UNIVERSITÀ DEGLI STUDI DI PADOVA

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Dipartimento di Ingegneria Industriale DII

Corso di Laurea Magistrale in Ingegneria Energetica

Energy poverty in Italy:
Analysis and some proposals to reduce it

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Anno Accademico 2017/2018

Summary

This study concerns the issue of energy poverty. Research and analysis have been carried out in collaboration between the University of Padua and Comillas Pontifical University of Madrid.

The continuous increase in consumer prices and the recent economic crisis of 2008 have excluded a significant percentage of the population to benefit from energy services adequately.

If energy must be considered as a common good there is an urgent need to find solutions that would make possible the access to a growing number of people.

Ultimately this work aims to identify the strategies that with the aid of economic sciences and engineering can improve the concept of "social energy" accessible to all.

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Introduction

Energy poverty is a global issue and one to which Europe is particularly sensitive.
Studies on energy poverty or more precisely on fuel poverty began in the 1980s in the United Kingdom; in fact, there were the first studies that analysed the problem using statistical data and finding indicators in order to identify the consumers affected by this condition.
Even today, energy poverty is still an important issue on the international scene: there has been an increase in energy poverty as a result of the economic crisis of 2008 and due to frequent increases in energy prices.
The concept of energy poverty in Europe and other more developed countries is closely linked to the concept of accessibility to energy services, while in poorer countries it is linked to the concept of availability: in the first case, energy is available but there are no means to pay for it, while in the second, there is a lack of technology to use energy services.
Energy poverty indicators provide information on the number of vulnerable consumers; however, they are not always accurate and complete. Sometimes they generate false positives and/or false negatives, so the current research now aims to find reliable indicators in accordance with the law of each country and to propose some strategies for solving or at least alleviating the problem of energy poverty.
In the first part there is a description of the state of the art of these indicators and a brief part on Italian regulation; finally, the current strategies adopted in Italy have been explained.
The second part analyses the indicators starting from the micro-data of the Households Budget Survey published by ISTAT (Italian National Institute of Statistics).
The third part introduces the concept of energy efficiency and explains the measures taken by the Italian Government to achieve the objectives set out in the European legislation on energy efficiency. Possible solutions in the field of space heating were then analysed in order to identify those that allow for greater energy and economic savings.

The final part includes chapter 4 and the conclusions in which the possible solutions and projects implemented at European and above all Italian level are analysed and explained, while carrying out a self-assessment of the work done and of what can be improved.
The ultimate goal is for the reader to gain critical awareness of this topic.

Chapter 1

State of the art of the current energy poverty policies

This chapter describes current policies and indicators used to estimate energy poverty. There will be a brief excursus on the most commonly used indicators at European level, on how energy poverty is being tackled in Italy and what strategies have been taken to combat it.

1.1 Energy poverty definition

Energy poverty or fuel poverty[1] is a condition whereby a household cannot pay bills such as heating, hot water and electricity, which are considered essential needs to maintain a minimum standard of life.

There are three main factors contributing to the definition of energy poverty in agreement with EU Fuel Poverty Network:

- The inability to keep home properly warm;
- Arrears on bills;
- The presence of leaking roofs, damp walls, floors or foundation, or root in window frames of floor.

Energy poverty can be linked to a concept of accessibility and availability. These two subsets, although united in the same set of energy poverty, refer to completely different conditions:

- Energy availability refers to the concept of lack of suitable technologies for making energy available in homes, especially in the poorest countries.

[1] This is the definition given by http://fuelpoverty.eu the fuel poverty network of European commission.

- Energy affordability, on the other hand, refers to a condition in which energy is available but financial resources are lacking to pay for the supply service, which is what can happen in developed countries.

This work focuses on the concept of energy poverty related to energy affordability.

So if energy poverty as a whole faces three major barriers[2], only the last two listed here have to do with the concept of accessibility:

- The technological barrier; when there is no suitable technology to make energy available;
- The physical barrier, when energy is available, but not enough to maintain a certain level of well-being;
- The economic barrier, when energy is available but is too expensive compared to the level of consumer income.

The last barrier is crucial in the European context and in the developed countries, because the economic barrier perfectly includes consumers suffering from energy poverty.

A further clarification should be made with regard to the definition of vulnerable consumers and energy poverty[3]:

- Vulnerable consumers are consumers at risk or suffering from energy poverty, who must be helped and supported to improve their condition.
- Energy poverty is an issue that can only be solved with major changes in terms of legislative reforms at national and European level, so there is a need for long-term strategies.

Helping vulnerable consumers does not tackle the problem of energy poverty; combating energy poverty and meeting this challenge is the ultimate goal.

As can be seen from the picture below, the main causes of energy poverty are: rising energy bill prices, low income and inefficient housing.

[2] González-Eguino M. (2015). *Energy poverty: An overview.* Renewable and Sustainable Energy Reviews.
[3] *Energy poverty and vulnerable consumers in the energy sector across the EU: analysis of policies and measures.* https://ec.europa.eu/energy/sites/ener/files/documents/INSIGHT_E_Energy%20Poverty%20-%20Main%20Report_FINAL.pdf

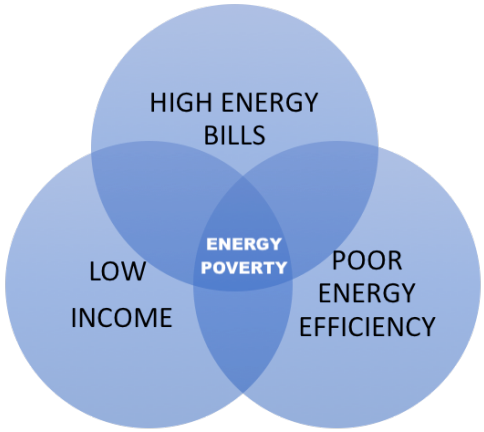

Figure 1. Energy poverty is the consequence of these three factors. Data source: INSIGHT_E Report, 2015.

The main instruments for combating energy poverty are

- Income subsides;
- Social tariffs that boundary the price level;
- Social bonus that limit the price impact on the bills;
- Improvement of energy efficiency[4].

The first step in understanding energy poverty is how to measure it and what the main indicators are: these are the Ten Percent Rule (TPR), the Low Income/High Cost (LIHC) indicator and the Minimum Income Standard (MIS) indicator.

1.2 Main Energy Poverty Indicators

The three main and best-known energy poverty indicators are the 10% rule (TPR), the low income/high cost indicator (LIHC) and the minimum income standard indicator (MIS).

All three of these indicators have been defined by researchers in the United Kingdom, because the first research and definitions of energy poverty come from there.

The 10% criterion is an expenditure-based criterion and was the first adopted as an official indicator by the British Government. It was estimated by Brenda Boardman in 1991 based on the Family Expenditure Survey for UK households of 1988.

[4] The energy efficiency laws and improvements will be treated in chapter 3.

It is fundamentally based on the idea that if energy spending exceeds 10% of total expenditure (or income), then energy poverty occurs.

This method is easy to use and understand, but it also has disadvantages: it is too sensitive to the rise in energy prices because as soon as the price rises, there is a large variation in the percentage of energy poverty; it considers the ratio between expenditure but does not look at the real economic possibilities of consumers. In addition, false positives can also be included in the analysis, for example consumers with high energy costs but also very high incomes, or false negatives, for instance consumers who consume little to save and therefore their expenditure does not exceed 10%.

The LIHC indicator is the current indicator adopted by the UK Government. It was defined by John Hills. This indicator is based on simultaneous verification of low income and high energy costs. Income is calculated on after housing costs basis and equivalised income to account for the household composition. After housing costs are the housing costs once mortgage, payments and rentals have been deducted.

The income threshold set by Hills is below 60% of the median net income (definition given by DEEC 2013).

Income is net when housing costs are removed, while the median value is referred to as it is less subject to fluctuations in extreme values.

The income is also called equivalised because it tends to make all families comparable and to do this is considered the size of the house. This has created many disputes, in fact even B. Boardman has contested that with equivalised income it could be said that those who live in a small house have a higher income than those who live in a large house and vice versa, but this is not always true.

This method better describes the conditions of vulnerable consumers and is useful for distinguishing between consumers in energy poverty and those in income poverty: consumers must have an income below a certain threshold, but also an energy expenditure above the median value.

One of the disadvantages of this method is that it is not sensitive to changes in energy prices, as it refers has a relative measure (median energy expenditure is considered). When, as a result of a large increase in prices, the whole population tries to consume less, the indicator does not detect the situation.

According to some researchers, the definition of LIHC identifies energy efficiency as a way out of this condition, and this is certainly the right solution, but it does not lead governments to focus their attention on social policies (relating to income) and market policies (relating to energy prices).

The MIS indicator has been proposed by Moore: MIS is the minimum income standard and is a minimum income level differentiated by family type necessary to maintain a lifestyle that does not lead to social exclusion.

According to this indicator, a consumer is in energy poverty when the net income is insufficient to bear energy costs after deduction of minimum living costs.

This is certainly the most complete indicator as it considers not only energy costs and income, but also the aspect of inclusion in society that is fundamental to life.

However, this method is difficult to calculate because it is not easy to estimate a basket of goods essential for an integrated life. Another disadvantage is that it is difficult to estimate a single indicator at European level because each Member State has its own particular characteristics, a different cost of living, different diets, different clothes and different habits. It is necessary for each country to estimate its basic baskets of goods and minimum needs, and therefore to assess the costs involved; only in the end will it be possible to jointly evaluate the indicator of energy poverty in the European context.

The main problems in assessing indicators are the following:

- Equivalised income or not;
- Consider income with housing costs or not (debate on before housing costs or after housing costs): among these costs there is also the opportunity cost of renting which is discussed in chapter 2;
- Consider actual expenditure or requested expenditure.

All these different assessments lead to different percentages of vulnerable consumers, so it is necessary to agree if energy poverty values need to be more consistent with each other.

1.3 Energy poverty in Europe

It is important to have an overview of how energy poverty in Europe is addressed; the first reference should be made to European legislation where energy poverty is mentioned in the following ways[5]:

- 2009/73/EC (50) about the natural gas market, it is explained that energy poverty is increasing in the European Union and the countries affected by this issue must find solutions and guarantee minimum energy needs for vulnerable consumers, defined as consumers who are in a state of energy poverty.
- 2009/72/EC (53) about the electricity market, states the same assertions as the previous article.

The objective of the European Union is to find common guidelines, such as energy poverty indicators, to assess the percentage of vulnerable consumers.

This can be achieved by means of a database common to all Member States in which data from each country are collected and by means of common guidelines accepted unanimously.

The means that the European Union has adopted for obtaining data and measures is the Energy Poverty Observatory whose objectives are:

- Improve the dissemination of data among European countries;
- Provide a user-friendly and open source;
- Facilitate the diffusion of knowledge;
- Promote teamwork among member states;
- Provide technical assistance.

The member states of the observatory are not only European, but there are also India, Japan, Israel, Mexico, Pakistan and South Africa[6].

The graphs below show the percentages of European and Italian households in energy poverty in according with the consensual-based approach of EU Fuel Network. The indicators used to measure them are:

- The inability to keep home adequately warm;
- Arrears on utility bills;

[5] Subsequently, the Energy Performance Building Directive (2010/31/EU) also refers to the concept of energy poverty by saying that increased energy efficiency in buildings helps to reduce it.

[6] *https://www.energypoverty.eu.*

- Presence of a leaking roof, damp walls, floors or foundation, or root in window frames of floor.

These data provided by Eurostat (EU – SILC) are not the result of a measurement or verification, but only declarations by survey households.

This information gives a first and rough idea of how many percentages of vulnerable consumers are.

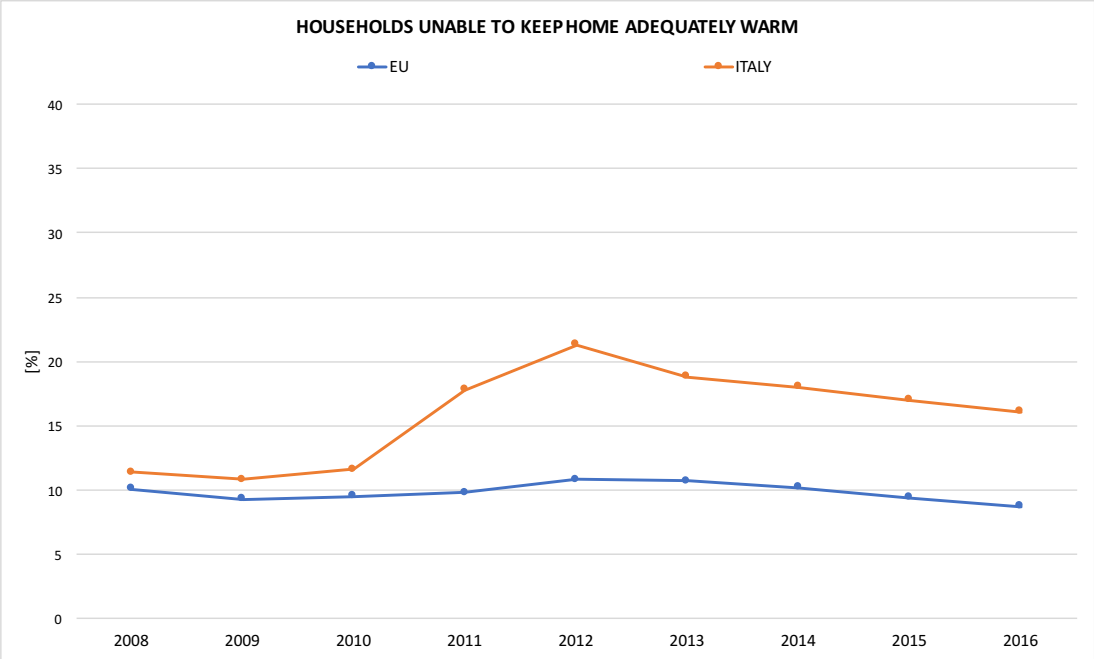

Figure 2. Percentages of households that are unable to keep home adequately warm. Source of data: Eurostat.

