%	5,5%	6,0%
Comunitat Valenciana	39,7%	10,7%	3,9%	1,8%	7,4%	7,9%	21,4%	31,3%	18,4%	11,7%	13,3%
Navarra, Comunidad Foral de	50,6%	17,9%	6,9%	3,9%	9,3%	4,1%	14,0%	21,8%	1,0%	3,9%	10,0%
Cataluña	44,7%	14,6%	6,1%	2,6%	9,6%	7,2%	19,0%	27,9%	8,7%	7,5%	7,5%
Madrid, Comunidad de	45,6%	12,5%	4,7%	1,9%	9,9%	6,0%	17,2%	24,5%	8,5%	5,7%	11,4%
Asturias, Principado de	41,1%	11,8%	4,0%	2,1%	7,6%	4,7%	16,3%	24,0%	13,7%	5,8%	15,5%
País Vasco	36,4%	8,2%	2,1%	0,8%	7,3%	3,8%	11,7%	19,0%	7,3%	3,5%	12,4%
España	45,5%	15,2%	6,1%	2,7%	9,6%	7,2%	21,3%	31,5%	11,1%	8,0%	16,6%

Table 1: Poverty metering for the different autonomous communities

[Source: "POBREZA, VULNERABILIDAD Y DESIGUALDAD ENERGETICA. Nuevos enfoques de análisis. España 2006-2016", (Asociación de Ciencias Ambientales, 2016)]

Also from this same study there was other data very interesting and useful like the energy poverty metering break down into rural or urban area.

This information was especially useful because being crossed with the percentage of rural and urban households the study could be totally separated into rural and urban with different properties in the households.

Tabla 8. Porcentaje de hogares en pobreza energética según indicadores EPF seleccionados, por densidad de población, España 2014.
Fuente: Datos elaborados por ACA a partir de microdatos EPF.

Categorías de desagregación	>10%	>15%	LIHC	MIS2
Zona densamente poblada	11%	4%	8%	19%
Zona intermedia	15%	6%	10%	23%
Zona diseminada	25%	11%	13%	24%

Categorías de desagregación	Temperatura inadecuada	Retraso en facturas	Goteras, humedades, podredumbre
Densamente poblada	11%	7%	14%
Semiurbana o intermedia	13%	10%	18%
Escasamente poblada	11%	7%	21%

Table 2: Poverty metering break down into rural and urban

The information to cross the rural and urban areas has been extracted from the study "Censos de Población y Viviendas 2011 Edificios y viviendas." (Instituto Naional de Estadística, 2013).

Distribución de la población Rural/Urbana a nivel provincial

		Población					Aglomeraciones
	Provincia	*Total*	*Urbana*	*Urbana (%)*	*Rural*	*Rural (%)*	*Urbanas*
01	Álava	301.926	243.381	80,6%	58.545	19,4%	3
02	Albacete	387.658	261.245	67,4%	126.413	32,6%	8
03	Alacant/Alicante	1.783.555	1.536.397	86,1%	247.158	13,9%	45
04	Almería	635.850	459.521	72,3%	176.329	27,7%	19
05	Ávila	167.818	62.494	37,2%	105.324	62,8%	3

Table 3: Distribution of the population

[Source: Estimaciones de la población rural y urbana a nivel municipal.

(Univeridad Politécnica de Valencia, 2015]

This table shows only a part of the conclusions of the study, the complete data is shown in the annex I: Distribution of the population.

Other important data used in the study are the consumptions of air conditioning and heating depending on the different kind of households (new construction/existing buildings) and their ubication (rural/urban).

All this information has been extracted from "the study "Escala de calificación energética para edificios existentes", (Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento", 2011) and "Escala de calificación energética para edificios de nueva construcción", (Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento", 2011).

In the next table, there are shown some of the reference demands for the heat demand and the air conditioning for the different provinces. The complete information for all the cases and provinces is shown in the annex II: Demands for existing new and Annex III: demands for existing buildings.

	Province	Heat demand single house kWh/m2	Heat demand block kWh/m2	Air conditioning demand single house kWh/m2	Air conditioning demand block kWh/m2
1	Albacete	172,3	135,9	23,5	17,1
2	Alicante	76,9	49,2	40,9	29,4
3	Almería	44,7	36,5	46,8	33,7
4	Ávila	221,5	187,5	0	0
5	Badajoz	123,1	85,4	42,4	30,2
6	Barcelona	117,1	87,4	21,3	14,6
7	Bilbao	132	106,1	0	0
8	Burgos	234,2	193,6	0	0
9	Cáceres	109,7	92,5	46,9	33,5
10	Cádiz	50,7	33,7	36,1	25,7

Table 4: Reference demands for existing households

Another key figure is the one that converts the population into households, i.e. people occupying the households with a rate higher than 1 person per household, and the data of this proportion break down by community has been extracted from the study "Censos de Población y Viviendas 2011 Edificios y viviendas.".

This table shows the data used:

Número de viviendas por comunidades autónomas. Variación absoluta y relativa respecto a 2001

	Viviendas			
	Censo 2011	Censo 2001	Variación absoluta	Variación relativa (%)
TOTAL Nacional	25.208.623	20.946.554	4.262.069	20,3%
Andalucía	4.353.146	3.531.124	822.022	23,3%
Aragón	778.316	654.483	123.833	18,9%
Asturias, Principado de	613.905	523.616	90.289	17,2%
Balears, Illes	586.709	501.840	84.869	16,9%
Canarias	1.040.945	851.463	189.482	22,3%
Cantabria	358.499	284.235	74.264	26,1%
Castilla y León	1.718.752	1.449.415	269.337	18,6%
Castilla - La Mancha	1.244.941	986.051	258.890	26,3%
Cataluña	3.863.381	3.314.155	549.226	16,6%
Comunitat Valenciana	3.147.062	2.547.775	599.287	23,5%
Extremadura	648.350	573.796	74.554	13,0%
Galicia	1.605.481	1.308.363	297.118	22,7%
Madrid, Comunidad de	2.894.679	2.478.145	416.534	16,8%
Murcia, Región de	776.700	592.613	184.087	31,1%
Navarra, Comunidad Foral de	308.602	258.721	49.881	19,3%
País Vasco	1.017.602	889.560	128.042	14,4%
Rioja, La	198.669	155.931	42.738	27,4%
Ceuta	26.652	22.776	3.876	17,0%
Melilla	26.233	22.492	3.741	16,6%

Table 5: Buildings per autonomous Community

[Source: "Censos de Población y Viviendas 2011 Edificios y viviendas,

(Instituto Nacional de Estadística, 2013)]

There is a total of 25 Million houses, but it has to be mentioned that not all the houses are habituated. There are many second houses or directly non-habited ones with a rate of 1.38 households per houses, what is to say, only in 72% of the houses there are people living. Finally, this makes a total of 18 Million households, that crossed with a mean of 2.44 inhabitants per household (CIS data) makes a population of 44 Million inhabitants which makes sense.

In order to be able to build the expenses of the households there were a necessity of data about the different water, gas and electricity tariffs. This information was extracted from different official documents: BOEs and RDs.

The main tariffs used are the electricity and gas ones. The gas tariff is shown in the next table.

Los precios sin impuestos de la tarifa de último recurso de gas natural que estarán en vigor desde las cero horas del día 1 de enero de 2017, serán los indicados a continuación:

		Tarifa	
		Fijo (euros/cliente)/mes	Variable cent/kWh
TUR.1	Consumo inferior o igual a 5.000 kWh/año . .	4,31	5,046543
TUR.2	Consumo superior a 5.000 kWh/año e inferior o igual a 50.000 kWh/año.	8,45	4,359143

Table 6: Gas tariffs

[Source: Real Decreto 1434/2002, de 27 de diciembre, por el que se regulan las actividades de transporte, distribución, comercialización, suministro y procedimientos de autorización de instalaciones de gas natural., (Agencia Estatal, 2003)]

For the electricity, the tariff used is the PVPC, Precio Voluntario del Pequeño Consumidor, and in the case of the water the supply Price depends on the region and the company.

The prices of water used are shown in the next figure and in different colours we can see the different prices per region. The data is in €/m3.

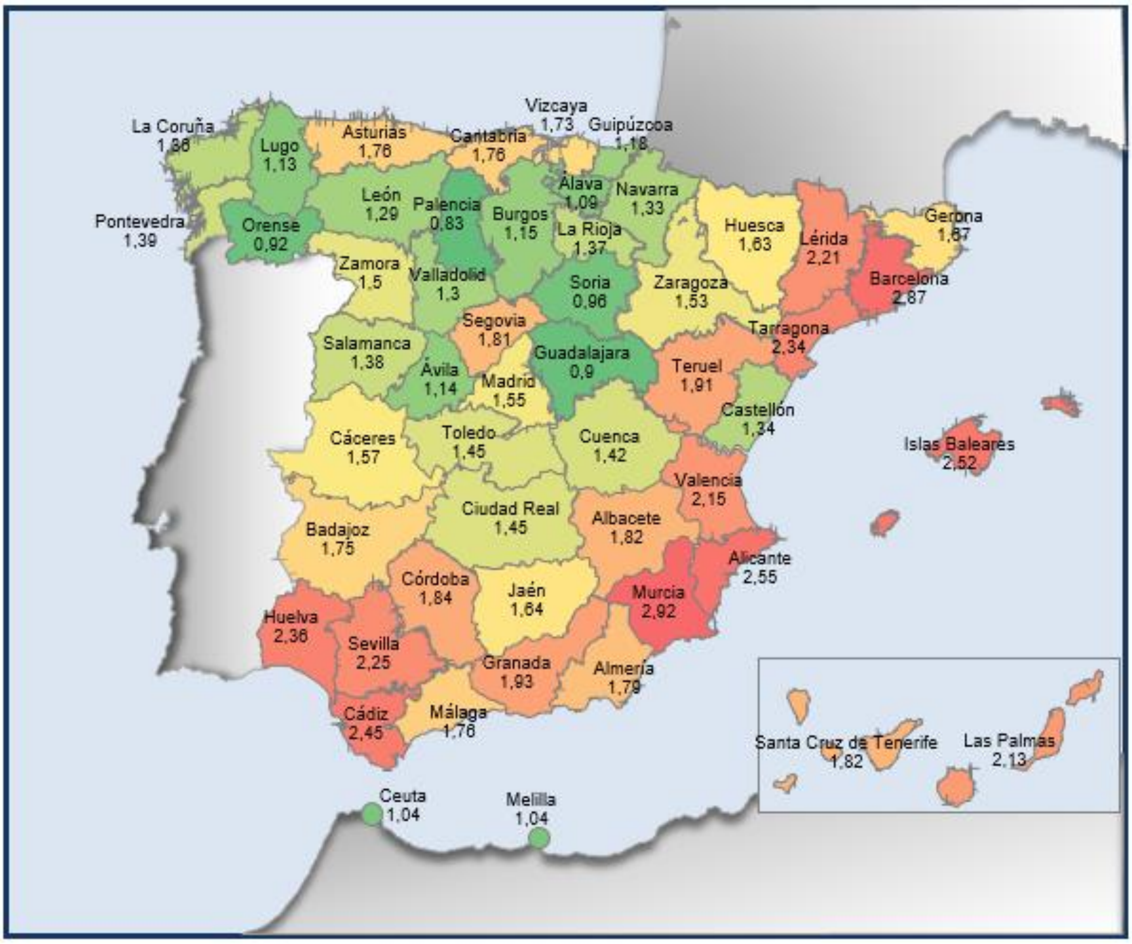

Figure 3: Average water price per province €/m3

[Source: Own elaboration with the Spanish map tool]

With the aim of keeping the hypothesis as close as possible to reality and the real habits and situations of the different possible cases of the energy poverty in Spain there have been a lot of data extracted from CIS surveys.

The CIS surveys cover a wide range of issues and themes. The explicit and implicit information contained in the surveys have been very useful for the project.

Some of the data extracted from CIS surveys and used in the project is for example:

Around the heating facilities installed in the household:

¿Tiene Ud. en su domicilio instalación de calefacción (individual o colectiva)?

Sí	80,9
No	19,1
N.C.	-
(N)	(2.495)

¿De qué tipo?

Calefacción eléctrica (incluidos radiadores portátiles)	32,3
Gas butano, propano, natural	44,5
Petróleo o derivados (gasoil, fueloil, gasolina)	14,3
Madera	5,3
Carbón y derivados	0,9
Biomasa, residuos, biogás	0,9
Otro tipo	1,1
N.S.	0,4
N.C.	0,2
(N)	(2.018)

Figure 4: CIS Survey extract

[Source: BARÓMETRO DE LA VIVIENDA Estudio nº 3044 Octubre-Noviembre 2014. (Centro de Investigaciones Sociológicas, 2014)]

About the air-conditioning facilities in the household:

Pregunta 4

¿Dispone la vivienda de...?

	Sí	No	N.C.	(N)
Cocina independiente	95,8	3,6	0,6	(2.472)
Aire acondicionado	42,3	57,5	0,2	(2.472)
Línea fija de teléfono	77,1	22,6	0,3	(2.472)
Acceso a Internet	67,0	32,8	0,2	(2.472)
Garaje	43,2	56,6	0,2	(2.472)
Trastero	42,8	56,9	0,2	(2.472)

Figure 5: CIS Survey extract II

[Source: BARÓMETRO DE LA VIVIENDA Estudio nº 3044 Octubre-Noviembre 2014. (Centro de Investigaciones Sociológicas, 2014)]

Apart from the specific information, the populations of the different provinces and the habits have also been extracted from the CIS.

2.5 Conclusions

To sum up, there exist many studies about the energy poverty, but there is a lack of quantification into monetary terms.

There is a significant difference in the energy poverty regarding the rural and the urban areas and thus, the study is going to break down the results into these two segments.

The study needs information very diverse and from many different sources, being these ones very critical in terms of reliability. That is why the main sources have been ministry official documents and CIS surveys.

There exist structural factors that explain that a part of the Spanish population is in conditions of energy vulnerability, such as the energy inefficiency of the housing stock or the persistence of layers of poverty and material deprivation, but the factors can also be operating on shorter temporary scales. These include variables such as economic growth, unemployment and occupation, which are macrofactors of energy vulnerability that determine the general context in which short-term energy poverty figures move.

In absolute terms, according to the ACA study, in 2014 there were:

- 15% of households spent more than 10% of their income on energy;
- 6% of households spent more than 15% of their income on energy;
- 7% of households (equivalent to 4.7 million people) would be in energy poverty according to the indicator MIS1 (minimum income threshold of 417 € / month in 2014 for the first person in the household).

3. PRESENTATION OF THE PROBLEM AND DEFINITION OF VARIABLES

This chapter is focused on the conception of the tool and the variables needed.

3.1 DESCRIPTION OF THE PROBLEM

The project's main objective is the development of a tool to compute different energy poverty scenarios and quantify in monetary terms the subsidies that would be needed to cover the problem break down into autonomous communities, provinces and rural and urban area.

There must be a distinction between the water, electricity and gas expenses taking into account the different demands and consumes of the different regions in Spain.

The program has been developed in Excel due to the simplicity of the programming and the capacity to be easily extended during and after the project. There would be a sheet to introduce the modifiable data by the user and other sheets with results and with information that is not modifiable like demand coefficients or taxes etc. as well as the formulas and underlaying relations among the data.