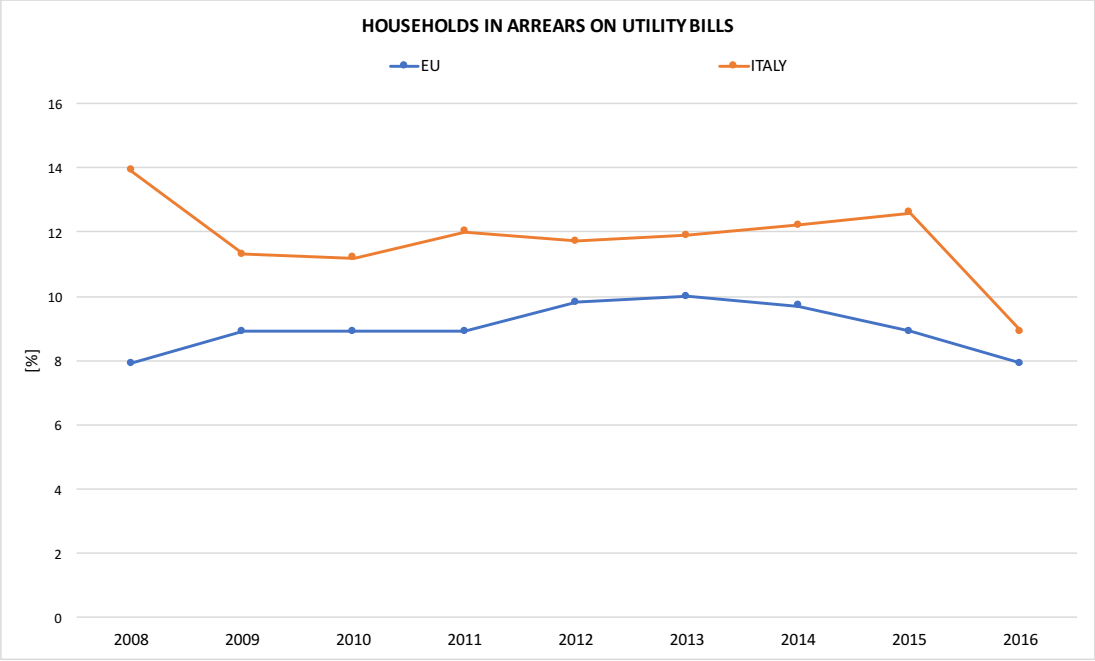

Figure 3. Percentages of households in arrears on utility bills. Source of data: Eurostat.

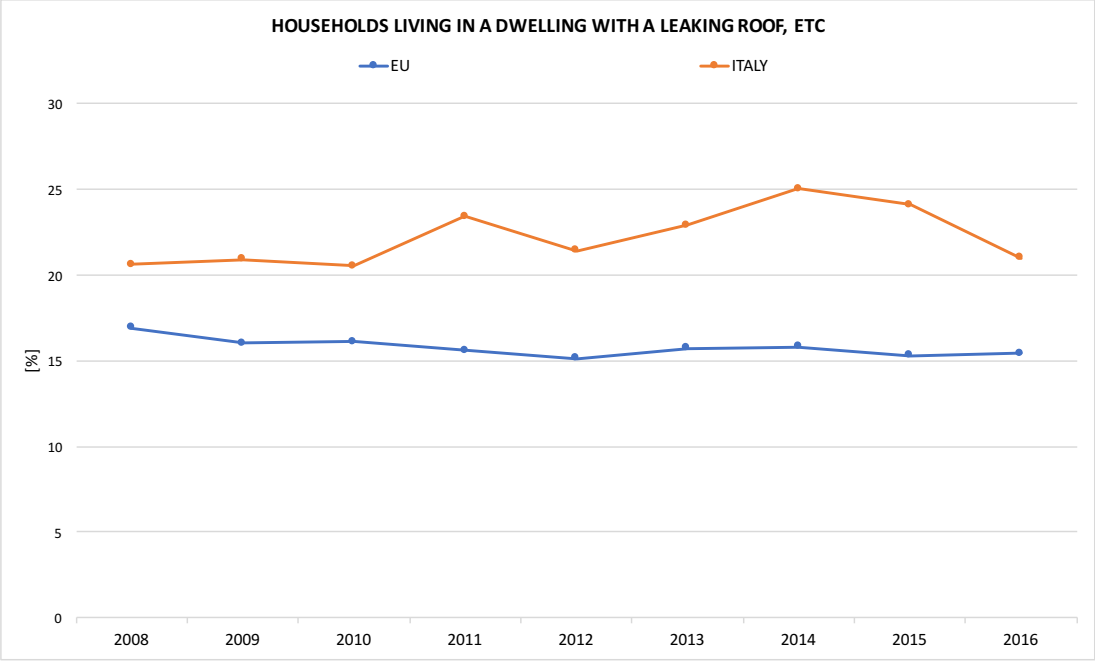

Figure 4. Percentages of households that declare to live in a dwelling with a leaking roof, damp walls, floors or foundation, or root in window frames of floor. Source of data: Eurostat.

The graphs refer to all households surveyed without any differentiation and are based on EU - SILC, the European Survey on Income Living Conditions.

At European level the trend of graphs is about constant over the years, between 8% and 10% are the percentages of consumers who cannot heat adequately the house and

are in backward with bills, while the % of consumers who live in a house in bad condition is a little higher and is between 15% and 20%.

At Italian level the situation is different: in fact, although there is a percentage decrease for all three graphs, the values are around 15-20% for fig. 2, 12% in fig. 3 and 20-25% in fig. 4.

This can mainly be caused by very high energy bills for the first two cases.

There are other interesting data in the Eurostat survey that are focused on household conditions: rent or mortgage arrears, houses defined as not very bright, etc.

However, those data shown in the previous graphs are the most relevant to the theme of energy poverty.

Referring always to the three previous conditions, it is interesting to note that the percentages vary according to the type of family considered.

The following graphs show the percentage over the years of single parent households with dependent children (considered to be a particularly vulnerable category) who claim that they cannot heat the house properly, that they are in arrears with their bills and that they live in poor housing.

In fact, it can be seen that both in Italy and in Europe the percentages are higher.

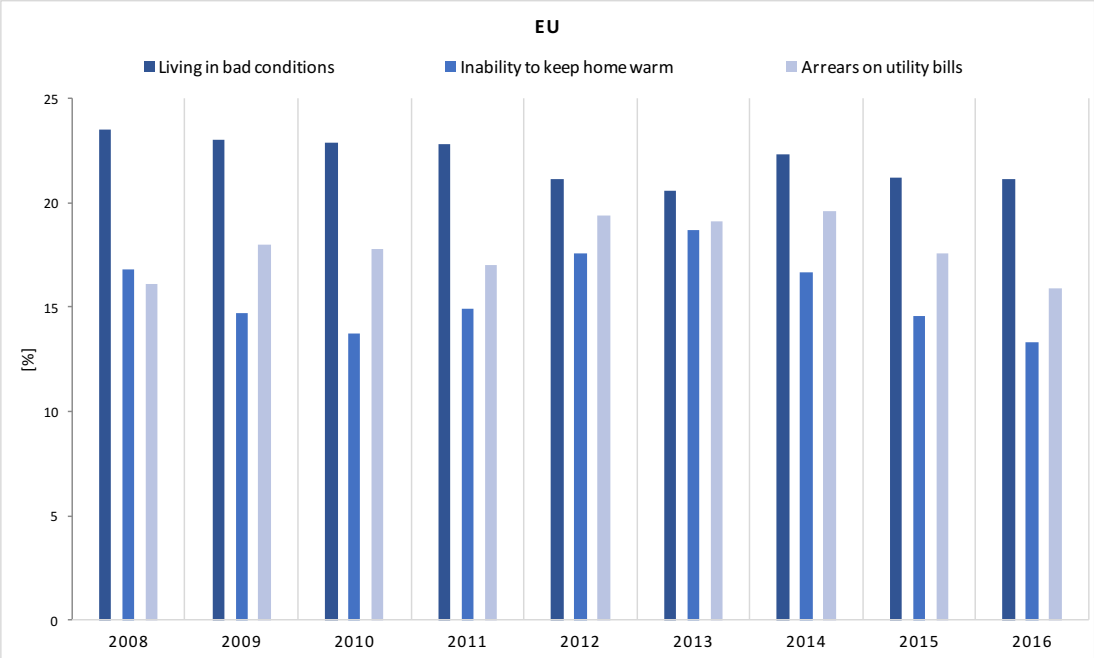

Figure 5. European indicators of households composed by single parent with dependent children. Data source: Eurostat.

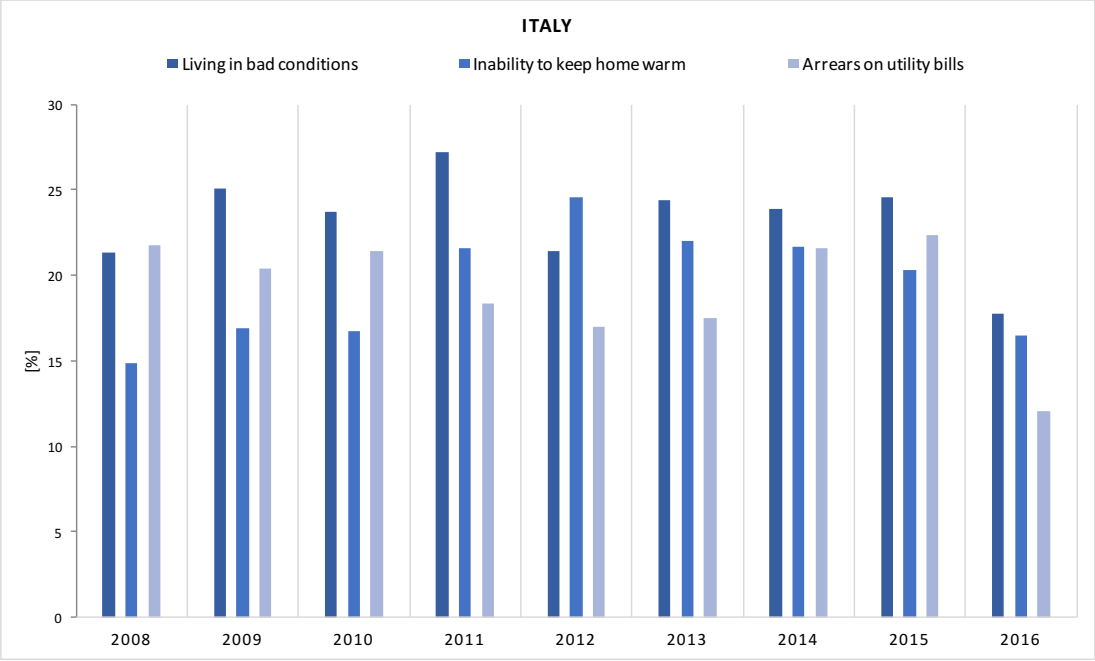

Figure 6. Italian indicators of households composed by single parent with dependent children. Data source: Eurostat.

1.4 Energy poverty in Italy

Energy poverty in Italy today is an important issue. In 2015, the families who declared that they could not heat their homes adequately were:

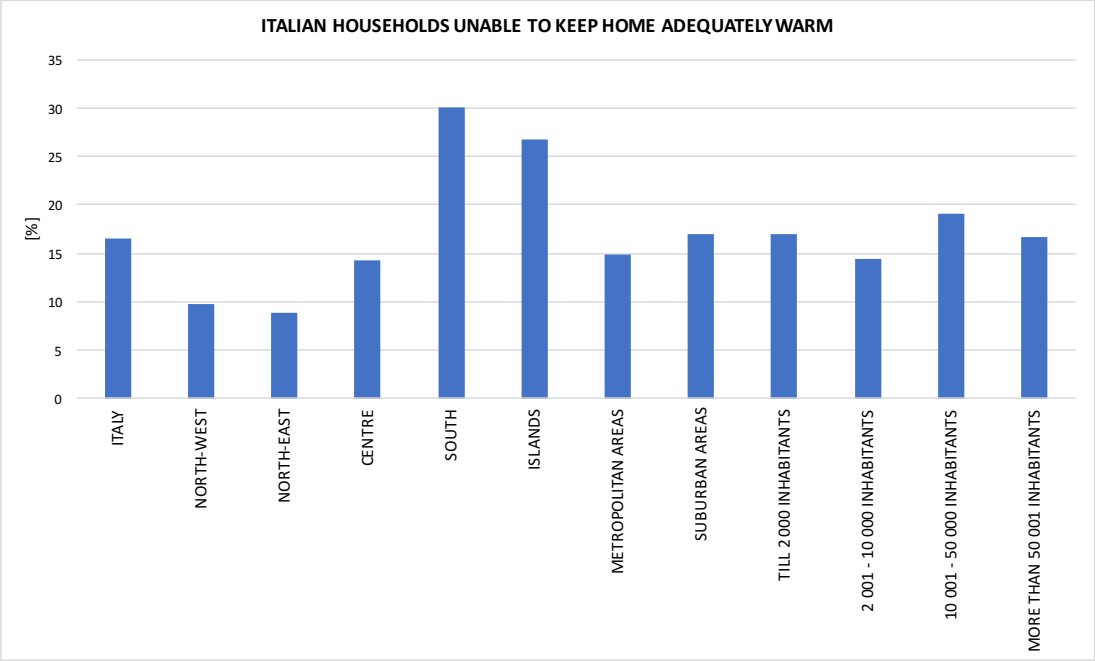

Figure 7. Percentages of families who could not properly heat their homes in 2015 in Italy. Data source: ISTAT.

Another important analysis conducted by ISTAT concerns households in absolute and relative poverty. This is particularly important because low income is one of the factors leading to energy poverty.

The graph below shows the percentages of poor households in Italy in 2016.

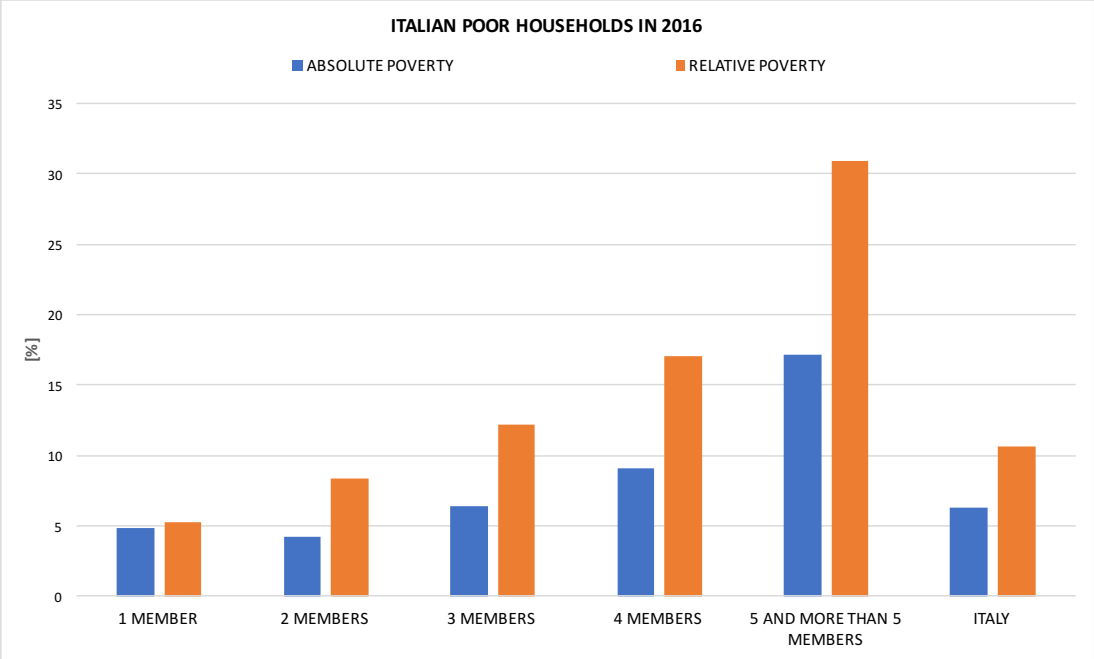

Figure 8. Italian poor families in 2016. Data source: ISTAT.

This chart shows the Italian poor households divided by number of household members and the Italian average of them.

It is easy to identify the families most affected by poverty. It is also necessary to outline the difference between absolute poverty and relative poverty adopted by ISTAT:

- A household in absolute poverty is a household with an average monthly expenditure below the minimum spending threshold defined by ISTAT following a study in 2009;
- A household in relative poverty is a household with a lower average monthly expenditure than the ISPL[7], which is a reference value for which a household of two members has an average monthly expenditure lower than or equal to a household of one component. Coefficients are then calculated through the Carbonaro's scale to report ISPL values for households with more than two

[7] International Standard of Poverty Line.

components. That is a reference value of a two-components family that spends as a single-component family.

Another clarification concerning the two types of poverty: the data represent the incidence of absolute/relative poverty for 100 households with the same characteristics.

In the Italian political landscape in 2017, a whole paragraph dedicated to energy poverty was published in the national energy strategy edited by the Ministry of Economic Development and the Ministry of the Environment[8]. This suggests how much this problem is emerging more widely and how necessary solutions need to be found.

The main objectives set out in the document are as follows:

- Officially define the LIHC indicator in order to have a reliable and concrete measure of energy poverty in Italy;
- Establish a national observatory for energy poverty as proposed by the European Commission;
- Reforming social bonus to make the procedure easier and faster to apply for.

The social bonus is the solution adopted by the Italian government to help low-income families by relieving them of part of the cost of gas and electricity bills.

The bonus is divided into electric bonuses and gas bonuses because the second one also depends (apart from income) on the climate area to which the consumer who benefits from it belongs; in fact, consumers in colder climatic areas receive a higher bonus because consumption is higher.

The bonus was regulated in Italy in 2005[9], but only in 2007[10] the government decreed the rules.

For 2018, the Electricity, Gas and Water System Authority[11] has defined the following quotas to be subtracted from bills for households who have access to the bonus.

[8] Ministero dello Sviluppo Economico e Ministero dell'Ambiente e della Tutela del Territorio e del Mare.
[9] Law No. 265, 23/12/2005.
[10] Legislative Decree No. 28/12/2007.
[11] AEEGSI, Autorità per l'Energia Elettrica, il Gas e il Sistema Idrico.

HOUSEHOLD COMPONENTS	ELECTRICITY BONUS [€/year/sampling point]
1-2	125
3-4	153
more than 4	184

Table 1. Value of the electric bonus for low-income consumers. Data source: AEEGSI.

	MINIMUM	MEDIAN	MAXIMUM
extra consumption	≤ 600 kWh/year	600<cons≤1 200 kWh/year	>1 200 kWh/year
[€/year/sampling point]			
bonus up to 3 kW	193	318	460
bonus from 4,5 kW	452	572	692

Table 2 Value of the electric bonus for consumers in situations of physical discomfort. Data source: AEEGSI.

GAS BONUS [€/year/delivery point]	CLIMATIC AREA				
	A/B	C	D	E	F
Households up to 4 components					
Water and/or cooking systems	32	32	32	32	32
Water, cooking and heating systems	74	92	121	150	189
Households with more than 4 components					
Water and/or cooking systems	50	50	50	50	50
Water, cooking and heating systems	103	134	175	213	273

Table 3. Value of the gas bonus for low-income consumers. Data source: AEEGSI.

Although the bonus is a positive solution and an aid that not all governments have given their citizens, the award of the bonus is determined exclusively on the analysis of the applicants' economic situation and not on the analysis based on the identification of an energy poverty condition.

A further problem with the social bonus is that all consumers who do not have gas and/or electricity cannot claim the bonus because they are not connected to the grid, although some of them are in energy poverty.

The bonus award is awarded on the basis of the ISEE[12] (Equivalent Economic Situation Indicator) declaration of the applicant, who consequently obtains the bonus if one of the following conditions is met:

[12] Indicatore Situazione Economica Equivalente.

- The ISEE is less than 8 107.5 €;
- The ISEE is less than 20 000 € for families with at least three dependent children;
- One of the members of the household requires special medical treatment with the use of electrical energy-intensive machinery.

1.4.1 The ISEE indicator

The ISEE is an Italian indicator used to claim tax deductions, social bonus, university tuition and other benefits of various kinds in order to help low income families economically.

The ISEE is the ratio between the economic situation indicator (ISE[13], which is the sum of income, 20% of the assets and properties of all household members) and the equivalent scale parameter, which assumes the following values depending on the number of members of the household:

Number of family components	Equivalence scale parameter
1	1.00
2	1.57
3	2.04
4	2.46
5	2.85

Table 4. Equivalent scale parameter used to calculate the ISEE. Data source: INPS.

As there is no data available on the ISEE indicator, it is useful to refer to a report on the INPS (Institute National Social Security Institute[14]) ISEE for 2015[15].

Following the 2015 ISEE reform, the estimated values of households that compiled the ISEE declaration are estimated:

- 10.8%, 0 €;
- 13.9%, 0-3 000 €;
- 16.3%, 3 000-6 000 €;
- 14.5%, 6 000-9 000 €;

[13] Indicatore della Situazione Economica.
[14] Istituto Nazionale di Previdenza Sociale.
[15] http://www.lavoro.gov.it/documenti-e-norme/studi-e-statistiche/Documents, *2005 Monitoring Report*.

- 9.6%, 9 000-12 000 €;
- 7.4%, 12 000-15 000 €;
- 8.8%, 15 000-20 000 €;
- 5.8% 20 000-25 000 €;
- 3.9% 25 000-30 000 €;
- 4.4% 30 000-40 000 €;
- 4.5% over 40 000 €.

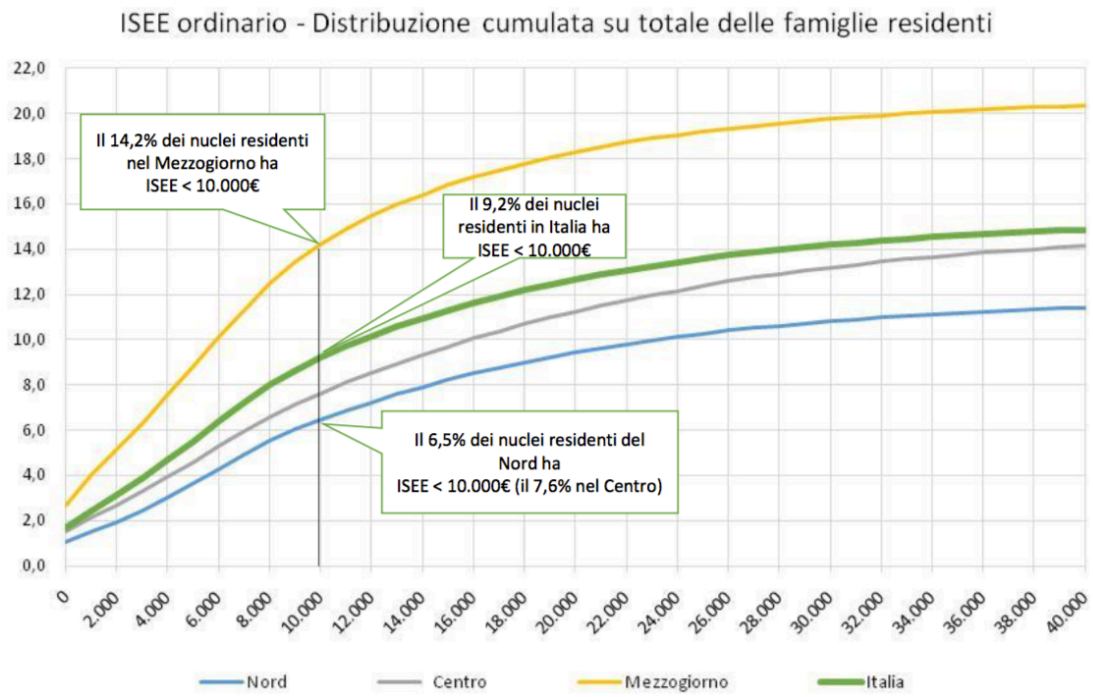

Figure 9 Distribution of the ISEE values according to different geographical areas; the vertical line separates families with an ISEE of less than 10 000 €. Data from the monitoring report of the 2015 ISEE declarations (Ministry of Labour and Social Affairs[16]).

About 52% of the families that made the ISEE declaration (not the entire amount of Italian families) could receive the bonus, while referring to the entire Italian population about 8% have an ISEE of less than 8 000 € (12% are resident in southern Italy, 7% in central Italy and approximately 6% in the North).

[16] Ministero del Lavoro e delle Politiche Sociali.

The graphs of the report reveal important observations about the ISEE according to different typologies and family numbers:

- The growth in the value of the ISEE is directly proportional to the increase in family numbers up to families of four members and then becomes inversely proportional from five components upwards;
- Dependent children decrease the median value;
- The lowest ISEEs are found in households with few working members (families with dependent children, families with elderly people and families with unemployed):
- The ISEE is less than 3 000 € when family members are unemployed;
- If all members are workers, the median value of the ISEE increases above 15 000 €;
- For pensioners, the value of the ISEE is around 7 900 €.

As a result, pensioners, large families and the unemployed are the best candidates for the social bonus.