3.2 DESCRIPTION OF THE APPROACH

Although there are many ways to fight against the energy poverty like for example investing in energy efficiency, giving structural behavioural aid to poor people like complements in education etc. but in many cases this aid is useful in the long term, but the reality is that in the moment the households are not able to afford their energy expenses and some kind of immediate aid is needed despite probably the next month or year it will be under the same conditions.

In this sense, there exists the social bond. The social bond, as defined, is a palliative measure that contemplates a 25% discount on the Small Consumer Voluntary Price (PVPC, electricity). It is only available for the electricity supply (other types of energy do not enter) and is therefore considered to be insufficient to cope with situations where households cannot cope with their domestic energy costs other than electricity. However, it is one of the few measures available to mitigate energy poverty and prevent potential defaults in certain vulnerable population groups from occurring.

In addition, article 45 of Law 24/2013, of December 26, of the Electricity Sector, determines that the social bond should be applied to the vulnerable consumer, whose specific definition (that consumer that meets certain social, consumer Purchasing power) is delegated to a regulatory development, which has not yet been carried out.

Trying to have a wider scope than the social bonus, this project also covers the consumption of water and gas. It is important to keep in mind that this project is focused on the minimal habitability conditions, and thus the consumptions covers:

3.2.1. WATER

The water is assumed to be consumed in a modifiable consumption profile according to the number of people living in the household.

The consumption profile is divided into four different activities that requires water:

- Taking a shower
- Washing the dishes
- Flushing
- Washing machine

In order to have the water of the shower at the correct temperature it is assumed that half of the water required for the personal hygiene and the shower will be heated.

These activities are done daily or weekly generating the following water consumption profile for the base case:

	Washing Machine	Shower	Flush	washing
Consumption (L)	40	50	6	23
Hot water (L)	0	25	0	0
Frequency (/día)	0,25	1	4	1
TOTAL	310	1550	744	713

Table 7: Water consumption profile (L)

This consumption profile leads to the consumptions resumed in the next table in each household:

Members	Consumption (L/day)	Consumption (L/mont	Consumtion (L/year)
1	107	3254,583333	39055
2	214	6509,166667	78110
3	321	9763,75	117165
4	428	13018,33333	156220
5	535	16272,91667	195275

Table 8: Water consumption

The water heated for the personal hygiene consumes energy too. These the consumptions are:

Members	Consumption (kWh/day)	Consumption (kWh/month)	Consumption (kWh/year)
1	1,3189	40,11576788	481
2	2,6377	80,23153576	963
3	3,9566	120,3473036	1444
4	5,2755	160,4630715	1926
5	6,5944	200,5788394	2407

Table 9: Water heating consumption

3.2.2.GAS

Although gas consumption is measured in units of volume (m3), an equivalence to kWh is made for better understanding, similar to the electricity bill. As in the case of the electric bill, the total amount is also applied to the general VAT (21%).

Bottled gas is used by about 8 million consumers and in this period of unfavourable economic conditions has meant an alternative for many households that have decided to start (or return) to use it and to dispense with other alternatives such as natural gas or electricity, A priori with higher cost. It is also a prepaid system that allows the household to better control their consumption and adapt to the duration of the bottle, without surprises in the payment of the invoice. This system of prepayment implies that many households disconnect from the supply voluntarily and without being registered, as they simply stop buying the bottle.

The gas is assumed to be consumed used in three activities:

- To heat the water each household for the personal hygiene
- To cook
- For the heating of the household

The consumption profile of the cooking facilities and the water reveals the following consumptions for the base case:

Consumption (kWh/month)		
members	hot water	Cook
1	40	11
2	80	13
3	120	15
4	160	17
5	201	20

Table 10: Gas consumption (Cooking and water heating)

The heating of the household depends on the city. According to the reference consumption amount for each city the energy consumed is computed taking into account the efficiency of the building through the year of construction. Also, the value took as the reference consumption for a city is the mean value between the value for the block buildings and the unifamilial houses.

The consumption of gas for the heating is also divided into two cases; a basic one and the optimal living conditions one:

- Only the living room is heated. 20m2 of heated area for the base case.
- All the household is heated.

Some of the mentioned coefficients are shown in the following table:

	NEW		EXISTING	
Localidad	Heat demand single house kWh/m2	Heat demand block kWh/m2	Heat demand single house kWh/m2	Heat demand block kWh/m2
Albacete	72,2	49,1	172,3	135,9
Alicante	23	13,2	76,9	49,2
Almería	19,8	10,8	44,7	36,5
Ávila	101	69,5	221,5	187,5
Badajoz	41,6	27,4	123,1	85,4
Barcelona	43,4	28,3	117,1	87,4
Bilbao	61,9	40	132	106,1
Burgos	113,1	77,1	234,2	193,6
Cáceres	48,4	32,1	109,7	92,5
Cádiz	17,2	9	50,7	33,7

Table 11: Reference Heating Demand

These demands have to be multiplied by a factor that takes into account the efficiency of the building, these factors are around 0.5-0.8.

All the gas consumption depends on the penetration of the gas in the area. This mean that there exist households with no access to gas. In these households, the amount of energy consumed in gas would be covered by electric cooking facilities, electric water heater and electric heating.

3.2.3. Electricity

The electricity consumed comports the living with a normal use of the basic household appliances such as:

- Fridge
- Lighting
- TV
- Washing machine

If the household has no access to gas there has to be included:

- Cooking facilities
- Water heater
- Heating

There is also considered an optimal living conditions scenario including:

- Computer
- Air conditioning

The use of the air conditioning is considered only in the living room, with 20m2 for the base case and according to the reference values for the main cities.

Finally, the consumptions of energy are summarised in the next table:

	Consumption (kWh/month)				
members	1	2	3	4	5
Fridge	45,0	48,7	55,0	58,7	63,7
Lightening	2,6	2,8	3,2	3,4	3,7
Television	8,9	8,9	10,7	10,7	10,7
Hot water	40,1	80,2	120,3	160,5	200,6
Cook	10,9	13,0	15,2	17,4	19,6
ashing machine	2,3	4,6	6,8	9,1	11,4
Computer	10,5	10,5	11,9	11,9	11,9

Table 12: Electric household appliances consumptions

3.3 SOCIAL BOND

The social bonus is a discount of 25% on the Voluntary Price for the Small Consumer, whose calculation methodology is regulated in Royal Decree 216 / 2014, March 28, establishing the methodology for calculating voluntary prices for the small electricity consumer and its legal regime of contracting. Thus, the social bond or social bonus is only applicated to electricity expenses.

However, until adequate regulatory development occurs, it is understood, by default, that the definition of a vulnerable consumer is, similar to the profiles or assumptions that, since its implementation, have been defined as beneficiaries of the social bond, which are the following ones:

Pensioners with minimum benefits. The holder must be 60 years of age or older and must prove that he / she is a Social Security pensioner due to retirement, permanent disability or widowhood, and that he / she receives the minimum amounts in force at each moment for such pension classes with respect to holders with spouses Or the holders without a spouse who live in a single-person economic unit, as well as pension beneficiaries of the extinguished Obligatory Old Age and Invalidity Insurance and non-contributory retirement and disability pensions over 60 years.

Families with all members in unemployment. The holder must be part of a family unit in which all its members are unemployed. Applicants and members of the family unit who, without having the status of pensioner, do not carry out any work for hire or reward.

Consumers with less than 3 kW of contracted power. The supply point must have a power of less than 3 kW.

Tabla 20. Evolución de los usuarios beneficiarios del bono social. Años 2009-2014.
Fuente: Datos elaborados por ACA a partir de CNMC.

Años	Consumidores con P< 3 kW	Desempleados	Familias numerosas	Pensionistas	Total
2009	2.646.928	15.032	64.832	277.815	3.004.607
2010	2.402.511	23.776	100.581	317.205	2.844.073
2011	2.169.869	31.067	118.611	307.893	2.627.440
2012	2.067.585	33.735	129.466	283.110	2.513.896
2013	1.986.822	48.881	150.872	283.790	2.470.365
2014	1.961.179	54.824	162.174	289.113	2.467.290
% 2014 / 2009	-25,91%	264,72%	150,14%	4,07%	-17,88%

Table 13: Social Bonus break down

[Source: "POBREZA, VULNERABILIDAD Y DESIGUALDAD ENERGETICA. Nuevos enfoques de análisis. España 2006-2016", (Asociación de Ciencias Ambientales, 2016)]

Given the situation of a power outage, a household, depending on the municipality and autonomous community where it resides, is entitled to receive certain aid for the payment of bills of basic supplies. There is no regulation to harmonize these aid at the state level, but they exist in a generalized way in many municipalities and Autonomous Communities. The most well-known case is the law 24/2015 of Catalonia, which establishes that a declared home in a situation of residential exclusion by social services should be guaranteed basic supplies.

Finally, to point out that the payment of the unpaid invoice does not solve the root problem, it merely alleviates a situation of vulnerability which, with few exceptions, is not only a temporary problem of the home, but a chronic situation in time. For this reason, it is thought that this type of measures must be accompanied by other measures of greater depth that allow to mitigate the energy poverty. However, it must be realized that certain situations of social urgency require funds to be allocated to measures that, although mitigating, are those that can be implemented more quickly and those that allow an emergency to be dealt with immediately.

4. Analysis of variables, implementation and base case study

In this chapter, there is a discussion on the application of the variables to the project and the elaboration of the main hypothesis, the internal ones and the ones used to elaborate the base case.

Also, there is an explanation of the base case and the explanation of the development, parts and utilization of the tool.

4.1 Analysis of variables

The variables taken into account are the mainly energetic vectors in the households needed for the day a day life: water, electricity and gas.

4.1.1. Water bill

The water is assumed to be consumed in a modifiable consumption profile according to the number of people living in the household.

The water value depends highly on the area of consumption as there are many different supply companies with different prices.

For all of them the bill is computed in a similar way:

- There exists a variable part linked with the consumption that depends on the city that covers the supply and the sanitation. The value of the factor depends on the city and is expressed in €/m3.
- There exists a fixed part that covers the network and is supposed to be the same for all the cities for the base case. Thus, the value is fixed and expressed in €-
- There is a tax of 10% applied to the water consumption.

Finally, the monthly bill is computed as:

$$Water\ bill = \left(\frac{Cons(L)}{1000} * Vble.coef + Fixed\ coef\right) * (1 + 10\%)$$

The consumptions for the base case oscillates around 15€ for 1 person and the cheapest cities and 50€ for 5 people living in the same household and the most expensive cities.

As it has been shown before, the variable part of the bill depends on the cost of each m3 of water that varies widely in the different provinces.

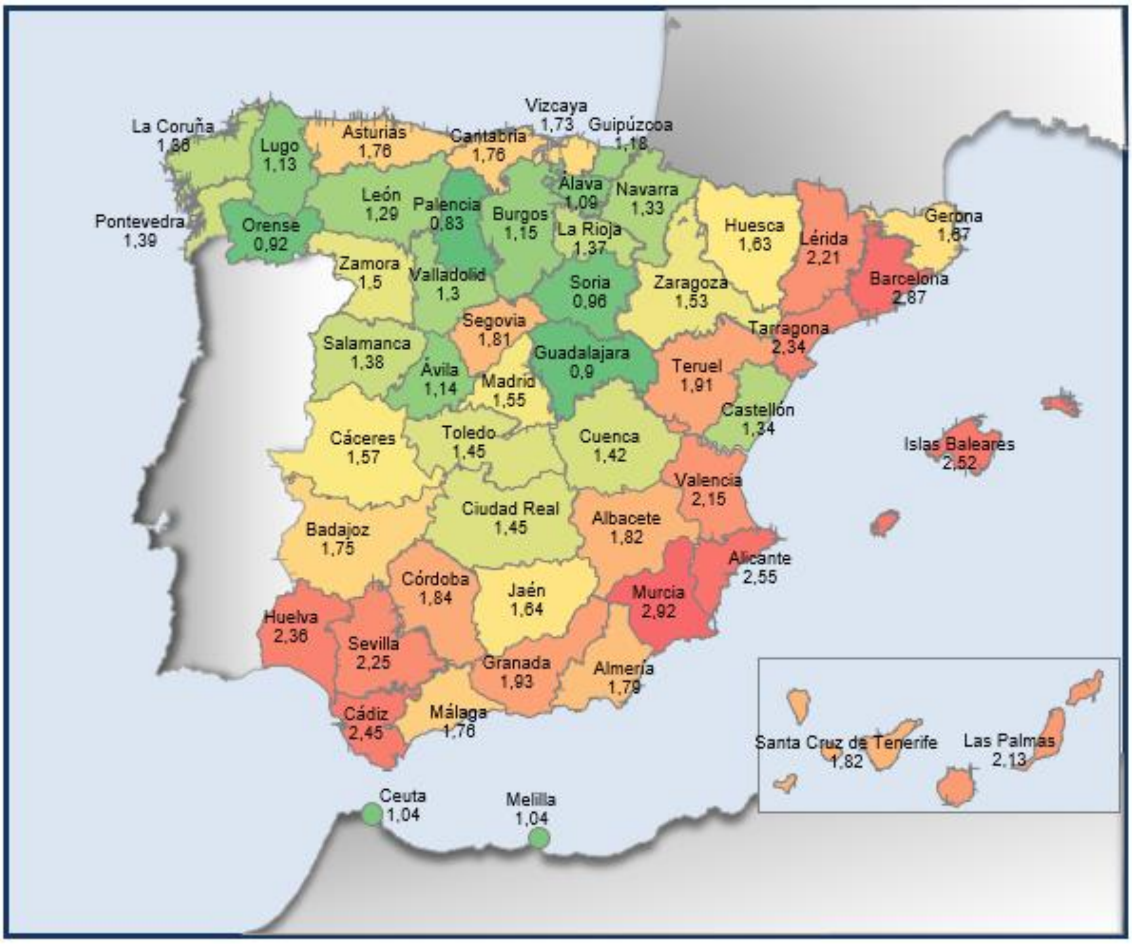

Figure 6: Cost of water €/m3

[Source: Own elaboration with the Spanish map tool]

4.1.2. GAS BILL

The gas does not depend on the city in its price, but as it has been mentioned before, the gas penetration is considered in the study.

The gas bill is composed by:

- Variable term depending on the consumption.
- Fixed term to cover the network.
- The “Impuesto de hidrocarburos” applied over the variable part of the consumption.
- The rent of the gas-meter.
- 21% AVT applied to all the other concepts.

There exist two basic contracts for different yearly consumptions, the TUR1 and the TUR2 with the same structure but with different prices.

One household can contract TUR1 as long as its yearly consumption is under 5000kWh and has to contract TUR2 if is between 5000kWh and 50000kWh a year.

The values for the different coefficients of the components are:

	Gas, TUR.1	Gas, TUR.2	
Fixed term (€/month)	4,36	8,84	€/mes
Consumption term (€/kWh)	0,050239	0,044858	€/kWh
Hidrocarbures tax (€/kWh)	0,00234		
metering (€/day)	0,041		
IVA	21%		

Table 14: Gas bill structure

[Source: Real Decreto 1434/2002, de 27 de diciembre, por el que se regulan las actividades de transporte, distribución, comercialización, suministro y procedimientos de autorización de instalaciones de gas natural., (Agencia Estatal, 2003)]

The formula to compute the bill is:

$$Gas\ bill = (Fixed + (HCtax + Vbl) * Consumption(kWh) + Rent * 30) * (1 + 21\%)$$

The gas bills are around 17€ and 30€ depending on the number of people living in the household and the geographic situation of the city, as there are different heat demand coefficients for the different cities.