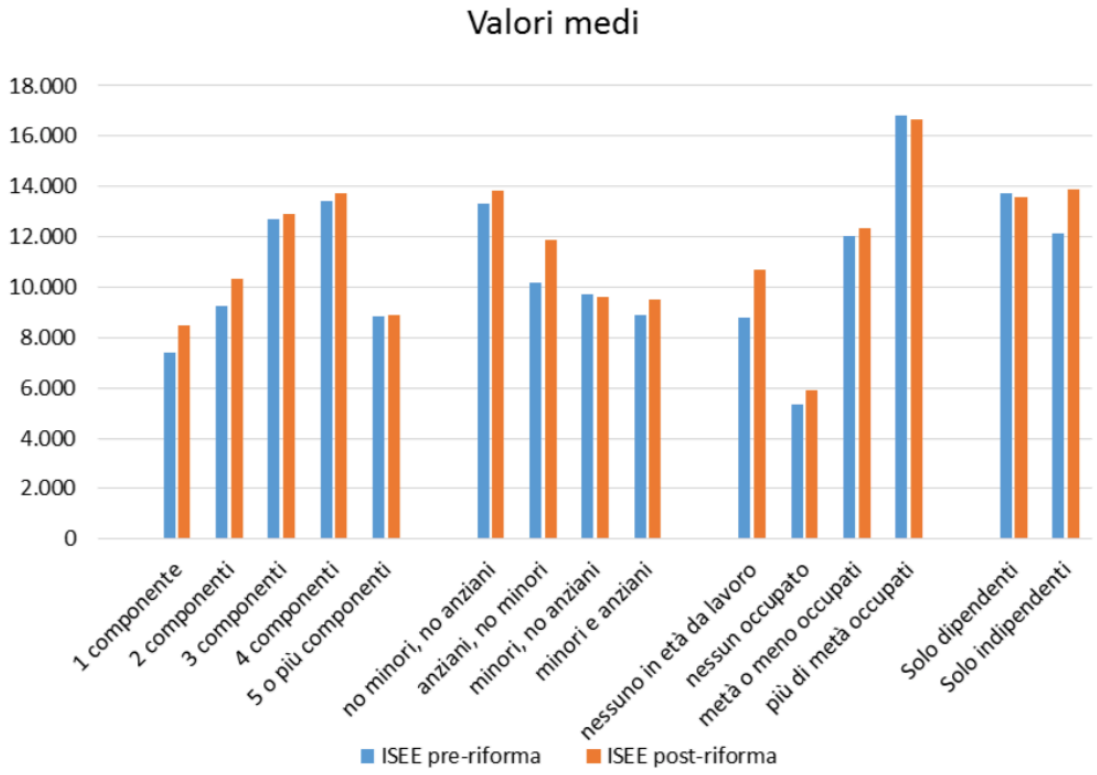

Figure 10. Average values of ISEE: orange values refer to the post-reform ISEE, in any case both the pre-reform and post-reform assume the same trend with reference to the same family categories and family numbers. Data from the monitoring report of the 2015 ISEE declarations (Ministry of Labour and Social Affairs).

Chapter 2

Analysis of EP indicators in the Italian case

The essence of the following chapter is the analysis of energy poverty indicators: first of all, they have been described in more detail and then the analysis of some indicators has been made, motivating the choice, which are better suited to the Italian case in accordance with other research.

2.1 Assumptions

The first important assumption is that the available data are not complete; in fact, ISTAT does not provide information (by means of data for public use) about the incomes of the households interviewed. As a result, this analysis is based only on monthly consumer spending (total expenditure, energy expenditure, rent, food and residual expenditure).

The decision was taken to carry out the analysis with the following three approaches:

- The method of Valbonesi et al.[17];
- The TPR approach;
- The method of Faiella and Lavecchia[18].

These methods were chosen in line with the available data (expenditure and non-income data). Moreover, the first and third methods have been studied by Italian researchers and applied to the Italian case, so they are the ones that best adapt to this analysis.

[17] R. Miniaci, C. Scarpa, P. Valbonesi (2014). *Fuel poverty and the energy benefit system: The Italian case.* Working paper n.66 IEFE.

[18] I. Faiella, L. Lavecchia (2014). *La povertà energetica in Italia.* Occasional papers n. 240, Banca d'Italia.

The TPR was chosen because it is a method that can also be expenditure-based and was also the first method used to assess energy poverty.

The graphs that report the results are not subdivided according to the number of components of the household since the available data were not sufficiently homogeneous regarding the distribution of family size. The results shown in the diagrams were therefore not significant.

It is important to note that in the analysis of indicators only monthly expenditure [€/month] is considered and not the physical quantities that constitute expenditure.

Another important clarification is related to the division of Italy into three geographical areas; here below are listed the areas and regions that belong to it:

- North: Valle d' Aosta, Piedmont, Liguria, Lombardy, Trentino Alto Adige, Veneto, Friuli Venezia Giulia and Emilia Romagna;
- Centre: Tuscany, Umbria, Marche, Lazio;
- South: Campania, Molise, Abruzzo, Basilicata, Apulia, Calabria, Sicily, Sardinia.

The last fact to be taken into account is that Sardinia is not considered in the analysis because it does not have the methane network.

2.2 First approach

The first approach dates back to a research published in 2014 and consists of setting certain expenditure thresholds and verifying the proportion of consumers below or over them depending on the indicator.

The thresholds are subdivided by electricity consumption and gas consumption and are chosen in different ways, so this approach will lead to different results depending on the thresholds set.

Another important distinction on which the study intends to shed light, still using new thresholds (this time undifferentiated between gas and light), is that between poor income consumers and under-consumers.

2.2.1 Definition of the needs and minimum expenditures

ISTAT has drawn up a very useful document[19] on the estimate of absolute poverty of Italian households in 2005, which defines the minimum monthly expenses (electricity, fuel, rent, food, residual) below which a family is in absolute poverty.

Expenditure figures had to be carried forward to 2016, using the price index[20]; this index is provided annually by ISTAT in two different ways:

- Nic, which are the consumer prices reported to the whole nation;
- Foi, which are the consumer prices reported to families of white and blue-collar workers.

The choice was made in Foi because complete data were provided.

The monthly needs are diversified by family size (from 1 to 6 members) and by Italian geographical area (North, Centre, South).

FOOD [€/month]			
Components	North	Centre	South
1	174	154	148
2	299	266	255
3	413	367	351
4	516	458	439
5	643	571	546
6	731	649	622

Table 5. Minimum monthly expenditure on food. Values have been evaluated in accordance with the standard values of some components necessary to lead a healthy lifestyle. Data source: ISTAT.

[19] ISTAT (2009). *La misura della povertà assoluta*. Metodi e norme n. 39, 2009.

[20] *http://www.istat.it/it/files/2011/06/NM_variazioni_coefficienti_2016.pdf,* methodology for changing the price indexes.

RENT [€/month]				
Components	North	Centre	South	Italy
1	258	258	188	234
2	286	286	201	257
3	308	308	211	276
4	345	345	225	305
5	371	371	234	326
6	395	395	242	344

Table 6. Minimum monthly rental and mortgage expenses. The values are consistent with the values that households reported to pay into the HBS in 2016. Data source: ISTAT.

ELECTRICITY [€/month]			
Components	North	Centre	South
1	9	9	9
2	12	12	12
3	17	17	17
4	19	19	19
5	21	21	21
6	22	22	22

Table 7. Minimum monthly expenditure on electricity. Data source: ISTAT.

FUEL [€/month]			
Components	North	Centre	South
1	41	36	6
2	50	45	15
3	58	53	22
4	66	60	30
5	75	70	40
6	88	83	53

Table 8. Minimum monthly expenditure on fuels. Data source: ISTAT.

RESIDUAL GOODS [€/month]			
Components	North	Centre	South
1	130	116	112
2	219	196	188
3	305	249	261
4	397	355	340
5	514	459	441
6	588	525	504

Table 9. Minimum monthly expenditure on residual goods. Data source: ISTAT.

2.2.2 Budget share approach

This approach aims to identify vulnerable consumers. Once thresholds representing the impact of energy expenditure on total expenditure have been set, it is necessary to verify whether the impact of energy expenditure on the total expenditure of the consumer in question is lower or higher than the threshold chosen. If the value is higher, this consumer is in energy poverty.

The budget share is divided into three indicators that differ according to how thresholds are determined:

- Normative indicators: one for electricity and one for fuels;
- Positive indicators: one for electricity and one for fuels;
- Standard indicators: one for electricity and one for fuels.

The normative indicators

This procedure defines the thresholds using the monthly values provided by ISTAT of the minimum expenditure on gas and electricity and the minimum total expenditure differentiated by family size and geographical area.

The thresholds are then calculated in this way:

$$r_{el}^{st} = {}^{r_{el}}/_{r_{tot}} \quad (2.1)$$

$$r_{gas}^{st} = {}^{r_{gas}}/_{r_{tot}} \quad (2.2)$$

TENANTS OR IN MORTGAGE	TOTAL EXPENDITURES [€/month]		
Components	North	Centre	South
1	612	574	462
2	867	805	671
3	1 101	993	862
4	1 342	1 237	1 054
5	1 624	1 492	1 282
6	1 823	1 673	1 442

Table 10. Total expenditure of rented or mortgaged households. Data source: ISTAT data revision.

r_{el}^{st} [-]			
Components	North	Centre	South
1	0.015	0.016	0.020
2	0.014	0.015	0.019
3	0.015	0.017	0.020
4	0.014	0.015	0.018
5	0.013	0.014	0.016
6	0.012	0.013	0.015

Table 11. Thresholds for electricity consumption.

r_{gas}^{st} [-]			
Components	North	Centre	South
1	0.067	0.063	0.013
2	0.058	0.056	0.022
3	0.052	0.053	0.026
4	0.049	0.049	0.029
5	0.046	0.047	0.031
6	0.048	0.049	0.037

Table 12. Thresholds for fuel consumption.

OWNERS	TOTAL EXPENDITURES [€/month]		
Components	North	Centre	South
1	354	316	274
2	581	520	470
3	792	685	651
4	997	892	828
5	1 252	1 120	1 048
6	1 428	1 279	1 200

Table 13. Total expenditure of owner households. Data source: ISTAT data revision.

r_{el}^{st} [-]			
Components	North	Centre	South
1	0.026	0.029	0.033
2	0.021	0.024	0.026
3	0.021	0.025	0.026
4	0.019	0.021	0.023
5	0.016	0.018	0.020
6	0.015	0.017	0.018

Table 14. Thresholds for electricity consumption.

r_{gas}^{st} [-]			
Components	North	Centre	South
1	0.117	0.114	0.022
2	0.086	0.086	0.032
3	0.073	0.077	0.034
4	0.066	0.067	0.037
5	0.060	0.062	0.038
6	0.062	0.065	0.044

Table 15. Thresholds for fuel consumption.

A further clarification should be made with regard to the thresholds: in fact, a distinction has been made between those that refer to households that own a house and those that refer to families that are rented or have a mortgage to pay.

This decision has been taken because the owners have a lower monthly cost than other households; consequently, this work does not take into account the opportunity cost of renting a house owned by the family that inhabits it.

The positive indicators

This second methodology defines, like the previous one, the thresholds as the ratio between the monthly energy expenditure for fuels/electricity and total expenditure.
The difference from the previous procedure is that the considered expenses are the mean expenditures of those households below the relative poverty line distinguished by family size, geographical area and status (owners or tenants/with mortgage).
The relative poverty line, as already explained, is defined annually by ISTAT on the basis of the ISPL value.
For the year 2016, the average monthly expenditure values below which consumers are in relative poverty are:

Relative poverty line, ISPL [€/month]		
Components	ISTAT's values for the tenants	Values for the owners
1	637	402
2	1 061	804
3	1 412	1 136
4	1 730	1 425
5	2 017	1 691
6	2 293	1 949

Table 16. The ISPL in 2016 provided by ISTAT.

In line with the analysis above, a subdivision was made between owners and tenants/mortgages because the opportunity rental cost is not included in the calculation.
Table 16 shows the ISTAT value which refers to the total monthly expenditure and to the value calculated by this study where opportunity rental costs have been subtracted. These rental values are taken from the minimum value of the rental costs, broken down by family size, derived from the ISTAT survey on the analysis of absolute poverty.

TENANTS	r_{el}^{st} [-]		
Components	North	Centre	South
1	0.041	0.039	0.059
2	0.038	0.038	0.053
3	0.038	0.039	0.061
4	0.032	0.030	0.052
5	0.036	0.020	0.056
6	0.035	0.049	0.040

Table 17. Thresholds for electricity consumption.

TENANTS	r_{gas}^{st} [-]		
Components	North	Centre	South
1	0.004	0.014	0.006
2	0.061	0.050	0.029
3	0.040	0.046	0.041
4	0.043	0.033	0.029
5	0.047	0.022	0.034
6	0.068	0.031	0.027

Table 18. Thresholds for fuel consumption.

OWNERS	r_{el}^{st} [-]		
Components	North	Centre	South
1	0.074	0.072	0.096
2	0.060	0.064	0.071
3	0.060	0.057	0.067
4	0.055	0.047	0.058
5	0.039	0.049	0.057
6	0.037	0.035	0.048

Table 19. Thresholds for electricity consumption.

OWNERS	r_{gas}^{st} [-]		
Components	North	Center	South
1	0.115	0.086	0.087
2	0.093	0.078	0.072
3	0.079	0.067	0.052
4	0.060	0.055	0.048
5	0.057	0.047	0.042
6	0.056	0.040	0.026

Table 20. Thresholds for gas consumption.

The standard indicators

This procedure states that in order not to be in energy poverty[21]:

- The electrical expenditure should be lower than the 5% of the total expenditure;
- The fuel expenditure should be lower than 10% of the total expenditure.

Therefore, in accordance with previous methods, a consumer is vulnerable if the impact of energy expenditure on total expenditure is greater than 0.05 in the electricity case, it is greater than 0.10 in the context of other fuels.

Headcount Indexes

The headcount indexes show the percentage of consumers in energy poverty.

For the budget share approach the HIs[22] are:

$$HI = \frac{\sum \mathbf{1}(r_h > r^{st})}{N} \qquad (2.3)$$

In which $\mathbf{1}(r_h > r^{st})$ is equal to 1 if the energy expenditure incidence of the consumer *h* exceeds the considered threshold and it is equal to 0 in other cases.

N is the set of consumers to whom the results are reported.

Finally r^{st} is the threshold calculated according to the method being analyzed (normative, positive, standard).

[21] Fankhauser, S. and S. Tepic (2007). *Can poor consumers pay for energy and water? An affordability analysis for transition countries.* Energy Policy, 32(2), pp. 1038-1049.

[22] Headcount Indexes.

2.2.3 Residual expenditure approach

This second approach, unlike the budget share one, aims not only to identify vulnerable consumers but also to include them in a specific category according to their spending characteristics.

These categories of consumers are: expenditure-poor consumers and under-consumers.

The original method actually refers to income, so its correct name would be residual *income* approach and *income*-poor consumers. However, since no income data were available, these names seemed inappropriate.

Expenditure-poor households

Being an expenditure-poor for a consumer means not having the opportunity to buy other goods except essential ones.

The decision to substitute income for expenditure in the analysis is due to the consideration that a low-income consumer is not able to save money and therefore his income is entirely spent, so expenditure and revenue coincide.

An expenditure-poor household is a consumer who has a residual expenditure lower than a standard residual expenditure.

The residual expenditure is the total expenditure less energy expenditure; the standard value refers to the minimum expenses differentiated by family size and geographical area published by ISTAT and elaborated by this research work.

It's necessary to clarify this again:

- The residual expenditure for those consumers who rent or have a mortgage to pay is different from the expenditure of the owners;
- The residual expenditure between network gas consumers and consumers of other fuels is the same. In fact, ISTAT has defined a standard fuel consumption expenditure and not a specific standard expenditure for the consumption of network gas.

RESIDUAL EXP. FOR TENANTS [€/month]			
Components	North	Centre	South
1	562	529	447
2	804	748	644
3	1 026	924	823
4	1 258	1 158	1 004
5	1 528	1 401	1 221
6	1 714	1 569	1 367

Table 21. Minimum residual expenditure that a consumer-tenant needs. Data source: ISTAT data revision.

RESIDUAL EXP. FOR OWNERS [€/month]			
Components	North	Centre	South
1	304	271	259
2	519	462	443
3	718	615	612
4	913	813	779
5	1 156	1 030	987
6	1 319	1 174	1 126

Table 22. Minimum residual expenditure that a consumer-owner needs. Data source: ISTAT data revision.

Under-consumers

Under-consumers are those who have an energy expenditure lower than the minimum value of energy expenditure calculated for a household of the same size and belonging to the same geographical area.

It often happens that some consumers do not appear to be in a situation of energy poverty when they spend less than the minimum expenditure on energy: in this case they are a false negative, in fact they spend little because they consume less than is necessary. These are the under-consumers.

However, it may happen that some consumers who are not under-consumers may be included in this set. They represent a false positive: they are consumers who need less heat because they live in warmer areas or live in energy-efficient buildings.

STANDARD ENERGY CONSUMPTIONS [€/month]			
Components	North	Centre	South
1	50	45	15
2	63	57	27
3	75	69	39
4	85	79	49
5	96	90	60
6	110	104	74

Table 23. The standard energy consumption. Data source: ISTAT data revision.

Headcount Indexes

The indexes that define how many household are in energy poverty are:

$$HI_{expenditure\ poors} = \frac{\sum \mathbf{1}(residual\ income_h < residual\ income^{st})}{N} \quad (2.4)$$

$$HI_{under-users} = \frac{\sum \mathbf{1}(energy\ bills_h < energy\ bills^{st})}{N} \quad (2.5)$$

2.2.4 Procedure

All the first approach is divided in the following way.

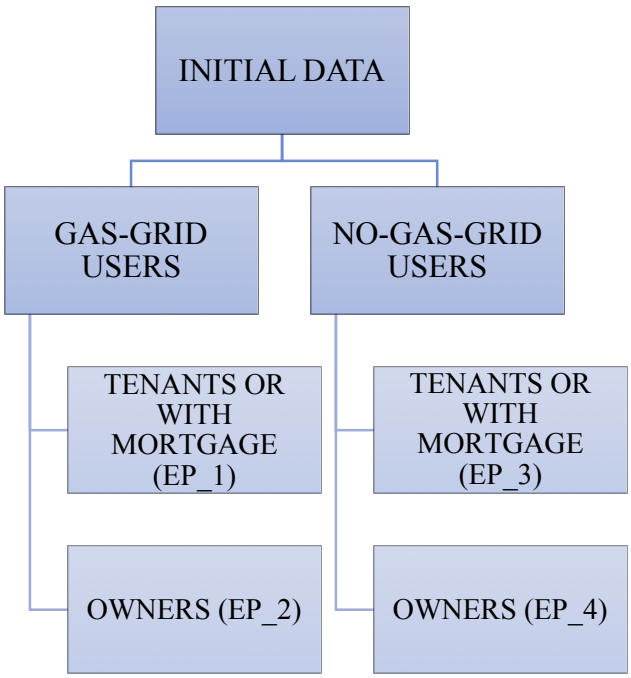

Figure 11. The scheme of the procedure for the first approach.

The whole approach that follows the Valbonesi et al. methodology is divided between consumers who use gas from the network and consumers who do not use it; each of these categories is then divided between consumers who have a rent/mortgage to pay and owner consumers.

The subdivision between owners and tenants is necessary because the set thresholds are different.

The division between those who use methane and those who do not use it, was considered interesting in order to better observe the differences.

For consumers who do not use network gas, the concerned fuels are the following ones:

- Liquefied gas, as LPG;
- Liquid fuels, as kerosene;
- Wood.

EP_1

The following graphs represent the headcount indexes of the vulnerable households of EP_1.

The percentages of vulnerable consumers differ according to the choice of *N* divider, which is:

- the whole number of the HBS[23] analysis (15 409) in fig. 12;
- the whole number of the EP_1 households (3 651) in fig. 13;
- the number of all the households per each Italian area (6 760 in the North, 2 825 in the Centre, 5 824 in the South) in fig.14.

It should be noted that figures 12 and 13 show the percentages of consumers in energy poverty compared to the two different sets (HBS and EP_1) and, for each indicator, the different percentages of consumers in energy poverty living in the three geographical areas can be noted.

Fig. 14 instead shows for each indicator the percentage of vulnerable consumers in the North compared to all consumers in the survey living in the North and the same applied to the South and Centre.

[23] HBS is the Household Budget Survey.

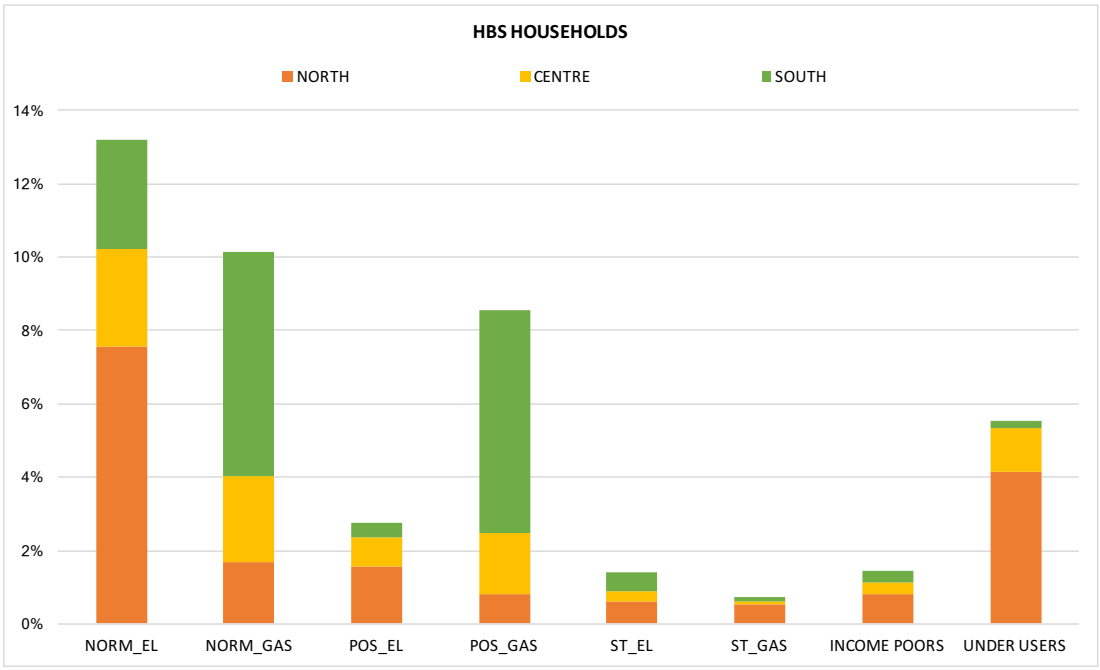

Figure 12. Energy poverty of EP_1 consumers in relation to the number of households of the whole survey.

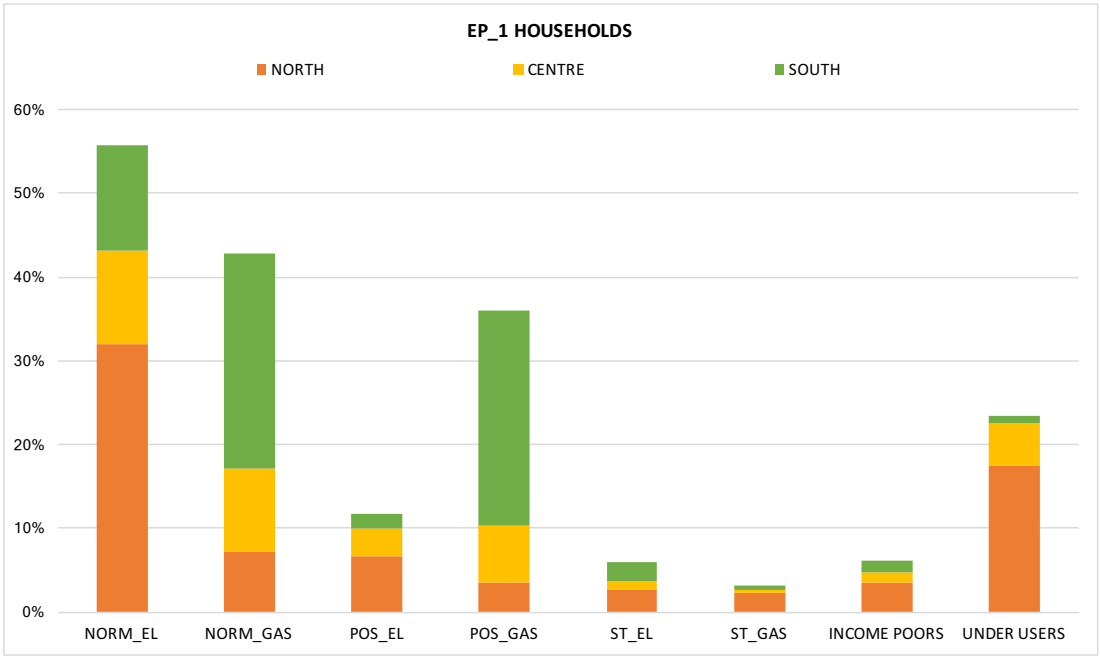

Figure 13. Energy poverty of EP_1 consumers in relation to the number of households of EP_1.