4.1.3. ELECTRICITY BILL

The electricity bill is the most complex. As the other ones, it has several parts:

-Variable term depending on the consumption with a factor in €/kWh coming from the price of the electricity in the market or agreed with the supplier. For the PVPC consumers this term is the market price.

-Fixed term depending on the capacity in kW contracted (C.C.) for the household, normally 3.3kW or 4.4kW. This term is in €/kW*year and has to be transformed to €/kW*month for monthly billing.

-Electricity tax (E.T.) applied over the sum of the previous ones (fixed+variable).

-Social bonus (S.B.) applied as a discount to the sum of the previous parts.

-Electricity-meter rent (M.R.) in a daily basis that has to be transformed to monthly basis.

-AVT of 21% applied to all the previous terms.

The values of the coefficients are:

	Electricidad, 2.0A
Contracted power (kW)	3,45
Fixed term (€/kW*year)	41,156426
Energy term (€/kWh)	0,11
Electricity tax	5,11%
metering (€/day)	0,026
Social bond (25%)	0%
IVA	21%

Table 15: Electricity bill structure

[Source: Real Decreto 216/2014, de 28 de marzo, por el que se establece la metodología de cálculo de los precios voluntarios para el pequeño consumidor de energía eléctrica y su régimen jurídico de contratación. (Agencia Estatal, 2014)]

The values shown in pink are the ones selected for the base case but can be modified in order to generate new scenarios.

The formula to compute the electricity bill is:

$$E.bill = ((C.C * Fixed * \frac{31}{365} + Price * Cons.) * (1 - S.B.)*(1+E.T.)+M.R.*31)*(1+21\%)$$

The values of the bill are the highest of the three variables taken into account. Also, the bills are much higher if there is no gas available and the heating of the household is done electrically.

The values are around 50€ and 120€ for the worst cases with no gas, 5 people living in the household and in a cold area.

4.2 MAIN SCENARIO GENERATION

To develop the tool the easiest way was to develop a single simple scenario and think about what results may be interesting to have of the different variables exposed before and how to achieve to calculate them.

There have been considered two scenarios as it was mentioned before, the basic one and the optimal one, including air conditioning and more heating area and computers.

The calculation of the water consumption was the easiest one because it only depends on the consumption profile and the province. Once having the different prices and the monthly consumptions the calculation was direct and there was no separation between optimal and base cases.

The calculation of the electricity and gas expenses is much trickier as it depends on the type of household, existing or new and if it is in a rural or urban area.

The rural households are considered mono-familiar, whereas the urban is considered to be allocated in blocks of buildings having each one its air conditioning and heat coefficients. This leads to much more data to be included and many more scenarios and calculations.

Also, the electricity and the gas consumptions depends on the gas penetration and the case of the scenario (basic or optimal). The rural households are considered to be completely electrified due to their lack of access to the gas network. This assumption does not take into account the gas bottles but a complete electricity consumption to cook and heat the household.

The efficiency of the household is included through the antiquity of the household. The coefficients of demand of heat and air conditioning of the existing buildings are higher and are applied to the number of buildings built before 1999, and the coefficients corresponding to new construction buildings are applied to the others.

The coefficients of heat demand vary widely among the different regions due to the weather, the ones used for the existing buildings in rural areas are:

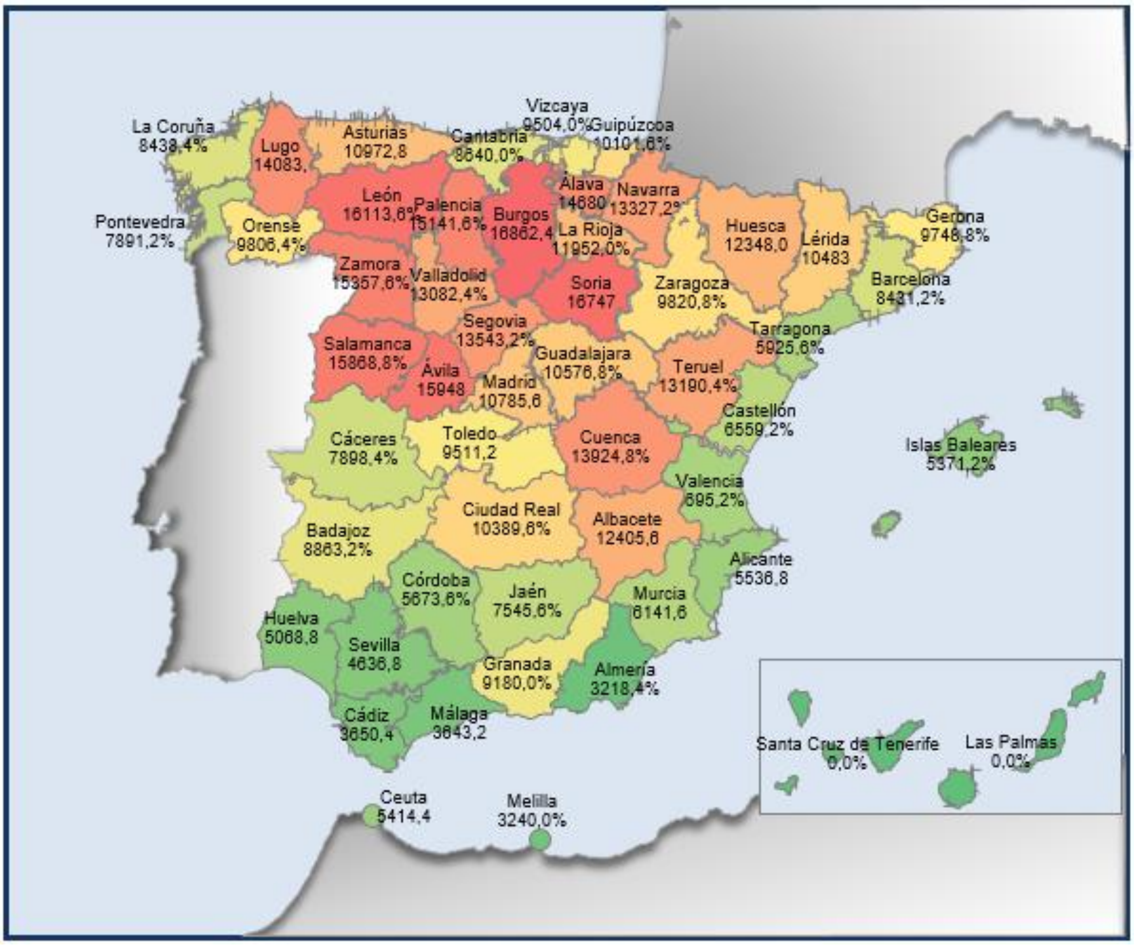

Figure 7: Heat demand in rural areas and for existing households

[Source: Own elaboration with the Spanish map tool]

The same happens to the Air conditioning demand, it varies depending the province and the kind of household, rural/urban and new/existing.

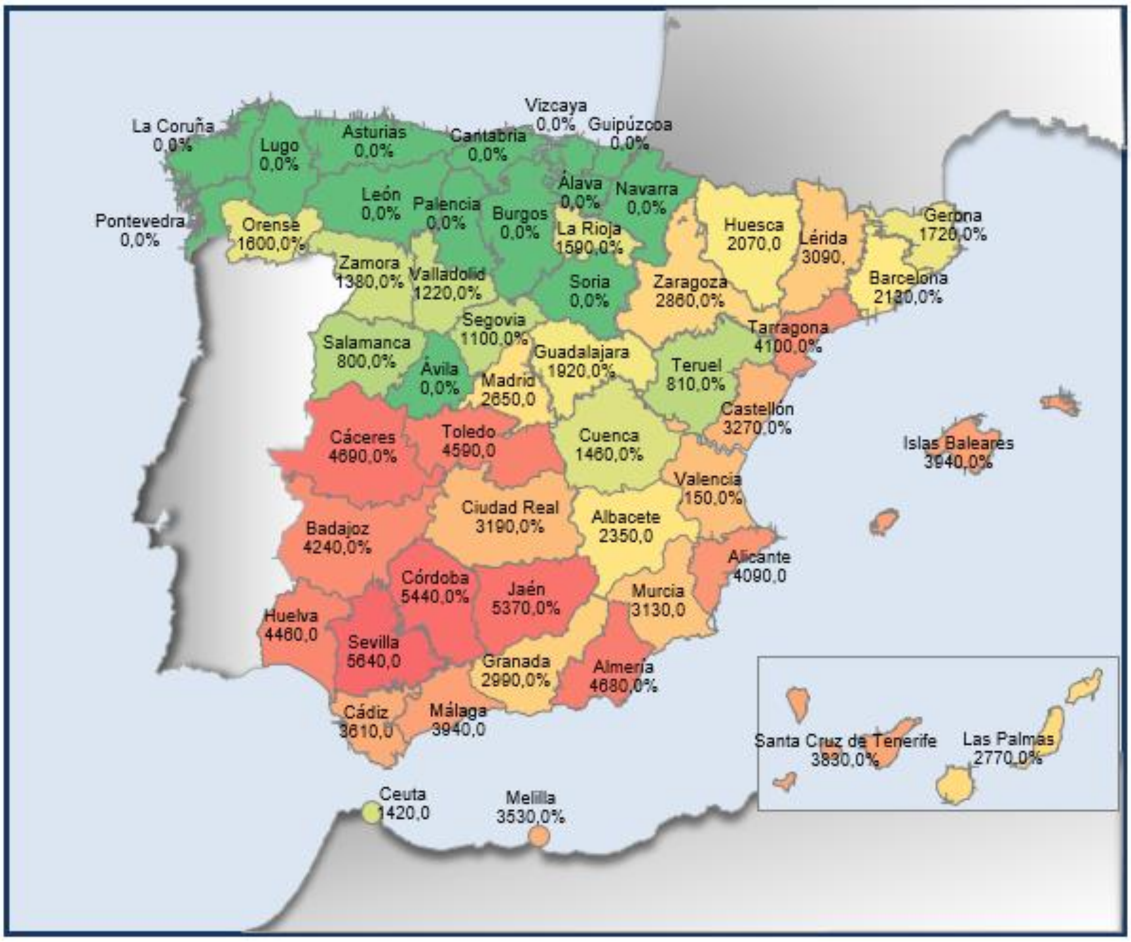

Figure 8: Air conditioning demand for rural existing households

[Source: Own elaboration with the Spanish map tool]

It is obvious that in the hotter parts the air conditioning demand is higher (red) and on the other hand in the north of Spain the heat consumption is very high whereas the air conditioning is cero or almost cero (green).

Once the different scenarios of the households are calculated, helped with the data of buildings and rural/urban percentage there can be an extrapolation of the expenses needed in each province.

Finally, having the results for each province there can be made another final extrapolation grouping them by autonomous community but being able to break down the results easily into rural and urban, and water, gas and electricity payments.

4.3 Structure of the tool

Finally, the tool is composed by 29 sheets. A brief description of the content of each one is made below:

General Information	Provides a general description of the tool.
General Data	Contains the consumption profiles and the general hypothesis. There are pink cells which are modifiable in order to create new scenarios regarding the needs of the user.
Base case	Contains the general data for the basic case and basic hypothesis.
Results	Summary of the resulting quantities to be covered by the different provinces and autonomous communities.
Graphics	Recompilation of useful comparative graphics.
Province calculations	Summary of the resulting quantities to be covered by the different provinces.
Building data	Calculations of the number of buildings used for the study and their types.
Households	Calculations of the number of households used for the study and their typesfor each scenario of the study.
Population data	Calculations of the population and their type.
Total bills	Summary of the household expenses for each scenario.
Rural bills	Summary of the household expenses for the rural scenarios.
Urban bills	Summary of the household expenses for the urban scenarios.
Water bill	Calculations of the water expenses.
Gas-Urban bill	Calculations of the gas expenses (only for the urban scenarios).
Electricity-Urban bill	Calculations of the electricity expenses for the urban scenarios.
Electricity-rural bill	Calculations of the electricity expenses for the rural scenarios.
Existing buildings coefficients	Coefficients used for the calculations of the demands of the existing buildings.
New buildings coefficients	Coefficients used for the calculations of the demands of the new buildings.
Household appliances	Summary of the consumptions of the different household appliances considered given the consumption profile stablished.
Fridge	Fridge consumption calculation.
Lightening	Lightening consumption calculation.
Television	Television consumption calculation.
Water	Water consumption calculation and water heating calculation.
Cooking	Cooking consumption calculation.
Washing machine	Washing consumption calculation.
Rural heating	Rural heating consumption calculation given the rural heat demand coefficients.
Urban heating	Urban heating consumption calculation given the urban heat demand coefficients.
Rural Air conditioning	Rural air conditioning consumption calculation given the rural air conditioning demand coefficients. (Only for the optimal case)
Urban Air conditioning	Urban air conditioning consumption calculation given the urban air conditioning demand coefficients. (Only for the optimal case)
Computer	Computer consumption calculation. (Only for the optimal case)

Table 16: Sheets of the tool

It is also complemented with the map tool to show the results in a summarized way.

[Source: Blog Análisis y decision. http://analisisydecision.es/nuevo-y-muy-mejorado-mapa-de-espana-por-provincias-con-excel/]

In the excel tool there are many freedom degrees in order to let the user create cases regarding its needs. For this purpose, there have been added especially modifiable quantities marked in pink in the general data sheet. These variables are:

- Water consumption: the frequency and quantities of water consumption can be modified in order to create different water consumption profiles.

- Cooking frequency: the number of cooks per week can be modified to adapt it to the case of study desired.

- Television and computer: the frequency and hours can be modified to create different consumption profiles.

- Fixed cost of water: due to the fact that it was too complex to take into account each water supply company, the different bills have been simplified with a variable term plus a fix term as it was explained before. The fixed term depends on the company and thus has been let free to change as a variable of the case.

- Electricity contracted power: contracted electricity power. Normally with a contracted power of 3.3kW of electric capacity is enough to cover the peak demand, but the term has been let variable to generate different cases.

- Electricity price: the electricity price is very volatile depending on the weather, costs of fuel etc. It is interesting to see how its different prices may affect energy poverty and quantify it.

- Social bonus: the social bonus is already acting and thus, it has been let free to be able to quantify the energy poverty with and without its effect.

- Size of the household: the size of the household is modifiable; for the base case, the size has been extracted from the minimum habitability cellule, but it has been let free to generate different cases. The size of the household is directly related to the heat and air conditioning consumptions.

- Heating coefficient: gives the percentage of the heated surface of the household in the optimal case. For the base case, it is only considered to have 20m2 of heated surface.

- Air conditioned surface: gives the possibility to modify the air-conditioned surface to create new scenarios or compute its effect.

- Percentage of energy poverty to cover: gives the possibility to adjust the percentage of the households that is under energy poverty whose energy expenses are going to be take into account to be covered.

- Gas penetration coefficient: this coefficient affects the hypothesis of the gas penetration. Let it in 0 the penetration of the gas is only in the urban areas, but if it is higher than 0 there exist buildings with gas in the rural areas. This tool allows the creation of new scenarios and is interesting to see how the gas penetration affects energy poverty.

- Energy efficiency factor: this factor can take values from 0 to 5. If 1, then the efficiency is the one extracted from the studies and used in the base case. If 0, all the buildings are considered old and thus, with bad efficiency characteristics. The higher the value, the higher the proportion of new buildings with better efficiency characteristics.

It is essential to mention another useful tool used to show the results in a summarized way. The map of Spain with the different provinces also developed in Excel allows to show the values of anything, for example, demands, water cost, electricity costs, etc. in a simple way

4.4 BASE CASE

The studied base case has been developed with the normal consumptions of a person taking into account the living standards of Spain.

The energy efficiency factor and gas penetration factors are so that the scenario reflects the actual reality of gas and buildings.

This case is the one to be compared with the other scenarios that can be made in order to study different effects of energy poverty measures.

I general terms and for the basic scenario the results per autonomous community are the following:

	BASIC				
€	Urban			Rural	
AUTONOMOUS COMMUNITY	Elect	Gas	Water	Elect	Water
Navarra	158631	145494	149699	330301	118798
Ceuta	192548	132534	159886	6613	2667
Andalucía	2637132	1797257	3239316	2385711	1384007
Aragón	334481	292319	358920	1075059	461534
Asturias	348811	296506	390593	490234	223350
Cantabria	244336	188553	274089	124042	61434
Castilla y León	732317	706630	667723	2547474	854978
Castilla-La Mancha	435003	372378	426959	1386760	530971
Cataluña	2108116	1632127	2859995	3209067	1749347
Extremadura	265129	204498	287261	825165	392754
Galicia	699062	556937	635039	2010955	733887
La Rioja	111641	95257	107322	163857	63853
Melilla	20463	12810	17016	59	26
Islas Baleares	349455	235180	501187	330777	234808
País Vasco	680169	591217	646766	454025	163644
Canarias	650746	357814	793791	413751	288477
Comunidad de Madr	2166989	1832604	2241945	383487	162153
Región de Murcia	520416	355699	831071	266659	208010
Comunidad Valencia	712994	499377	914428	336721	206772
TOTAL	13368437	10305191	15503008	16740717	7841470
TOTAL ANNUAL	160421250	123662297	186036096	200888603	94097644
	TOTAL URBAN			TOTAL RURAL	
		ubano	470119643	rural	294986247
	TOTAL BASIC				
	765105891				

Table 17: Results by autonomous community (€)

From these general results, there are many conclusions that can be extracted. One of the most important things to be taken into account are the differences between the rural and the urban areas.

The rural areas have heat and air conditioning demands higher than the urban areas and that is directly related to the final expenses. In addition, there is no rural gas grid and thus their electricity expenses are higher too. On the other hand, there are much more proportion of people living in urban areas than in rural areas.

Finally, in a quantitative view, the results show that 62% of the expenses should go to the urban area whereas the 38% left would go to the rural population. The total amount to be designated in the base case to cover the basic consumptions are 294 million € to the rural area and 489 million € to the urban areas.

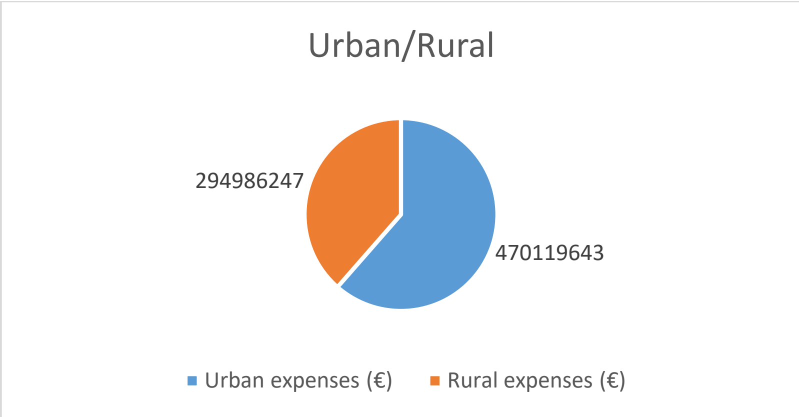

Figure 9: Global annual results of urban/rural expenses (€)

Here, it is important to remember that the energy poverty indicator is also different regarding if the area is rural (6% of population under E.P.) and urban (4%).

The autonomous communities with the higher rural share are Catalunya and Andalusia and on the other hand, Madrid, Ceuta and Melilla are the autonomous communities in which the expenses are mainly designated to the urban areas.

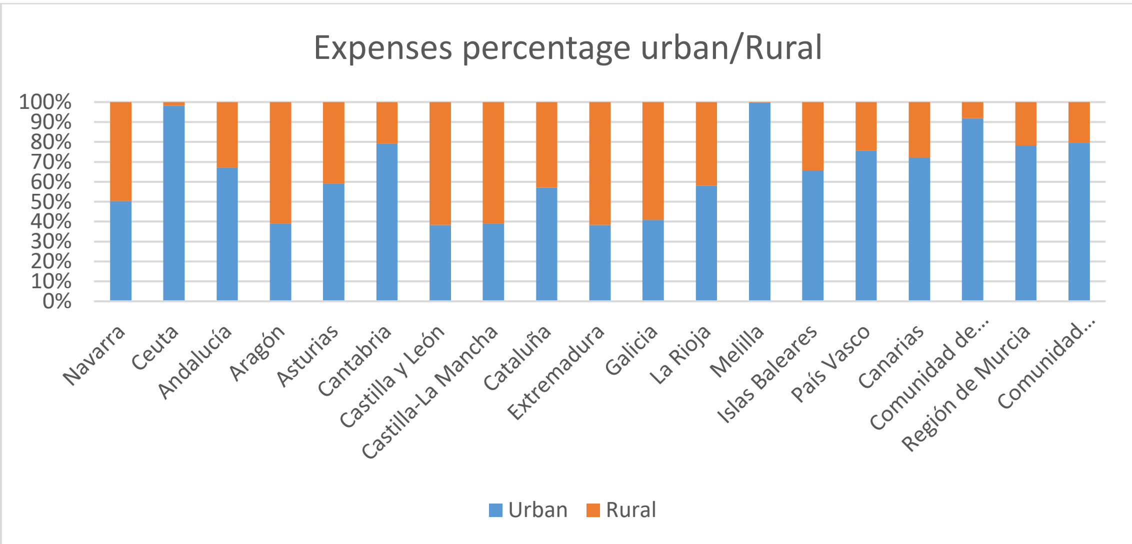

Figure 10: Percentages of urban/rural expenses by autonomous Community

The total numbers per autonomous Community are shown in the next figure:

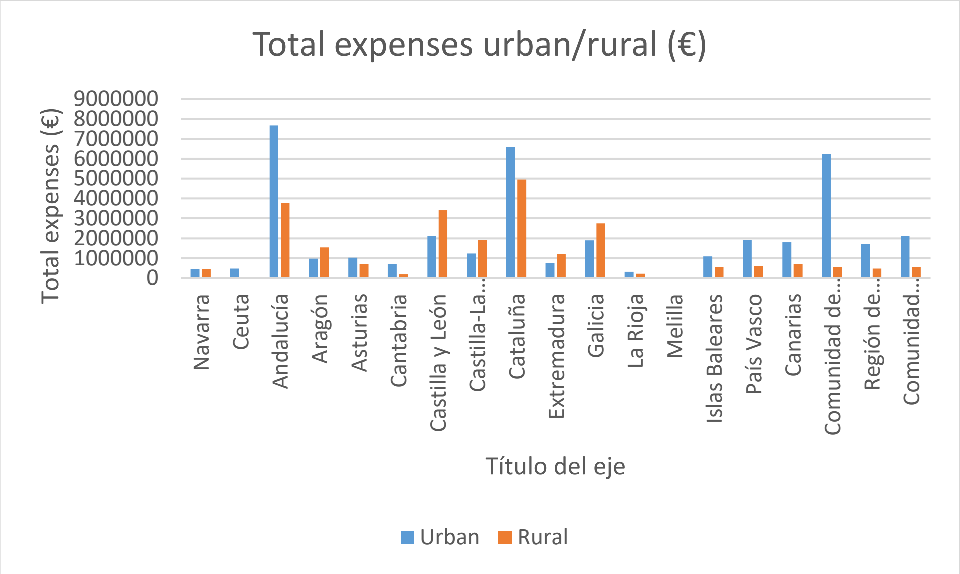

Figure 11: Total monthly expenses by autonomous Community (€)

As it can be seen, the major expenses are in the most populated autonomous communities. Andalusia, Catalunya and Madrid with 18%, 18% and 10% respectively are the most needed adding in total 46% of the expenses.

This is due to the fact of the high rural expenses in Andalusia and the heating in Catalunya, for the case of Madrid, it is the big population what increases the amount to be designated.

In the following figure, it is shown the total monthly expenses by autonomous community. Indeed, Madrid has the highest expenses followed by the provinces of Catalunya. These three provinces have in common high temperatures during the summer, low temperatures during the winter and a high population.

Figure 12: Monthly expenses by province (€)

[Source: Own elaboration with the Spanish map tool]

Regarding in detail the different bills there are many things to be considered too.

4.4.1. Electricity bill

The average electricity bill for the basic scenario is composed as following:

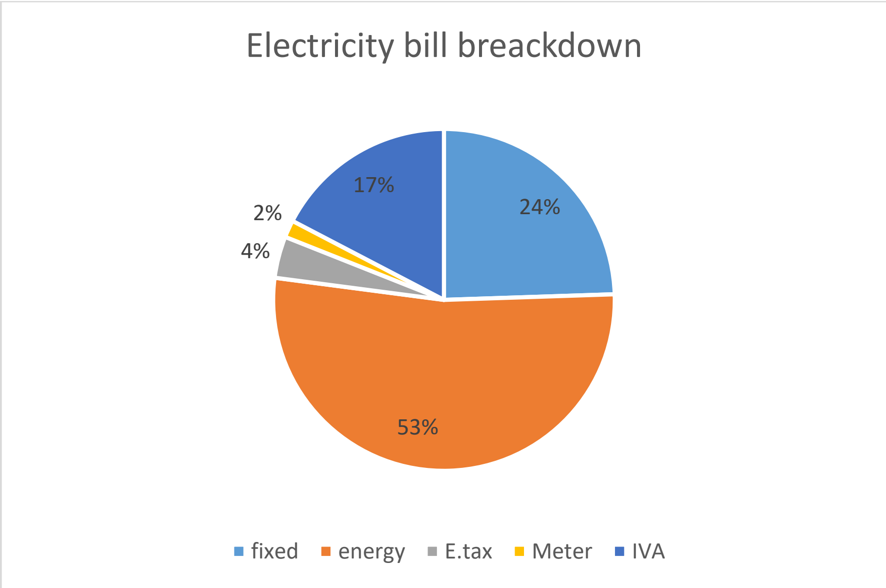

Figure 13: Electricity bill break down

As it is shown, only 53% of the bill reflects the consumption, the other 47% are fixed costs of taxes and metering. Also, it has to be mentioned that these percentages depend on the amount of electricity consumed, but are around the values shown in the figure.

The part of the electricity bill corresponding to the electricity consumption can be also decomposed to extract conclusions on the electricity consumption profile.

For the base case:

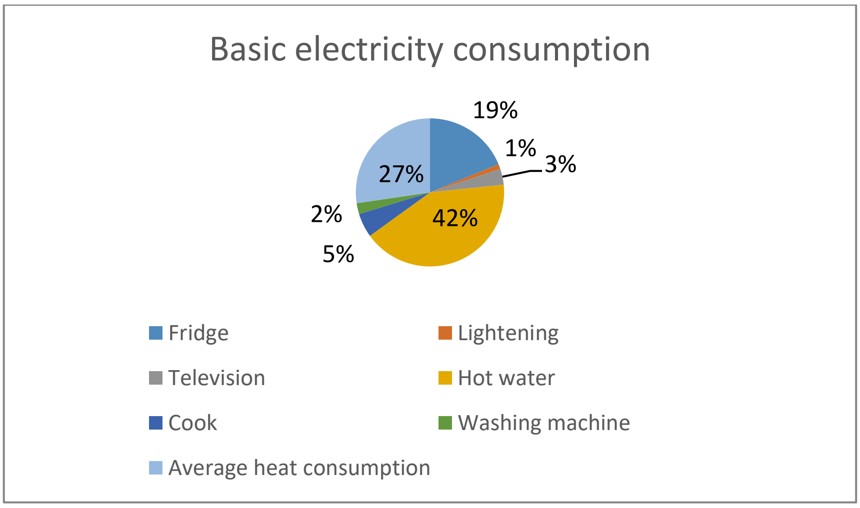

Figure 14: Electricity consumptions for the base case

To extract this figure an average consumption calculation has been made. The percentages depend on the amount of people living in the household, giving more importance to the water heating consumption if there are more people.

It is important to highlight that for the base case the water heating consumes the biggest proportion of electricity followed by the heat and the fridge.

For the optimal case the average consumptions are the following:

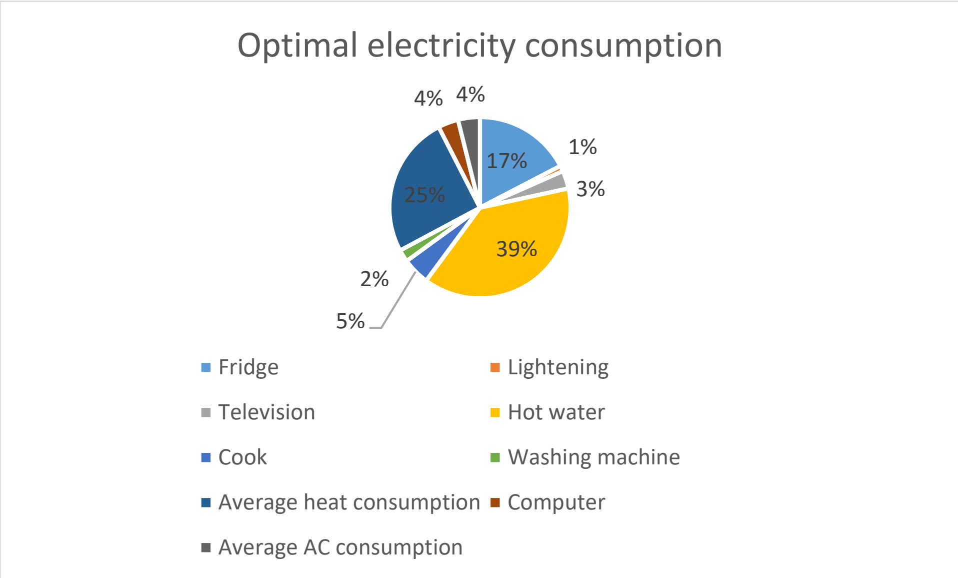

Figure 15: Electricity consumptions for the optimal case

For the optimal case the most critical part of the electricity consumption is the water heating followed by the heat. The air conditioning only corresponds to 5% of the consumption, but normally implies a higher contracted power.