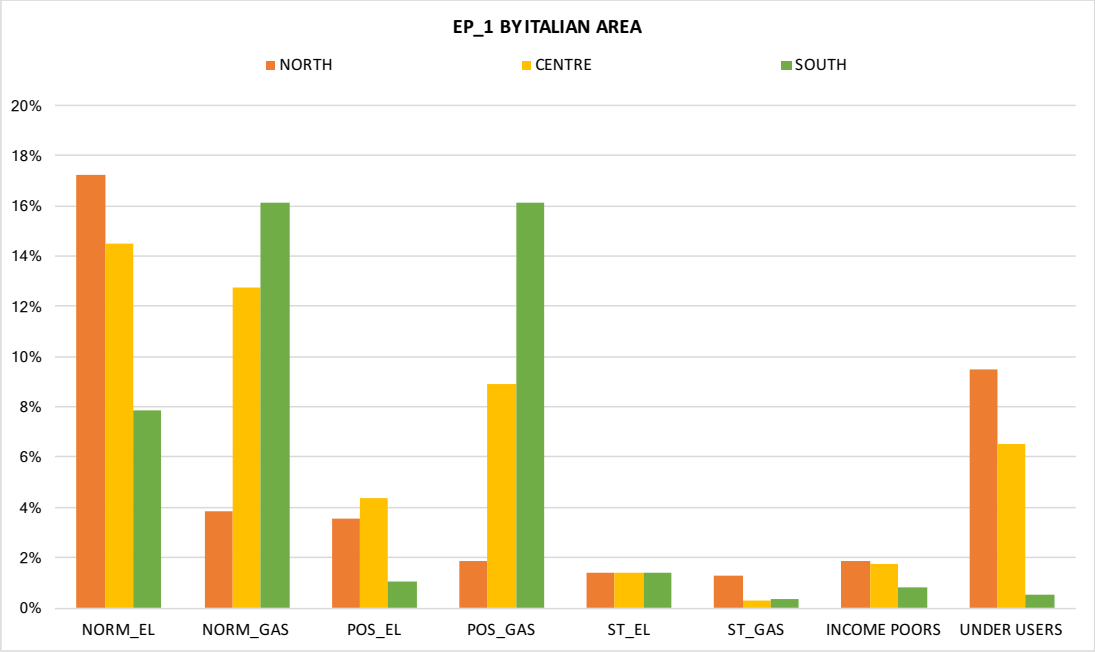

Figure 14. Energy poverty of EP_1 consumers in relation to the number of households of each geographic area.

As far as under-consumers are concerned, there is the problem of defining who is really an under-consumer: this study hypothesizes that those of them who are in absolute poverty are certainly also in energy poverty.

As a result, the graph below shows the totality of under-consumers and among these those who are in absolute poverty: it can be observed that there is a big difference between these percentages, especially in the North.

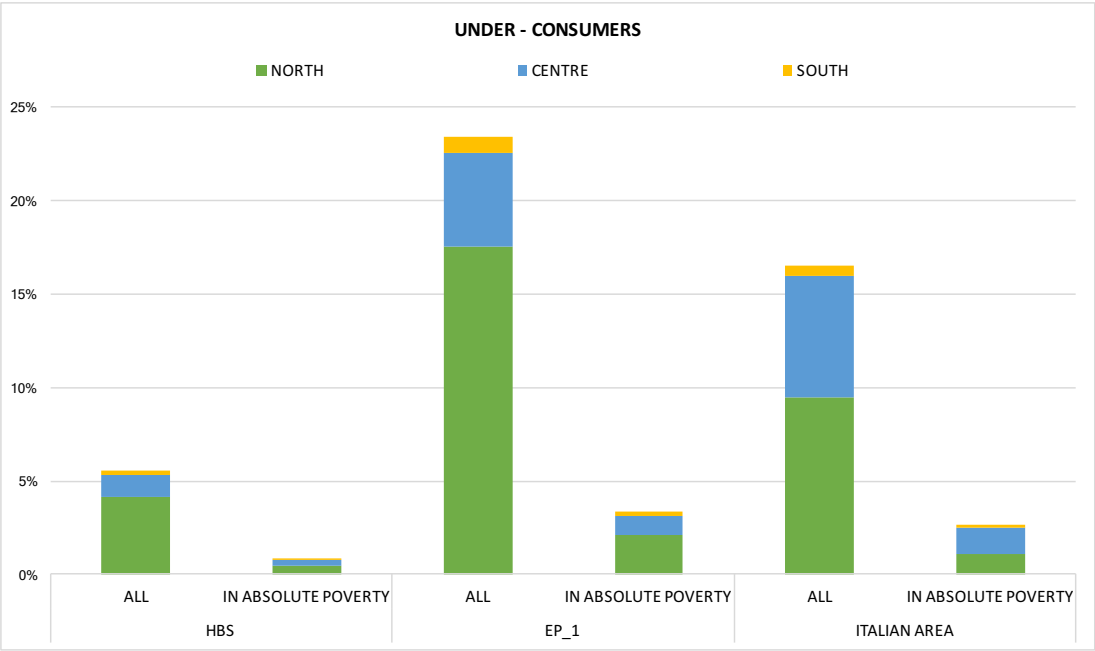

Figure 15. The difference between all under-consumers and those in absolute poverty.

This graph is divided in three parts (Italian area, EP_1 households and HBS) that represent the HIs calculated in relation to different *N*.

EP_2

The following graphs represent the headcount indexes of the vulnerable households of EP_2.

The percentages of vulnerable consumers differ according to the choice of *N* divider, which is:

- the whole number of the HBS analysis (15 409) in fig. 16;
- the whole number of the EP_2 households (9 216) in fig. 17;
- the number of all the households per each Italian area (6 760 in the North, 2 825 in the Centre, 5 824 in the South) in fig.18.

It should be noted that figures 16 and 17 show the percentages of consumers in energy poverty compared to the two different sets (HBS and EP_2) and, for each indicator, the different percentages of consumers in energy poverty living in the three geographical areas can be noted.

Fig. 18 instead shows for each indicator the percentage of vulnerable consumers in the North compared to all consumers in the survey living in the North and the same applied to the South and Centre.

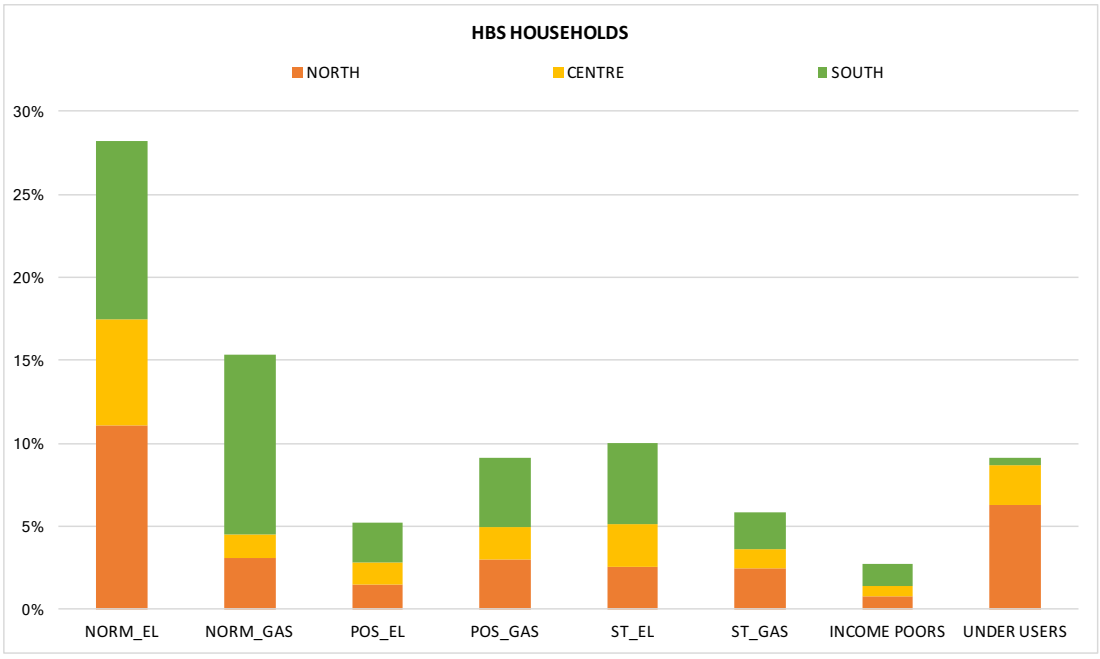

Figure 16 Energy poverty of EP_2 consumers in relation to the number of households of the whole survey.

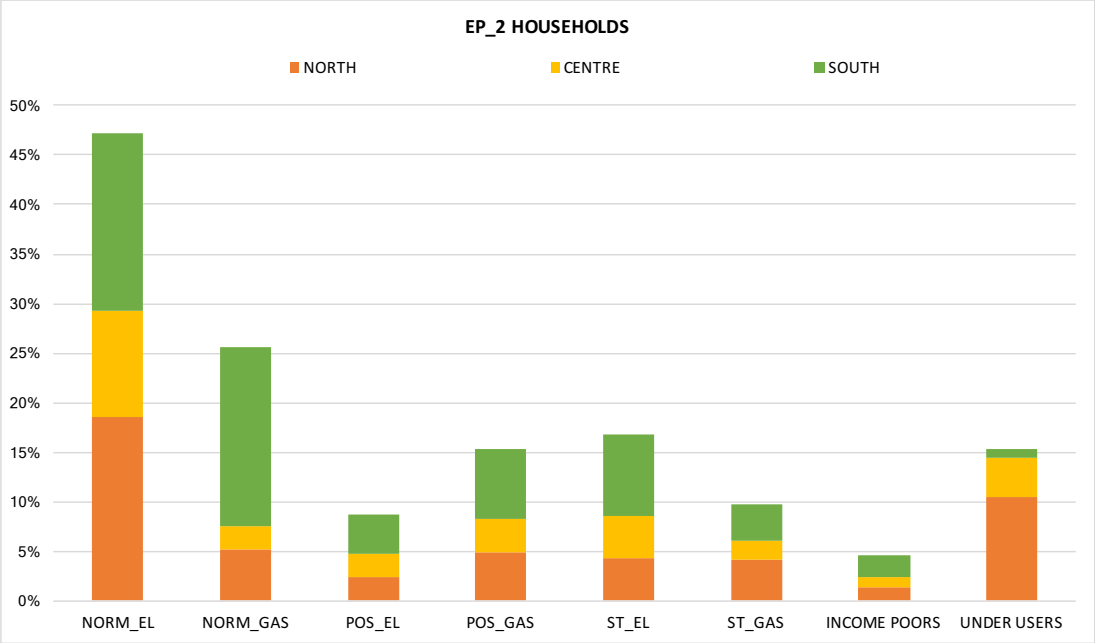

Figure 17. Energy poverty of EP_2 consumers in relation to the number of households of EP_2.

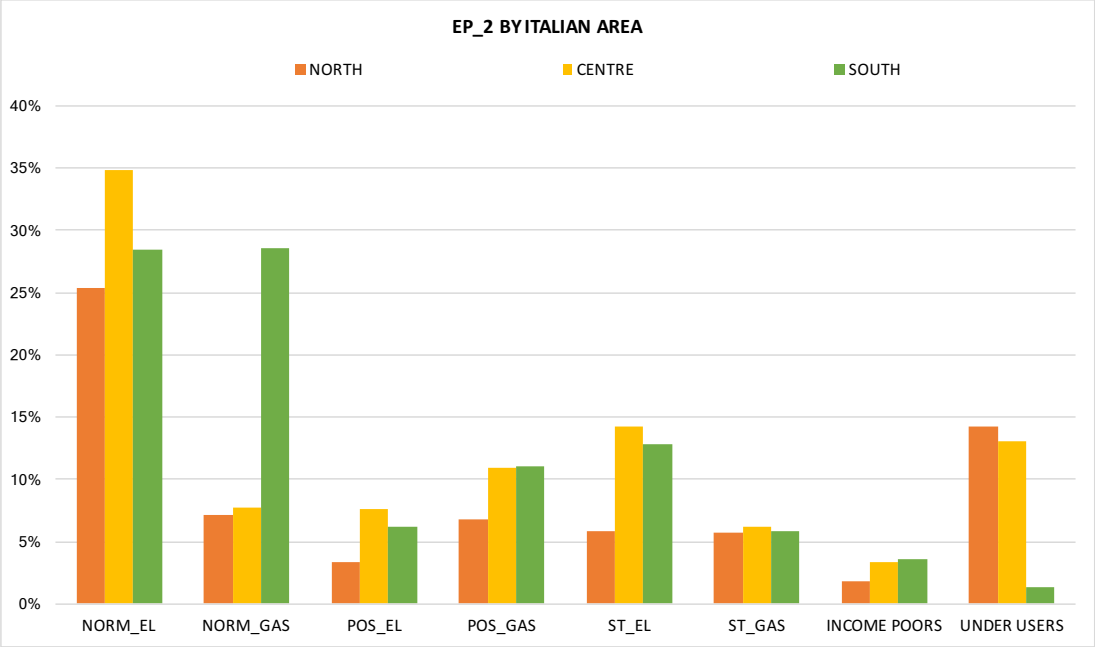

Figure 18. Energy poverty of EP_2 consumers in relation to the number of households of each geographic area.

The following graph is divided in three parts (Italian area, EP_2 households and HBS) that represent the HIs calculated in relation to different *N*.