4.4.2. Water bill

The water bill is composed in the following way:

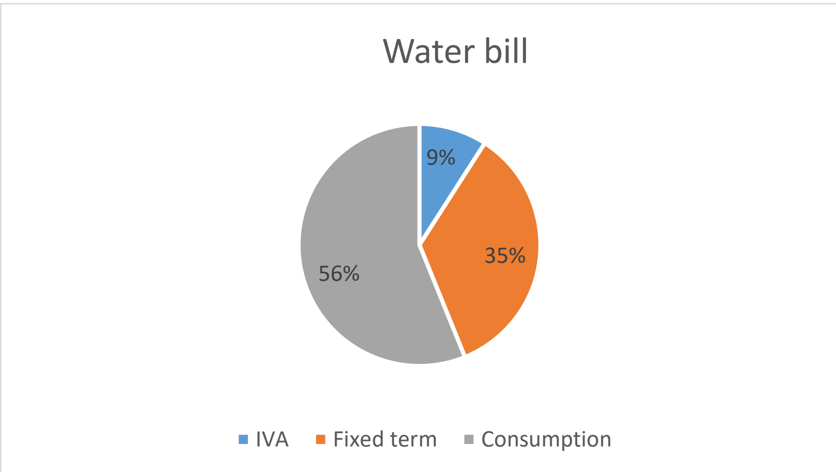

Figure 16: Water bill break down

As it can be seen the most important part of the water bill is the part depending on the consumption, but the fix term that covers the access and supply is also a very relevant part of the bill.

The consumption of water in the base case is the following:

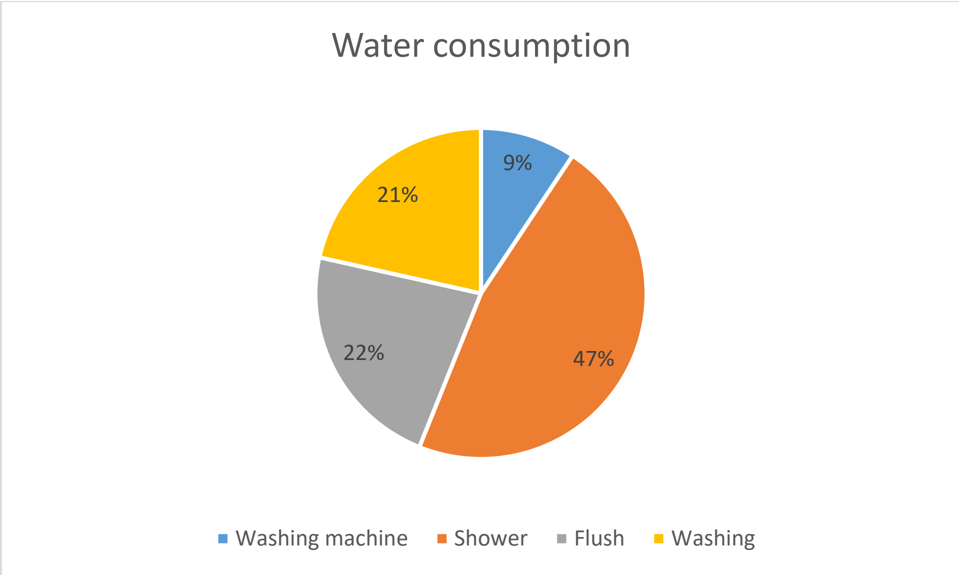

Figure 17: Water consumption break down

The highest amount of water is spent in the personal hygiene with more than 45% of the consumption. It is also important to mention that for the case where there is more than one person living in the household this proportion increases more rapidly than the others.

4.4.3. GAS BILL

The gas bill break down is the following:

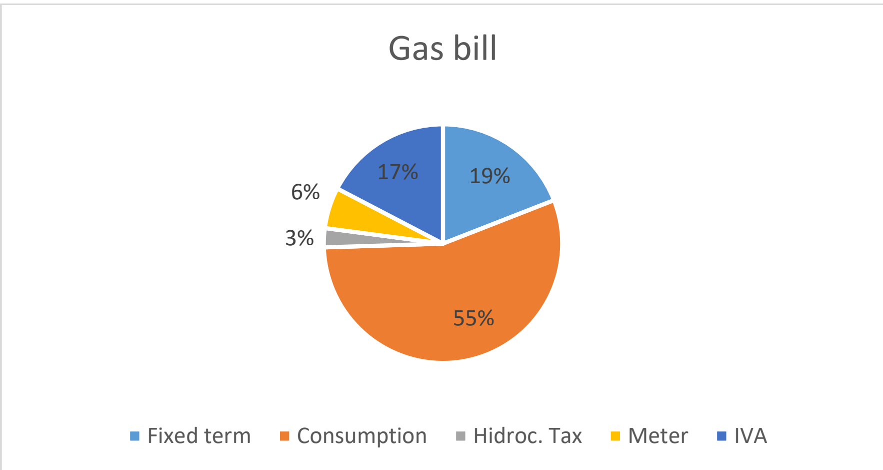

Figure 18: Gas bill break down

As it can be seen the most important part is the one associated to the consumption, but the fixed term is also very important and has to be taken into account as it is the part in which consumers are not able to modify.

The consumption of gas is the following:

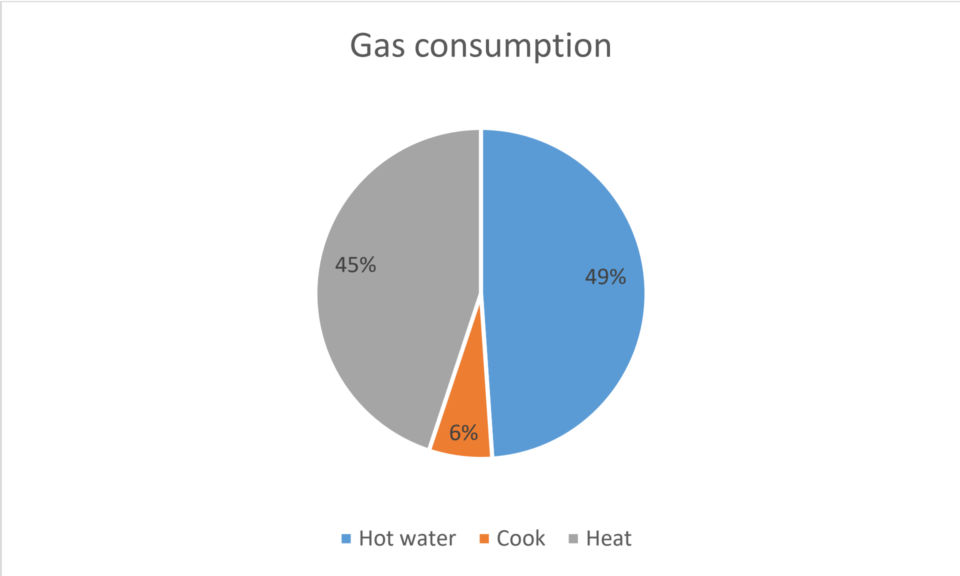

Figure 19: Gas consumption break down

Water heating and the heating are the most important consumptions and are more or less similar. They sum more than 90% of the gas consumption together.

4.4.4. OPTIMAL CASE COMPARISON

The optimal case includes some improvements to the living conditions regarded in the base case.

These improvements are the air-conditioning, the heat of a bigger part of the household and the usage of a computer.

The average distribution of the increase consumption due to these improvements is:

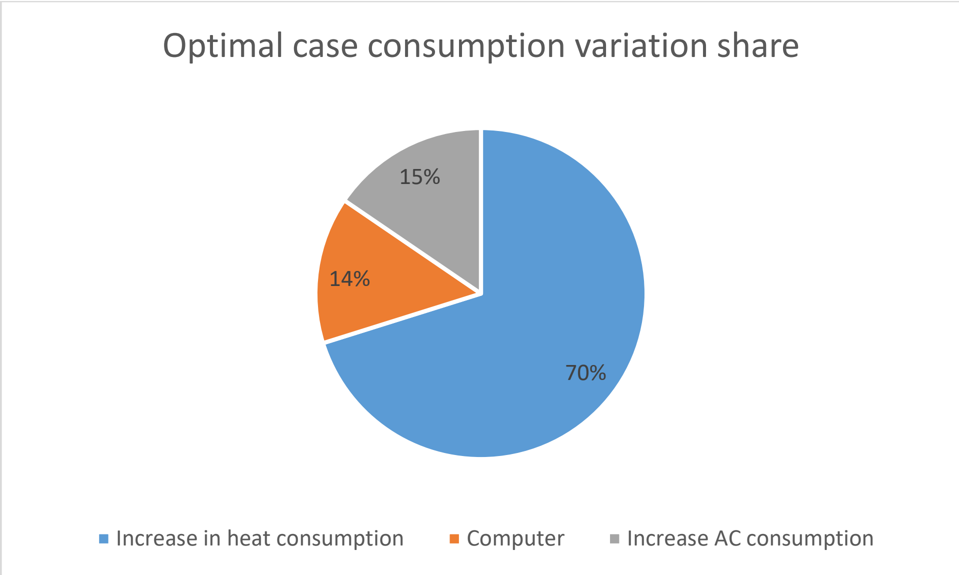

Figure 20: Distribution of the increase of consumption in the optimal case

It is interesting to highlight that the major increase in the consumption of the optimal case is in the heat consumption increase due to a bigger size to heat. It takes 70% of the consumption increase.

The results of the expenses needed to cover completely the optimal case are:

€	Urban			Rural	
Autonomous community	Elect	Gas	Water	Elect	Water
Navarra	169480	200136	149699	475451	118798
Ceuta	214883	154870	159886	8389	2667
Andalucía	3266078	2106379	3239316	3244023	1384007
Aragón	384523	395797	358920	1574477	461534
Asturias	372074	401166	390593	680423	223350
Cantabria	260147	241367	274089	163567	61434
Castilla y León	797160	981692	667723	3774169	854978
Castilla-La Ma	506830	500807	426959	2029776	530971
Cataluña	2465612	2094108	2859995	4536620	1749347
Extremadura	330139	262243	287261	1183521	392754
Galicia	752817	724023	635039	2771224	733887
La Rioja	125394	128212	107322	233698	63853
Melilla	24579	14110	17016	74	26
Islas Baleares	425874	270677	501187	437894	234808
País Vasco	725861	799785	646766	643156	163644
Canarias	771265	360361	793791	475926	288477
Comunidad de	2540969	2468173	2241945	554654	162153
Región de Mu	612035	414967	831071	348820	208010
Comunidad Va	843115	597051	914428	447351	206772
TOTAL	15588834	13115924	15503008	23583213	7841470
TOTAL ANNUA	187066008	157391090	186036096	282998558	94097644
	TOTAL URBAN			TOTAL RURAL	
	530493194			377096203	
	TOTAL ÓPTIMO				
	907589397				

Figure 21: Total expenses needed for the optimal case (€)

The variation regarding the optimal and the basic cases are:

Gas variation	21%
Elect. Variation	23%
Urban variation	11%
Rural variation	22%
Total variation	16%

Table 18: Increase of the expenses to cover the optimal case

The increase in the heated surface leads to an increase in the gas expenses, and the addition of the air conditioning to an increase in the electricity expenses.

Regarding the allocation of the expenses, the urban ones increases only in 11% whereas the rural ones increases in 22%. This is due to the fact of the high heat demands of the rural households and its antiquity.

The total increase in the expenses to be allocated is 16%, making a total of more than 900 million euros annually to cover the energy poverty in all of Spain.

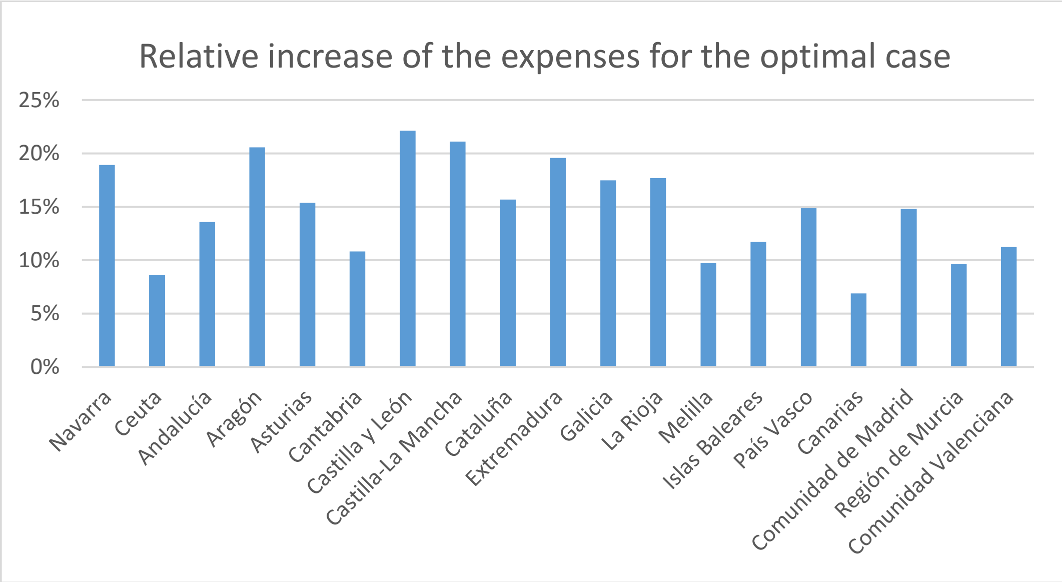

Figure 22: Relative increase of the expenses in the optimal case

Regarding the different autonomous communities, the ones that increases more the need of expenses to cover the energy poverty in the optimal scenario are the ones that have hot temperatures during the summer and low during the winter. These ones introduce air conditioning demand as well as heat for the optimal case making a big variation in relative terms. These autonomous communities are Castilla y León and Castilla-La Mancha with an increase of 20% each.

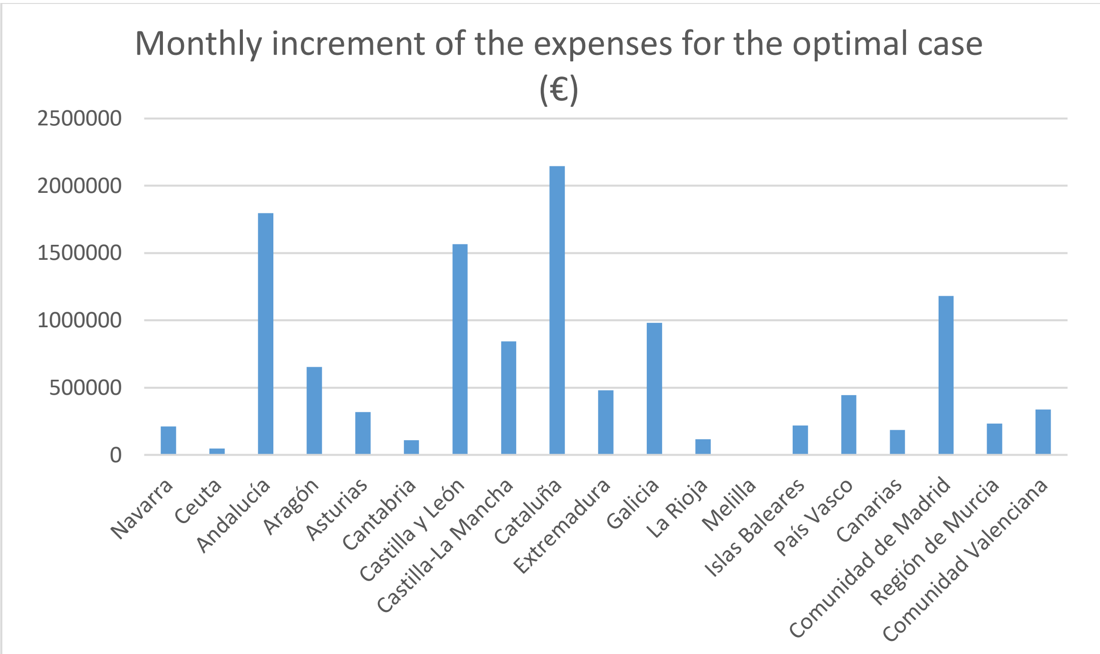

Figure 23: Increase of monthly expenses in the optimal case

Regarding the absolute increase figures, Catalunya and Andalusia are the ones that increase more; both due to the high air conditioning and heat demand respectively and their big population.

4.4.5. EFFICIENCY FACTOR

As it was mention before, the efficiency factor simulates an investment in efficiency in the households. It converts existing households with low efficiency coefficients to new households with better conditions.

The efficiency factor has to be a number between 0 and 5. A coefficient of 0, is to say "all the buildings are old" whereas a coefficient of 5 means that "all the buildings are new".

Both cases compared to the base case (efficiency coefficient equals to 1) gives the following results:

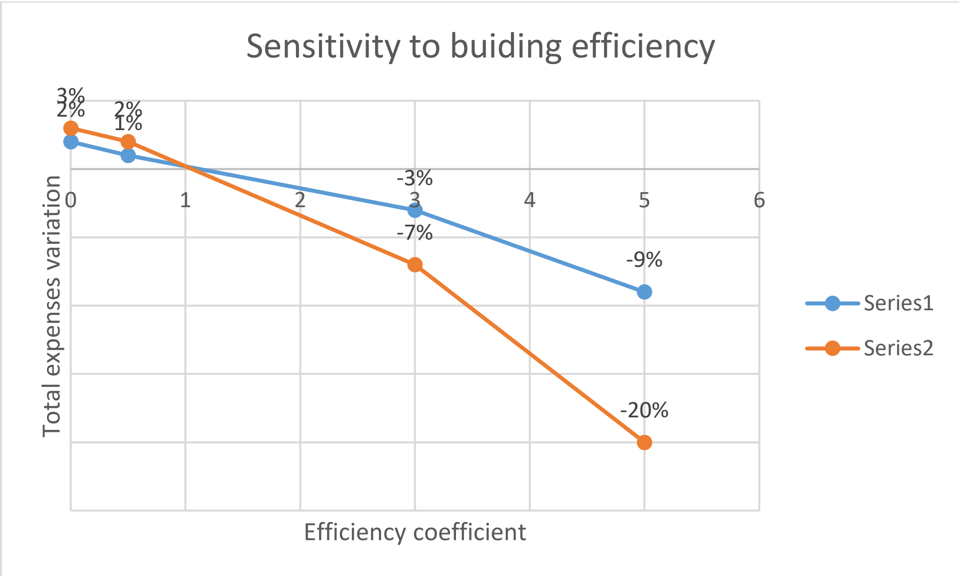

Figure 24: Sensitivity of the total expenses to the efficiency coefficient

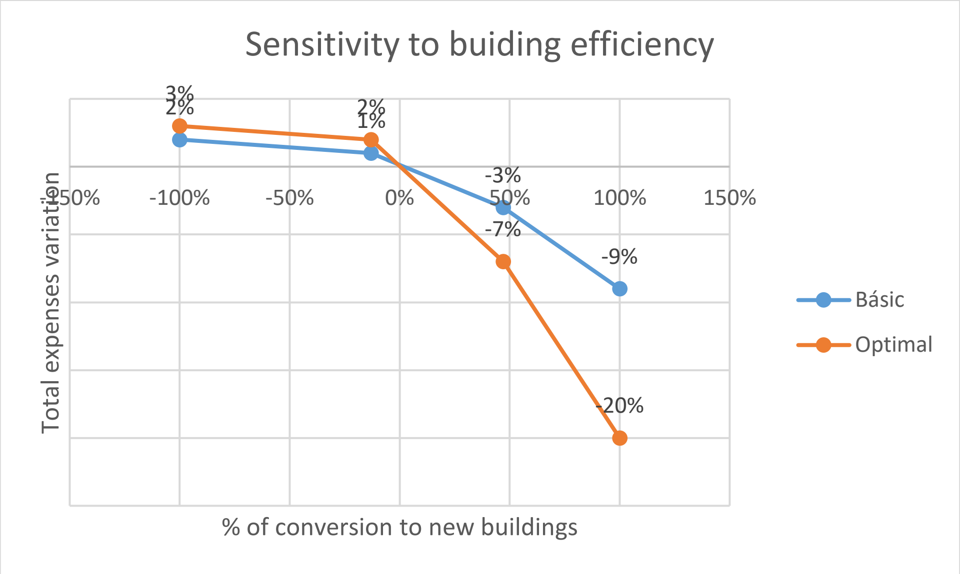

Figure 25: Sensitivity of the total expenses to the % of conversion to new buildings

As it can be seen, the investment in efficiency is a big issue to be taken into account. The renovation of the existing buildings can imply saves in Energy poverty context of up to between 9% and 20% in the optimal case, what is to say, up to 80 million euros annually.

4.4.6. GAS PENETRATION FACTOR

Taking into account that the gas is cheaper than the electricity per kWh, 47% cheaper, the gas penetration lead to another issue regarding Energy poverty. In the long term, it is important to take into account the savings thank to an improvement in the gas network.

The gas penetration factor is a value that is comprised between 0, base case, and 2, being 2 equals to all area considered as urban with gas penetration.

The sensitivity of Energy poverty expenses regarding the gas penetration factor is:

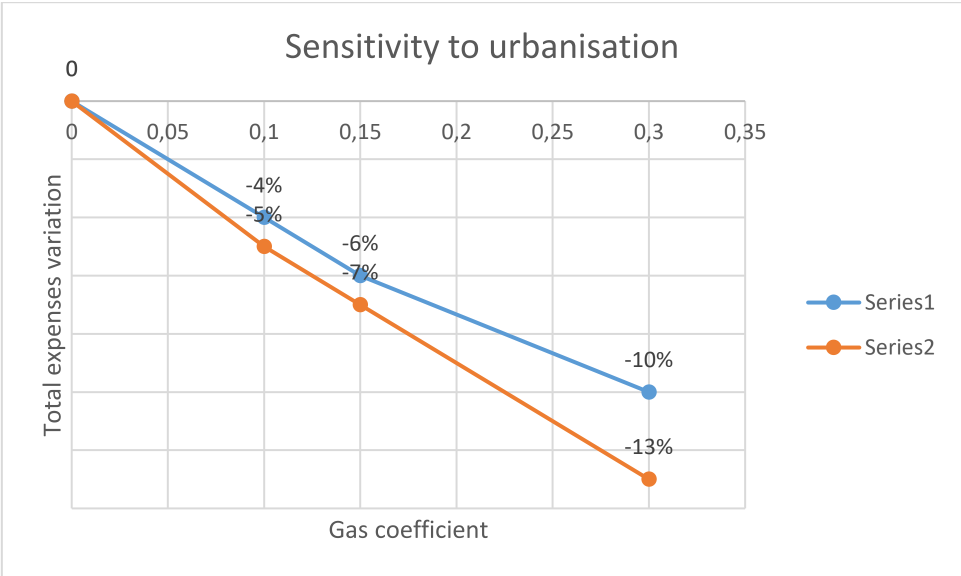

Figure 26: Sensitivity of the total expenses to the penetration gas coefficient

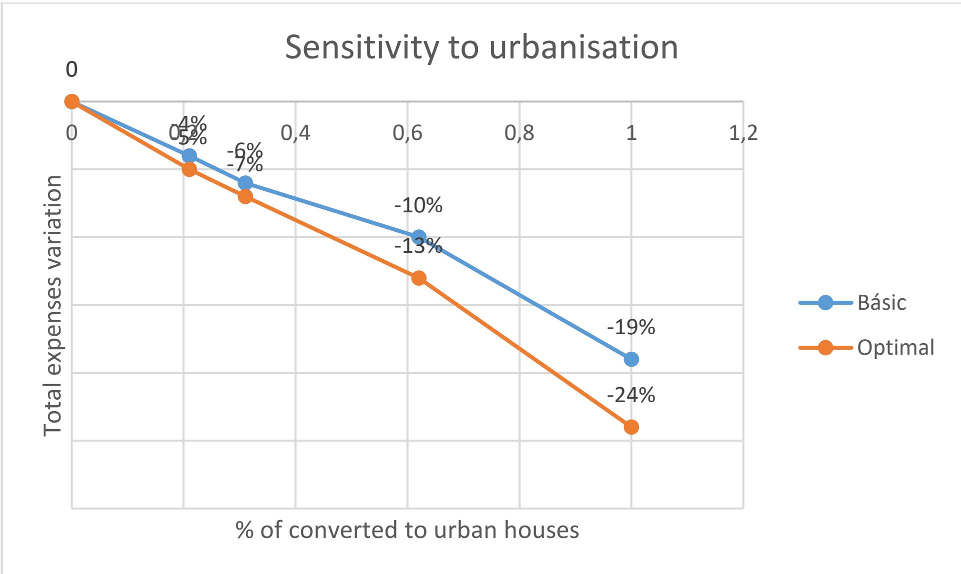

Figure 27: Sensitivity of the total expenses to the % of converted rural areas

As it can be seen, the urbanisation and the change from an electric heating and water warming systems implies big savings in the long term concerning Energy poverty expenses.

Between 19% and 24% of savings could be achieves if all the households had gas services taking into account the assumed hypothesis of complete electric consumptions for the rural areas. This leads to around 100 million euros savings per year in the long term concerning energy poverty expenses.

4.4.7. Electricity price increase

Electricity prices are another key issue. Energy poverty expenses needed vary with a high dependency on electricity prices as it can be seen in the next figure.

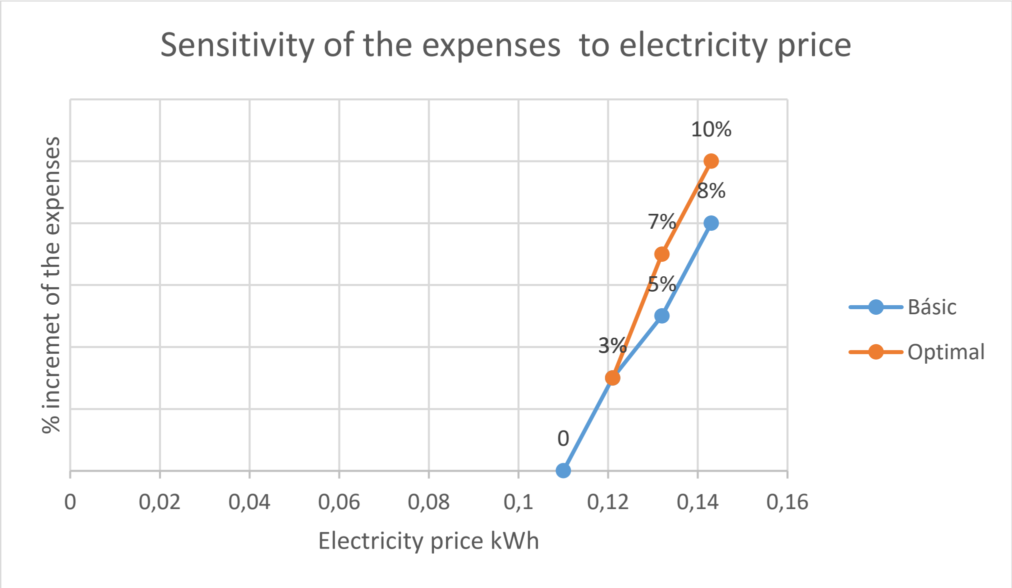

Figure 28: Sensitivity on the total expenses to the electricity Price

It is important to have an average Price constant or to give stability to the vulnerable consumers regarding the electricity price, specially the vulnerable ones whose dependency to prices is much higher too.

4.5 Application to other countries

The developed program is applicable to other countries in terms of its structure, that is to say, it is possible to use the way in which the variables have been studied and how they have been implemented provided there is a homogeneity in the construction of the invoices of electricity, gas and water and provided that the hypotheses of the study are valid for the new example, such as the lack of gas in the rural area or that the urban population lives in blocks of houses.

The part related to consumption is completely extrapolable to other countries and can be easily modified to fit the new situation, however the specific structure of Excel tables in terms of number of provinces and autonomous communities would be very tedious to change to adapt it, That is why, it is proposed that before an application to another country, the user makes an understanding exercise of the tool and then the part of the basic consumption is used the same way, whereas the part related to consumption of heating, air conditioning and calculation of invoices is completely restored following the same scheme of this study.

4.6 Conclusions

To sum up, the tool has been tested in a base case as close as possible to the actual reality of Spain. The tool is easily modifiable and gives very interesting results easy to understand which was one of the main objectives.

For the base case, the expenses by autonomous community to cover the energy poverty of Spain are the following:

	BASIC				
€	Urban			Rural	
AUTONOMOUS COMMUNITY	Elect	Gas	Water	Elect	Water
Navarra	158631	145494	149699	330301	118798
Ceuta	192548	132534	159886	6613	2667
Andalucía	2637132	1797257	3239316	2385711	1384007
Aragón	334481	292319	358920	1075059	461534
Asturias	348811	296506	390593	490234	223350
Cantabria	244336	188553	274089	124042	61434
Castilla y León	732317	706630	667723	2547474	854978
Castilla-La Mancha	435003	372378	426959	1386760	530971
Cataluña	2108116	1632127	2859995	3209067	1749347
Extremadura	265129	204498	287261	825165	392754
Galicia	699062	556937	635039	2010955	733887
La Rioja	111641	95257	107322	163857	63853
Melilla	20463	12810	17016	59	26
Islas Baleares	349455	235180	501187	330777	234808
País Vasco	680169	591217	646766	454025	163644
Canarias	650746	357814	793791	413751	288477
Comunidad de Madr	2166989	1832604	2241945	383487	162153
Región de Murcia	520416	355699	831071	266659	208010
Comunidad Valencia	712994	499377	914428	336721	206772
TOTAL	13368437	10305191	15503008	16740717	7841470
TOTAL ANNUAL	160421250	123662297	186036096	200888603	94097644
	TOTAL URBAN			TOTAL RURAL	
		ubano	470119643	rural	294986247
	TOTAL BASIC				
	765105891				

Table 19: Base case expenses to cover Energy poverty per autonomous Community

The total annual expenses ascend to 765 million euros given the hypothesis intrinsic of the study and the tool and the hypothesis given of the base case scenario.