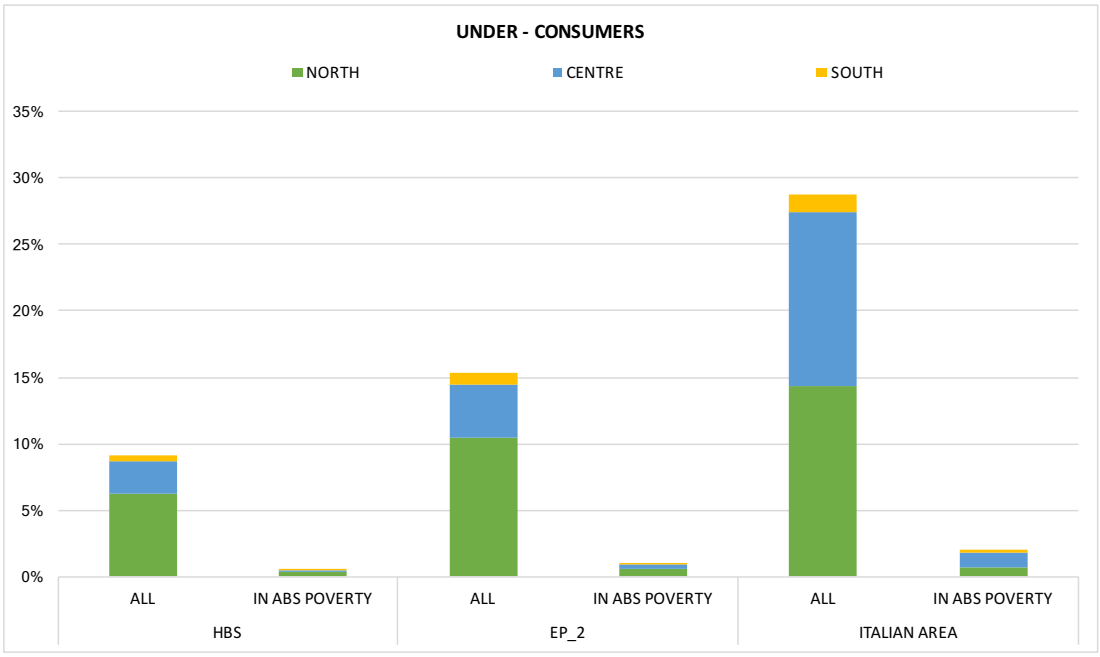

Figure 19. The difference between all under-consumers and those in absolute poverty.

EP_3

The following graphs represent the headcount indexes of the vulnerable households of EP_3 (tenants without network gas).

The percentages of vulnerable consumers differ according to the choice of *N* divider, which is:

- the whole number of the HBS analysis (15 409) in fig. 20;
- the whole number of the EP_3 households (595) in fig. 21;
- the number of all the households per each Italian area (6 760 in the North, 2 825 in the Centre, 5 824 in the South) in fig. 22.

It should be noted that figures 20 and 21 show the percentages of consumers in energy poverty compared to the two different sets (HBS and EP_3) and, for each indicator, the different percentages of consumers in energy poverty living in the three geographical areas can be noted.

Fig. 22 instead shows for each indicator the percentage of vulnerable consumers in the North compared to all consumers in the survey living in the North and the same applied to the South and Centre.

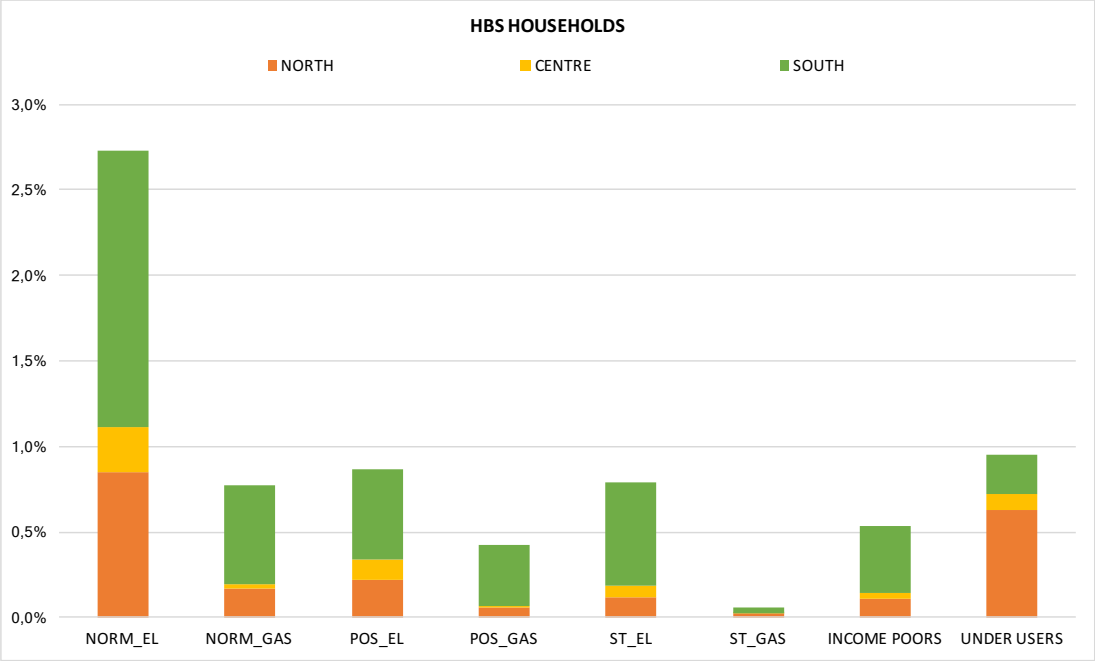

Figure 20. Energy poverty of EP_3 consumers in relation to the number of households of the whole survey.

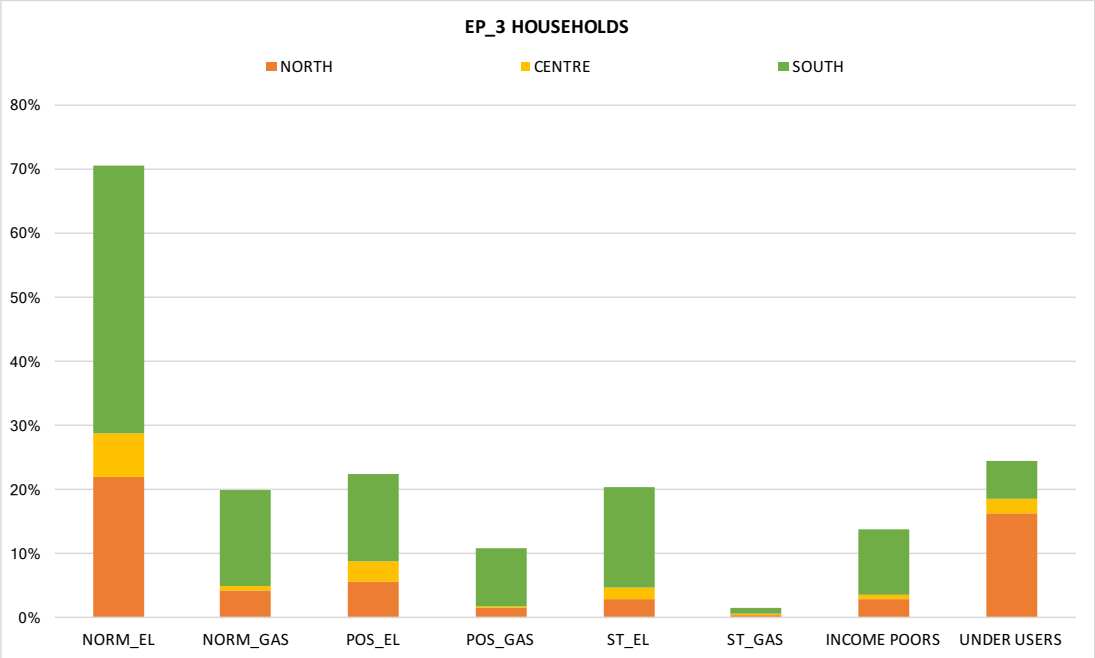

Figure 21. Energy poverty of EP_3 consumers in relation to the number of households of EP_3.

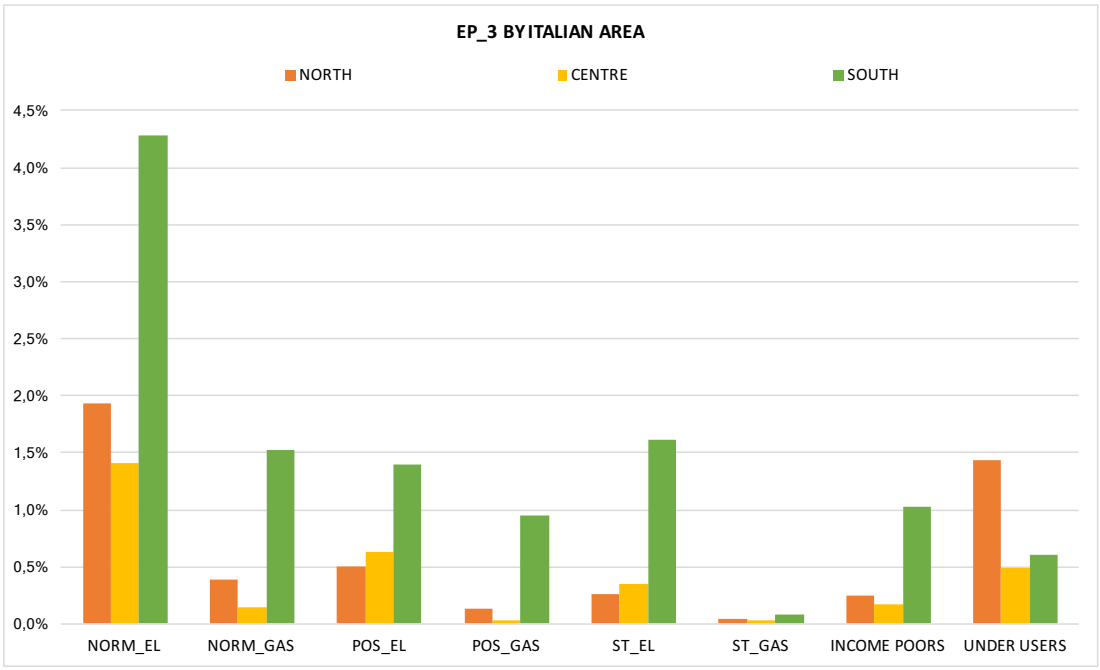

Figure 22. Energy poverty of EP_3 consumers in relation to the number of households of each geographic area.

The following graph is divided in three parts (Italian area, EP_3 households and HBS) that represent the HIs calculated in relation to different *N*.

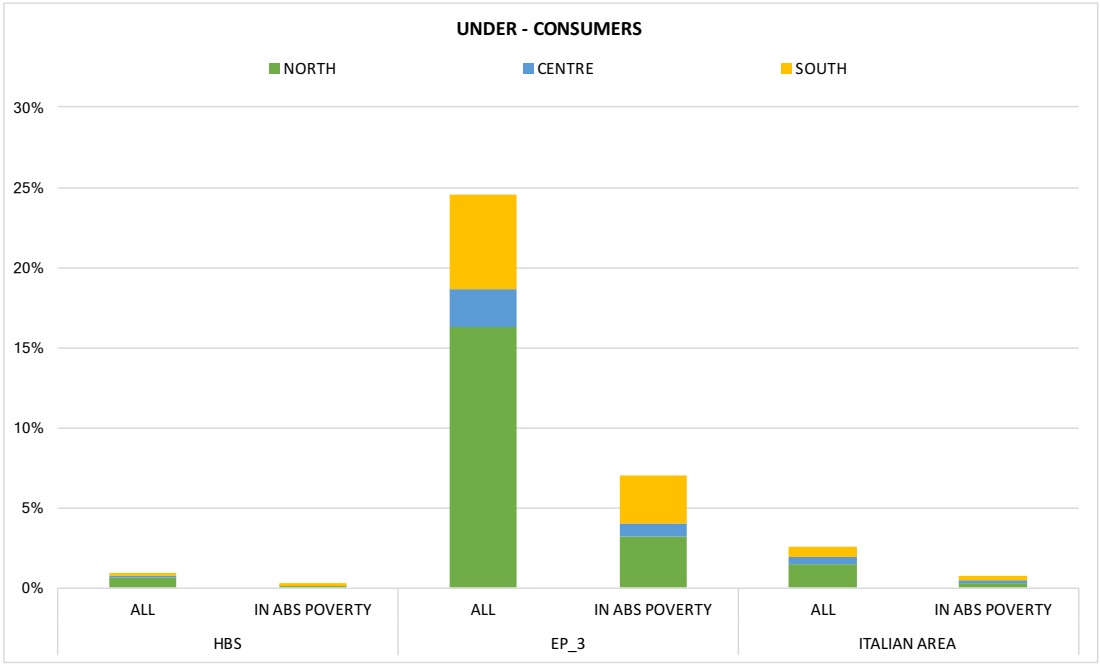

Figure 23. The difference between all under-consumers and those in absolute poverty.

EP_4

The following graphs represent the headcount indexes of the vulnerable households of EP_4 (owners without network gas).

The percentages of vulnerable consumers differ according to the choice of *N* divider, which is:

- the whole number of the HBS analysis (15 409) in fig. 24;
- the whole number of the EP_4 households (1 947) in fig. 25;
- the number of all the households per each Italian area (6 760 in the North, 2 825 in the Centre, 5 824 in the South) in fig. 26.

It should be noted that figures 24 and 25 show the percentages of consumers in energy poverty compared to the two different sets (HBS and EP_4) and, for each indicator, the different percentages of consumers in energy poverty living in the three geographical areas can be noted.

Fig. 26 instead shows for each indicator the percentage of vulnerable consumers in the North compared to all consumers in the survey living in the North and the same applied to the South and Centre.