To eradicate the energy poverty in Spain the government should put special attention to three aspects:

The most important part of the consumptions. This can also be decoupled into gas, water and electricity:

• Gas consumption: gas consumption is determined equally by heating and water heating. Among them, they account for more than 90% of the average consumption: 45% is heating and 49% is the water supply. It must be taken into account that the gas will not be present in the rural areas, where the penetration of the gas distribution network is non-existent. With regard to water heating, an improvement can be made in aid to the acquisition of more efficient gas boilers or boilers, and in terms of heating the house, consumption could be significantly reduced if the house is conveniently isolated , So in this case the best option would be to combat energy poverty by improving efficiency and also doing so over the long term.

• Water consumption: Regarding water consumption, 47% is the expenditure for hygiene and in this case the consumption is justified, there being no action other than awareness to make a responsible consumption of water.

• Electricity consumption: As with gas consumption, most of the electricity costs go to heating and heating, with 42% and 27% respectively. The measures are therefore similar to those of gas consumption, but it should be noted that the increase in the use of gas reduces the need to use electricity in these two concepts since they would be made with gas, reducing significantly the expense, reason why The previous measures would be added to facilitate greater integration of gas in homes, which in turn is a measure in the long term.

The most important part of the invoices: It is important to take into account that a large part of the final invoice is not manageable by the customer as is fixed and taxes. In this case it makes no mistake to decompose in the three variables separately since in them the part relative to the consumption realized is around 55%. That is, 45% are fees on the energy service. One measure that is obvious is the application of a social bond similar to the existing one that realocates the expenses in such a way that a vulnerable consumer does not have to pay taxes that will later be replaced elsewhere, that is, to withdraw part of the Fixed charge to services. The widest group of population affected: There is a greater proportion of necessity in the urban area due to the greater concentration of population, nevertheless it should not be forgotten that the conditions in the rural environment are already harder already by itself. The differentiation between rural or urban measures must be decided at Autonomous Community level since there are communities where the need is eminently urban given their characteristics. Also noteworthy is the case of Andalusia, currently without aid measures and which has major needs.

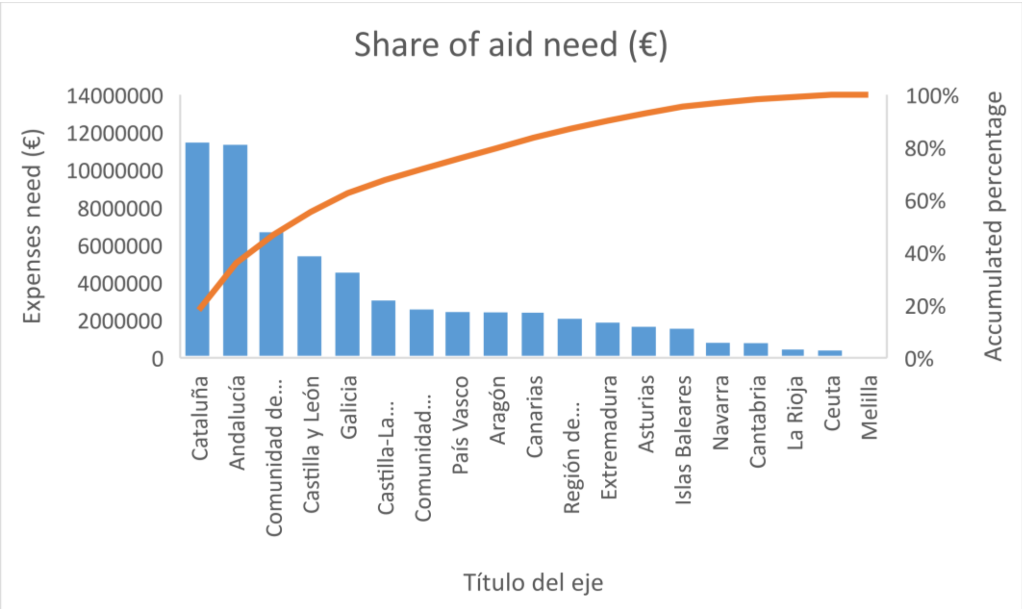

Figure 29: Autonomous Community needs share

As can be seen in the graph, the needs are fairly evenly distributed except for the case of Andalusia which comprises 18% of the total and together with Catalonia which has 18% also due to its high population and heating needs.

These are then the Autonomous Communities where the government should focus on more, maybe by designing specialised aid tools or schemes for them or just by giving bigger amounts of aids.

5. Results & Conclusions

Given the absence of direct policies to combat energy poverty by the central government beyond this incomplete social bond, it is at the regional and municipal levels that we find the most relevant initiatives. We highlight the case of the Generalitat of Catalonia that, for just over a year and a half, is working with the central government in relation to a regulation on energy poverty. This work aimed to establish a winter truce between November and March, both included, so that the energy supply (water, electricity and gas) would not be interrupted to families in vulnerable situation.

The calculated expenses to be carried out by the different Autonomous Communities are much higher than the actual expenses. The figures to cover the whole electricity, gas and water invoices of the vulnerable consumers are shown in the table below.

	BASIC				
€	Urban			Rural	
AUTONOMOUS COMMUNITY	Elect	Gas	Water	Elect	Water
Navarra	158631	145494	149699	330301	118798
Ceuta	192548	132534	159886	6613	2667
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Comunidad de Madr	2166989	1832604	2241945	383487	162153
Región de Murcia	520416	355699	831071	266659	208010
Comunidad Valencia	712994	499377	914428	336721	206772
TOTAL	13368437	10305191	15503008	16740717	7841470
TOTAL ANNUAL	160421250	123662297	186036096	200888603	94097644
	TOTAL URBAN			TOTAL RURAL	
		ubano	470119643	rural	294986247
	TOTAL BASIC				
	765105891				

Table 20: Total expenses by Autonomous Community

The objective of developing the tool is thus completed and the possibility to create new scenarios is now in the hand of the user.

There are many modifiable parameters, from the consumption profile to structural Spanish variables like the electricity price or the gas penetration.

Two other important results that lead to recommendations for the government at their decision taking are that there has to be a focus on the most needed areas, and that investing in energy efficiency and building renovation reduces a lot the long-term energy poverty expenses as it can be seen in the figures below.

Regarding the different Autonomous Communities needs:

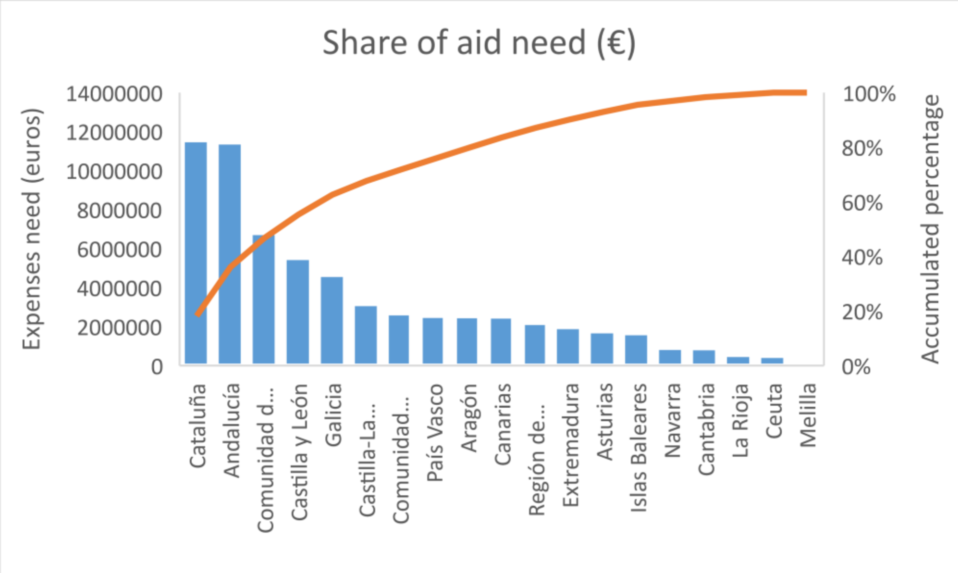


Figure 30: Autonomous Community needs share

As can be seen in the graph, the needs are fairly evenly distributed except for the case of Andalusia which comprises 18% of the total and together with Catalonia which has 18% also due to its high population and heating needs.

These are then the Autonomous Communities where the government should focus on more, maybe by designing specialised aid tools or schemes for them or just by giving bigger amounts of aids.

Regarding the efficiency of the buildings:

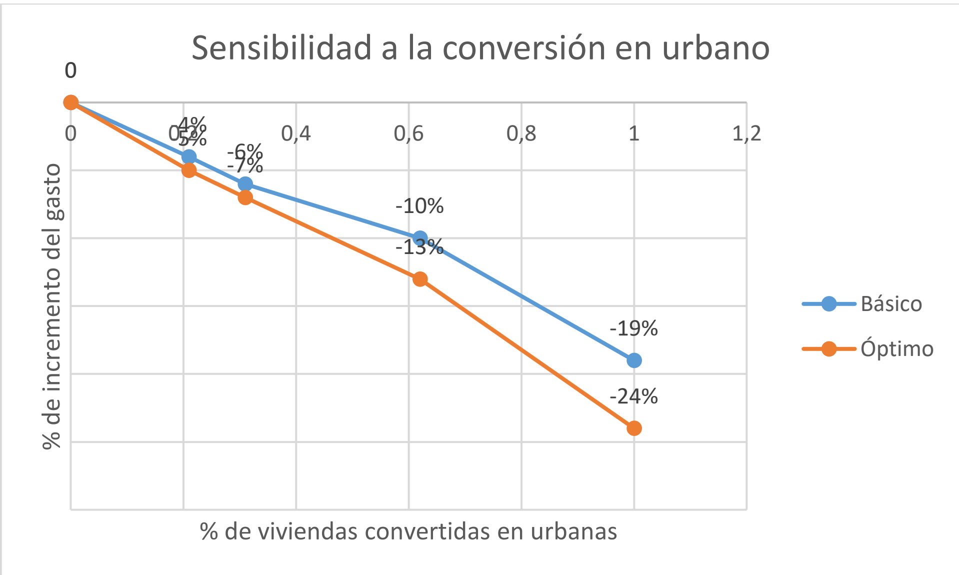


Figure 31: Sensitivity of the total expenses to the % of conversion to new buildings

As it can be seen, the investment in efficiency is a big issue to be taken into account. The renovation of the existing buildings can imply saves in Energy poverty context of up to between 9% and 20% in the optimal case, what is to say, up to 80 million euros annually.

5.1 Analysis of measures

The measures that are already being taken to fight against energy poverty in the short term i.e. payments to afford the expenses for the basic consumptions can be judged with the developed tool.

For the three main cases exposed before the analyses are the following:

- The Catalunya initiative of not stopping the supply during the winter months due to unpaid invoices cannot be directly analysed with the tool, but if the gas and electricity invoices of the 5% of energy poverty in Catalunya would not afford these invoices, the total amount would be of 12million euros considering all the electricity and gas expenses during these four months.

- The Basque Country only destinies 200.000€ to fight the energy poverty. The amount calculated for the vulnerable consumers is 19.2 million euros per year for all the electricity and gas consumptions but taking into account all the vulnerable consumers. Despite this number is overestimated because not all the vulnerable consumers will suffer from energy poverty and neither all of them will ask for the aid, the amount designated is considered lower than the real amount needed

- The Xunta de Galicia designates 1.5million euros to fight the energy poverty in the electricity and gas concepts. The calculated amount to cover the energy vulnerable consumers in Galicia is around 20 million euros per year. As in the above case, this includes all the expenses in electricity and gas taking into account all the vulnerable population of Galicia. The amount is small compared to the needs because estimating with the energy poverty percentage the amount needed is around 10 million euros.

As it can be seen, the money designated to cover the energy poverty issues in the short term is under the requirements. Despite so, it is important to highlight that other measures must be carried out to fight the energy poverty in the long term.

In addition to the government, there are also other institutions that have recognised the urgency and the social alarm and have come to help solve the problem of urgent energy poverty by paying the bills of the most vulnerable consumers. The Red Cross and Cáritas Española stand out in this area, which in addition to allocating funds for this purpose, are responsible for directly targeting the needs of people who are most at risk, this way, funds are especially well used as they meet the most urgent cases.

The contribution of Caritas with the City of Murcia and the municipal water company in Murcia, EMUASA, led to a solidarity fund to help families at risk of exclusion. It should be remembered that Murcia is the autonomous community with the highest price of water.

The families that receive this fund, endowed with 400,000 euros, are not cut off from supply due to non-payment of their invoices. At present, there are 2,917 families receiving this aid fund that allows them to make a single payment of 5 euros a month for consumption per person and day, provided they do not exceed 110 liters. Also, Aguas de Murcia plans to expand this fund to 500,000 euros in the coming months.

On the other hand, and the same way, the Diócesis de Cáritas Parroquial, last year spent € 95,206.38 to supply supplies, paying bills for electricity, water and gas, solving the most urgent call for energy poverty. This amount is intended for people who are cared for who live in very precarious situations, and who are mostly women between 45 and 65. This action is part of a more global action of the Church to make all people have a decent and adequate housing, so that they can grow in all their dignity.

There are also proposals from political parties such as the PODEMOS ones to address the problem using a dual approach:

- With urgent measures such as the prohibition of unauthorized non-payment of supply cuts or the complete restructuring of the expanded social security to the consumption of water and gas so that the fundamental parameter for its concession is the Income of the household weighted by the number of members of the same.

- With structural measures such as the development of a Plan for Energy Savings and Efficiency, in which the key point is the energy rehabilitation of housing. Such rehabilitation will be primarily targeted at households in a situation of energy poverty.

  An excellent example of this type of initiative is the MAD-RE plan which is already underway in the city of Madrid. In the first 6 months of operation, more than 9,000 homes have been asked to participate in this plan, most of them located in the most disadvantaged areas of the capital. The City Council funds part of the actions to improve accessibility and energy rehabilitation, which will reduce their consumption and, therefore, the energy bill. This initiative has particular interest in the great sensitivity of the amount of money needed to combat energy poverty if energy efficiency is improved.

5.2 Conclusions

Energy poverty reflects the inability of a household to meet the cost of its basic energy needs. As in some areas it is pointed out, energy poverty can manifest itself in essential needs (housing, health, education, etc.). It is possible to identify energy poverty independently of general poverty and it must be tackled independently.

We believe that a rigorous treatment of the issue of energy poverty from the economic point of view can contribute much to a serene and constructive analysis of the situation, in search of solutions to this problem. For this purpose, this tool has been developed. The tool will help make a quantitative analysis of energy poverty.

There are two ways to understand energy poverty. The first would be the difficulty or inability to maintain housing under adequate temperature conditions, as well as having other essential energy services at a fair price. This first definition is the one commonly used in developed countries. A second definition, particularly applicable to developing countries, describes energy poverty as the difficulty not only of addressing certain energy costs, but of accessing basic levels of energy supply with advanced forms of energy. The study has focused on Spain and therefore only with the first connotations.

An a priori mitigation strategy against energy poverty, which would focus on the concept of vulnerability, is not enough, but the 'a posteriori' or adaptation approach is also necessary. It is necessary to reach a formal and consensual definition of the term, something that has not yet been achieved at European level.

There is a broad consensus that energy poverty has three main causes. The first and foremost is a low household income level. While energy poverty can be considered as one more aspect of general poverty, its emergence is mainly due to the lack of resources to meet basic energy needs, as well as other basic needs such as housing, food, etc. However, precisely because it is an additional component of the basic household basket, there can be two other causes that, under other circumstances, make families unable to afford this expense: low energy efficiency of housing and a high impact of the cost of energy on the family budget.

In this sense, the possibility of creating scenarios incorporating this information has been included in the tool.

Energy poverty has direct impacts on health. The most serious are associated with exposure to cold temperatures and their consequences can be severe, especially in children and the elderly.

Another effect of energy poverty more diffuse than that related to health is the social impact. This is a problem with two facets. For adults, energy poverty tends to add to an already existing problem of social exclusion. Social agents note cases of households in which their inability to cope with the energy bill leads them to keep the temperature of the house below the minimum comfort. Another economic impact has to do with the reduction of productivity, mainly due to the work losses that diseases related to energy poverty entail. The chapter on premature deaths because of energy poverty is worth mentioning as it also carries economic costs. There are several methods proposed for the calculation of the same that do not have to date a specific for the case of Spain. This analysis should also include an allocation of the aforementioned costs or benefits to the various components of general poverty.

To eradicate the energy poverty in Spain the government should put special attention to three aspects:

The most important part of the consumptions. This can also be decoupled into gas, water and electricity:

• Gas consumption: gas consumption is determined equally by heating and water heating. Among them, they account for more than 90% of the average consumption: 45% is heating and 49% is the water supply. It must be taken into account that the gas will not be present in the rural areas, where the penetration of the gas distribution network is non-existent. With regard to water heating, an improvement can be made in aid to the acquisition of more efficient gas boilers or boilers, and in terms of heating the house, consumption could be significantly reduced if the house is conveniently isolated , So in this case the best option would be to combat energy poverty by improving efficiency and also doing so over the long term.

• Water consumption: Regarding water consumption, 47% is the expenditure for hygiene and in this case the consumption is justified, there being no action other than awareness to make a responsible consumption of water.

• Electricity consumption: As with gas consumption, most of the electricity costs go to heating and heating, with 42% and 27% respectively. The measures are therefore similar to those of gas consumption, but it should be noted that the increase in the use of gas reduces the need to use electricity in these two concepts since they would be made with gas, reducing significantly the expense, reason why The previous measures would be added to facilitate greater integration of gas in homes, which in turn is a measure in the long term.

The most important part of the invoices: It is important to take into account that a large part of the final invoice is not manageable by the customer as is fixed and taxes. In this case it makes no mistake to decompose in the three variables separately since in them the part relative to the consumption realized is around 55%. That is, 45% are fees on the energy service. One measure that is obvious is the application of a social bond similar to the existing one that reallocates the expenses in such a way that a vulnerable consumer does not have to pay taxes that will later be replaced elsewhere, that is, to withdraw part of the Fixed charge to services. The widest group of population affected: There is a greater proportion of necessity in the urban area due to the greater concentration of population, nevertheless it should not be forgotten that the conditions in the rural environment are already harder already by itself. The differentiation between rural or urban measures must be decided at Autonomous Community level since there are communities where the need is eminently urban given their characteristics. Also noteworthy is the case of Andalusia, currently without aid measures and which has major needs.

The needs are fairly evenly distributed except for the case of Andalusia which comprises 18% of the total and together with Catalonia which has 18% also due to its high population and heating needs.

These are then the Autonomous Communities where the government should focus on more, maybe by designing specialised aid tools or schemes for them or just by giving bigger amounts of aids.

Finally, it is important to point out that the payment of the unpaid invoice does not solve the root problem, it merely alleviates a situation of vulnerability which, with few exceptions, is not only a temporary problem of the home, but a chronic situation in time. For this reason, it is thought that this type of measures must be accompanied by other measures of greater depth that allow to mitigate Energy poverty. However, it must be realized that certain situations of social urgency require funds to be allocated to measures that, although mitigating, are those that can be implemented more quickly and those that allow an emergency to be dealt with immediately.

The tool can be improved with the addition of other variables like for example the use of the butane bottle that would give a more real approach of the rural situation or the addition of new energy poverty indicators depending on the autonomous community.

It has been shown that the money designated to cover the energy poverty issues in the short term is under the real requirements given the actual situation of Spain. Despite so, it is important to highlight that other measures must be carried out to fight the energy poverty in the long term.

To sum up, there has to be an increase in the aids to fight energy poverty in the short term. The expenses needed in every Autonomous Community are much higher than the actual aids, but these aids must be enhanced with other kind of aids to fight the problem in a longer time scale like for example energy efficiency awareness campaigns and aid to improve energy efficiency of buildings or gas penetration.

The developed program is applicable to other countries in terms of its structure, that is to say, it is possible to use the way in which the variables have been studied and how they have been implemented provided there is a homogeneity in the construction of the invoices of electricity, gas and water and provided that the hypotheses of the study are valid for the new example, such as the lack of gas in the rural area or that the urban population lives in blocks of houses.

REFERENCES

1. POBREZA, VULNERABILIDAD Y DESIGUALDAD ENERGETICA. Nuevos enfoques de análisis. Asociación de Ciencias Ambientales. España 2006-2016

2. ACER Market Monitoring Report 2015 - CONSUMER PROTECTION AND EMPOWERMENT, ACER 2016

3. Censos de Población y Viviendas 2011 Edificios y viviendas. Instituto Nacional de Estadística, 2013

4. Escala de calificación energética para edificios existentes. Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento

5. Escala de calificación energética para edificios de nueva construcción. Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento

6. Estimaciones de la población rural y urbana a nivel municipal. Univeridad Politécnica de Valencia, 2015

7. Second consumer market study on the functioning of the retail electricity markets for consumers in the EU", European Commission, September 2016

8. Estimaciones de la población rural y urbana a nivel municipal. Francisco J. Goerlich Gisbert Universidad de Valencia e Instituto Valenciano de Investigaciones Económicas

9. The role of information for energy efficiency in the residential sector. Eforenergy. 2014.

10. La pobreza energética en Gipuzkoa. Gipuzkoako Foru Aldundia. Septiembre 2013

11. Tackling Fuel Poverty in Europe. Recommendations Guide for Policy Makers. EPEE Consortium. 2009.

12. Pobreza energética; Definiciones, el contexto Catalán y Español. Diputación de Barcelona, Daniel Calatayud. 2016.

13. Real Decreto 1434/2002, de 27 de diciembre, por el que se regulan las actividades de transporte, distribución, comercialización, suministro y procedimientos de autorización de instalaciones de gas natural. Agencia Estatal, 2003.

14. Real Decreto 216/2014, de 28 de marzo, por el que se establece la metodología de cálculo de los precios voluntarios para el pequeño consumidor de energía eléctrica y su régimen jurídico de contratación. Agencia Estatal, 2014.

15. BARÓMETRO DE LA VIVIENDA Estudio nº 3044 Octubre-Noviembre 2014. Centro de Investigaciones Sociológicas, 2014.

16. Blog Análisis y decision. http://analisisydecision.es/nuevo-y-muy-mejorado-mapa-de-espana-por-provincias-con-excel/

17. Pobreza energética en España. Análisis económico y propuestas de actuación. Economics for Energy, Vigo, 2014.

18. Cáritas Española.

    http://www.caritas-sc.org/actualidad/noticias/1104-caritas-dedico-95-000-a-remediar-la-pobreza-energetica

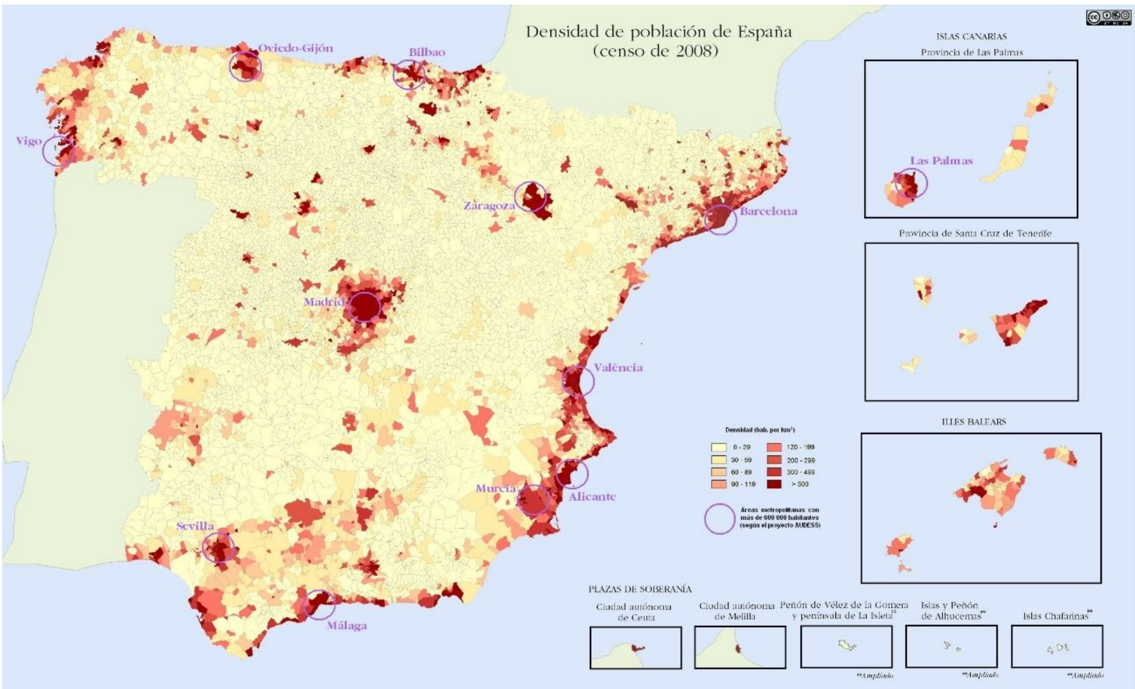
19. VIII Informe del Observatorio de la Realidad Social, Cáritas Española, 2013

20. Podemos, 2017.

    https://podemos.info/pobreza-energetica-espana-situacion-actual-causas-medidas-terminar/#_ftn5

ANNEXES

ANNEX I: DISTRIBUTION OF THE POPULATION



Distribución de la población Rural/Urbana a nivel provincial

		Población					Aglomeraciones
	Provincia	Total	Urbana	Urbana (%)	Rural	Rural (%)	Urbanas
01	Álava	301.926	243.381	80,6%	58.545	19,4%	3
02	Albacete	387.658	261.245	67,4%	126.413	32,6%	8
03	Alacant/Alicante	1.783.555	1.536.397	86,1%	247.158	13,9%	45
04	Almería	635.850	459.521	72,3%	176.329	27,7%	19
05	Ávila	167.818	62.494	37,2%	105.324	62,8%	3
06	Badajoz	673.474	374.583	55,6%	298.891	44,4%	19
07	Illes Balears	1.001.062	762.693	76,2%	238.369	23,8%	25
08	Barcelona	5.309.404	4.962.163	93,5%	347.241	6,5%	27
09	Burgos	363.874	243.148	66,8%	120.726	33,2%	4
10	Cáceres	412.899	201.371	48,8%	211.528	51,2%	11
11	Cádiz	1.194.062	1.060.106	88,8%	133.956	11,2%	31
12	Castellón/Castelló	559.761	436.080	77,9%	123.681	22,1%	18
13	Ciudad Real	506.864	373.346	73,7%	133.518	26,3%	21
14	Córdoba	788.287	599.562	76,1%	188.725	23,9%	24
15	Coruña, A	1.129.141	714.841	63,3%	414.300	36,7%	13
16	Cuenca	208.616	92.820	44,5%	115.796	55,5%	7
17	Girona	687.331	451.355	65,7%	235.976	34,3%	19
18	Granada	876.184	614.974	70,2%	261.210	29,8%	13
19	Guadalajara	213.505	117.713	55,1%	95.792	44,9%	4
20	Guipúzcoa	691.895	587.278	84,9%	104.617	15,1%	18
21	Huelva	492.174	341.408	69,4%	150.766	30,6%	20
22	Huesca	218.023	106.387	48,8%	111.636	51,2%	6
23	Jaén	662.751	458.020	69,1%	204.731	30,9%	25
24	León	498.223	275.535	55,3%	222.688	44,7%	6
25	Lleida	407.496	195.466	48,0%	212.030	52,0%	8
26	Rioja, La	306.377	219.345	71,6%	87.032	28,4%	8
27	Lugo	356.595	146.668	41,1%	209.927	58,9%	8
28	Madrid	6.008.183	5.729.723	95,4%	278.460	4,6%	42
29	Málaga	1.491.287	1.262.540	84,7%	228.747	15,3%	21
30	Murcia	1.370.306	1.174.768	85,7%	195.538	14,3%	29
31	Navarra	601.874	393.325	65,4%	208.549	34,6%	10
32	Ourense	338.671	154.416	45,6%	184.255	54,4%	6
33	Asturias	1.076.896	780.201	72,4%	296.695	27,6%	19
34	Palencia	173.153	100.077	57,8%	73.076	42,2%	4
35	Palmas, Las	1.024.186	880.029	85,9%	144.157	14,1%	14
36	Pontevedra	943.117	681.169	72,2%	261.948	27,8%	11
37	Salamanca	353.110	215.500	61,0%	137.610	39,0%	4
38	Santa Cruz de Tenerife	971.647	845.061	87,0%	126.586	13,0%	15
39	Cantabria	568.091	423.206	74,5%	144.885	25,5%	10
40	Segovia	156.598	68.190	43,5%	88.408	56,5%	3
41	Sevilla	1.835.077	1.638.454	89,3%	196.623	10,7%	43
42	Soria	93.503	42.102	45,0%	51.401	55,0%	2
43	Tarragona	730.466	521.249	71,4%	209.217	28,6%	16
44	Teruel	142.160	53.218	37,4%	88.942	62,6%	3
45	Toledo	615.618	293.410	47,7%	322.208	52,3%	20
46	Valencia/València	2.463.592	2.139.802	86,9%	323.790	13,1%	36
47	Valladolid	519.249	385.676	74,3%	133.573	25,7%	7
48	Vizcaya	1.139.863	1.024.687	89,9%	115.176	10,1%	15
49	Zamora	197.492	91.848	46,5%	105.644	53,5%	3
50	Zaragoza	917.288	715.671	78,0%	201.617	22,0%	10
51	Ceuta	75.861	75.009	98,9%	852	1,1%	1
52	Melilla	66.871	66.805	99,9%	66	0,1%	1
	Total	44.708.964	35.654.036	79,7%	9.054.928	20,3%	758

[Source: Estimaciones de la población rural y urbana a nivel municipal. Francisco J. Goerlich Gisbert Universidad de Valencia e Instituto Valenciano de Investigaciones Económicas (Ivie)]

ANNEX II: 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

Tabla I.2 (Continuación) Valores de referencia para calefacción, refrigeración y demanda de ACS antes de considerar la contribución sola mínima de CTE-HE 4 en viviendas unifamiliares

[Source: Escala de calificación energética para edificios de nueva construcción. Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento]

ANNEX III: DEMANDS FOR NEW 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
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

abla 3.2. Demanda de referencia para viviendas unifamiliares y bloques de viviendas

[Source: Escala de calificación energética para edificios existentes. Instituto para la Diversificación y Ahorro de la Energía (IDAE) y el Ministerio de Fomento]