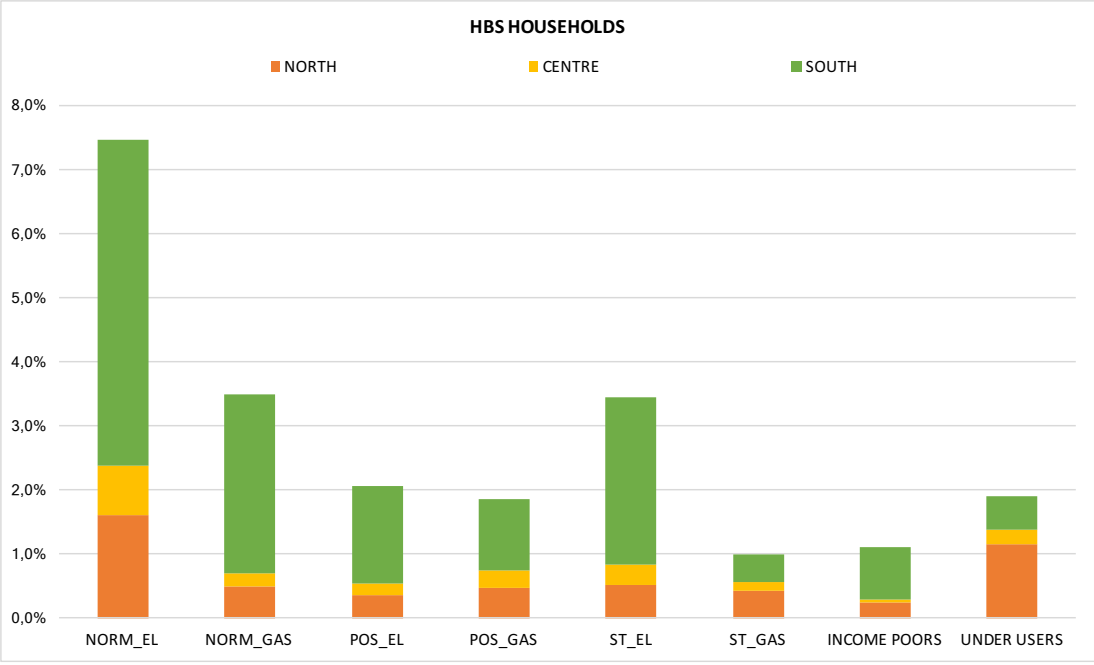

Figure 24. Energy poverty of EP_4 consumers in relation to the number of households of the whole survey.

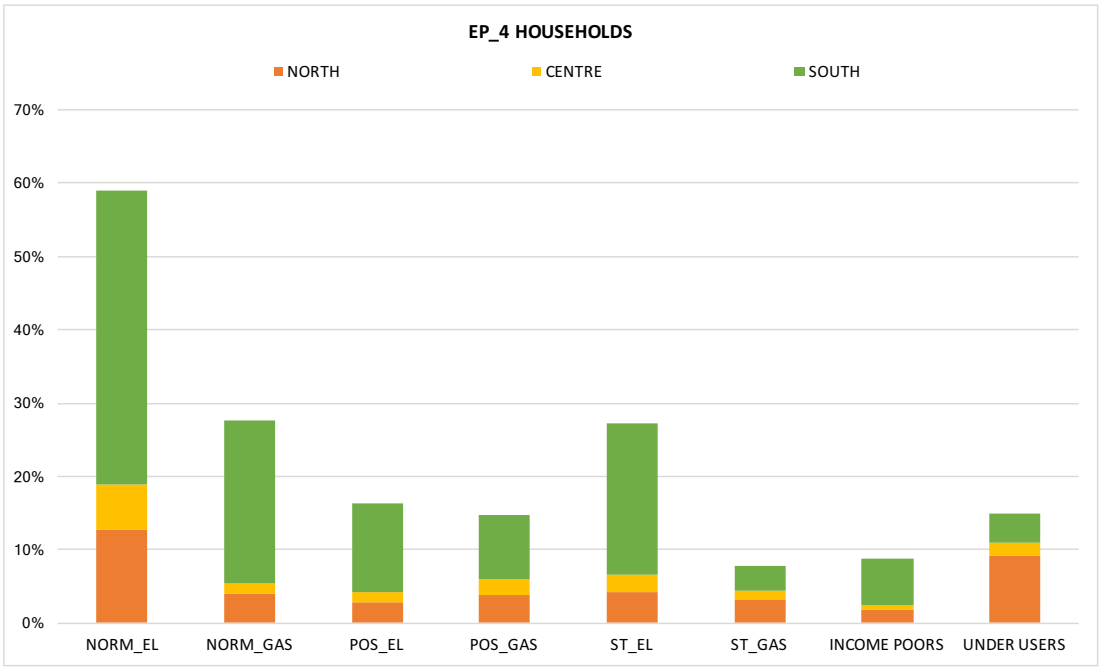

Figure 25. Energy poverty of EP_4 consumers in relation to the number of households of EP_4.

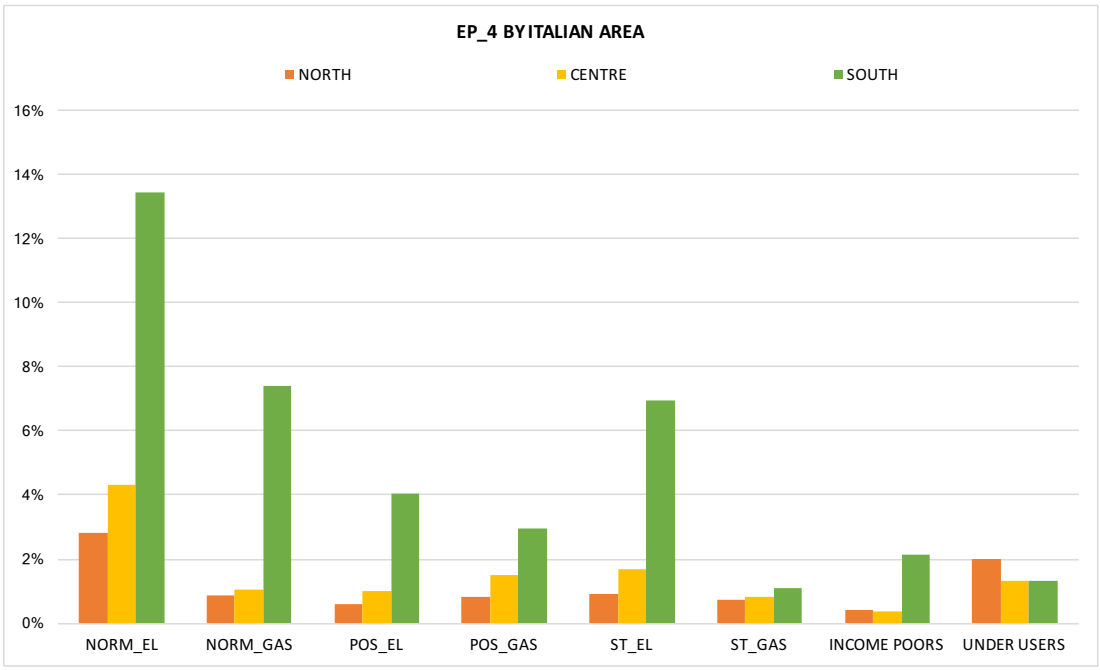

Figure 26. Energy poverty of EP_4 consumers in relation to the number of households of each geographic area.

The following graph is divided in three parts (Italian area, EP_4 households and HBS) that represent the HIs calculated in relation to different *N*.

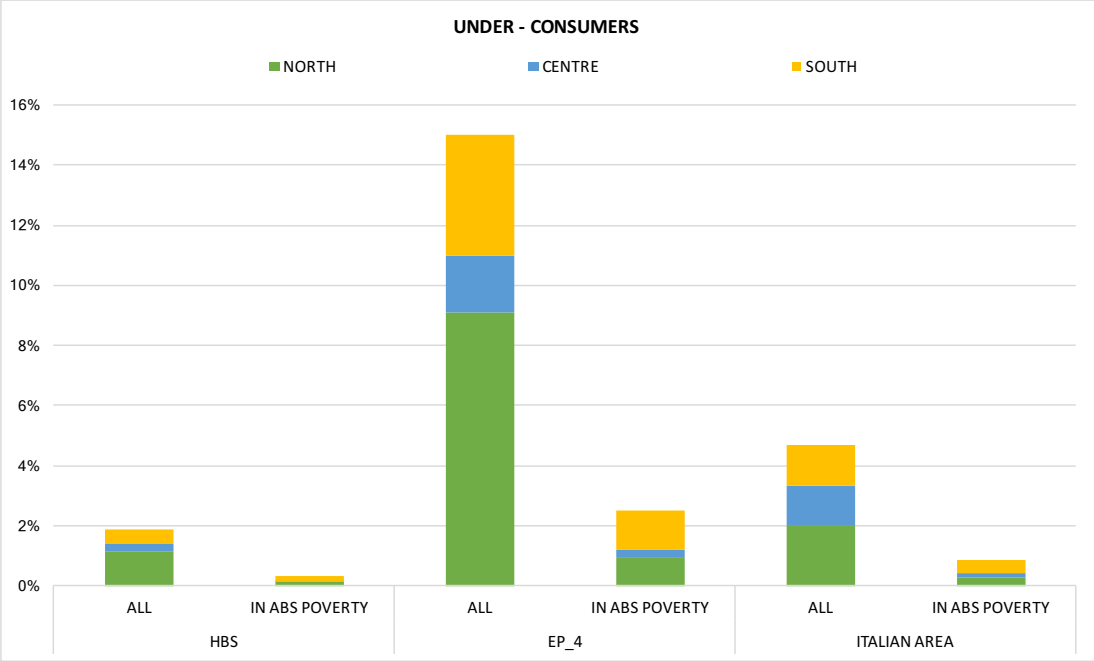

Figure 27. The difference between all under-consumers and those in absolute poverty.

2.2.5 Conclusions of the first approach

Some comments about results and graphs:

- EP_1: there is a higher percentage of vulnerable consumers in the North about the electricity normative approach.

  In the South, however, there are higher percentages of consumers in energy poverty regarding gas, both in the normative and positive approach. This is due to the fact that there is a large disparity in gas consumption both between consumer spending and the standard spending value of the ISTAT document and between the expenses that the interviewed consumers themselves have declared to have to bear.

  It should also be borne in mind that the price of gas in Italy is not the same for everyone, but there are price disparities between region and region. Finally, in the South there are different climatic areas with different consumption levels.
- EP_2: The values of this subset are higher than for other groups, but this is because EP_2 is the largest group and therefore there is a greater probability that the percentage of energy poverty is higher.

- For the North and the Centre, the trend in the number of vulnerable consumers compared to the various approaches is the same as for EP_1; for the South, the situation is different.

  There are always many vulnerable consumers because of high gas costs, but electricity costs here also increase as the number of vulnerable consumers increases in the regulatory and standard approach. This can be caused by:

  - Higher number of the subset leading to higher values for vulnerable consumers;
  - Lower monthly fixed costs for owners who can therefore also spend more on electricity.
- EP_3: this subset is the least numerous and assumes higher percentages of vulnerable consumers only in southern Italy.

  This is because in this geographical area the methane network is less widespread than in the rest of Italy.

  Values in the North and the Centre are very low, although the disparity between the normative electric method and other approaches is maintained.

  All the values of consumers in energy poverty are higher in the South because they are higher:

  - It is the largest area of this subset;
  - There is more poverty.

  It should be noted that the higher value of this group does not exceed 1.6%.
- EP_4: this subset shows the same trend as EP_3. The only difference as between EP_1 and EP_2 is that electricity expenditure in the South increases.

The normative approach in each subset has higher values for electricity expenditure. This is mainly due to two factors:

- In the ISTAT document on the estimation of absolute poverty, dishwasher and air conditioning are not considered as electrical appliances that a *standard* household has. In the Italian household expenditure survey, 51% of the 15 409 households surveyed were equipped with dishwashers and 35% had an air conditioner, so that average consumption was higher and this made it possible to easily exceed the threshold set by ISTAT.

- In this analysis, only families are considered, broken down by family size and not by family type. However, it is well established that the presence of older people or children increases consumption because they spend at least half a day at home; or even it has been proven that an elderly person tends to spend more on energy than a young person in a single household.

2.3 The Ten Percent Rule

The 10% rule defines a household in a situation of energy poverty when its energy expenditure exceeds the total expenditure by 10%.
The *pros and cons* of this method have been explained in Chapter 1.
The formula is shown below.

$$Energy\ expenditure > 10\% \cdot Total\ expenditure \tag{2.6}$$

All expenses are in [€/month].
The results of this approach follow the previous procedure and have been divided into four subsets (EP_1, EP_2, EP_3, EP_4).

2.3.1 Results

For this method, the results have been aggregated in the following two graphs.
The first represents the HIs of vulnerable consumers for each subset calculated from the whole number of consumers in the survey (15 409).
The second graph compares for each geographical area the percentage of consumers in energy poverty in each subset. The *N* divider in this case is:

- 6 760 for the North;
- 2 825 for the Centre;
- 5 824 for the South.

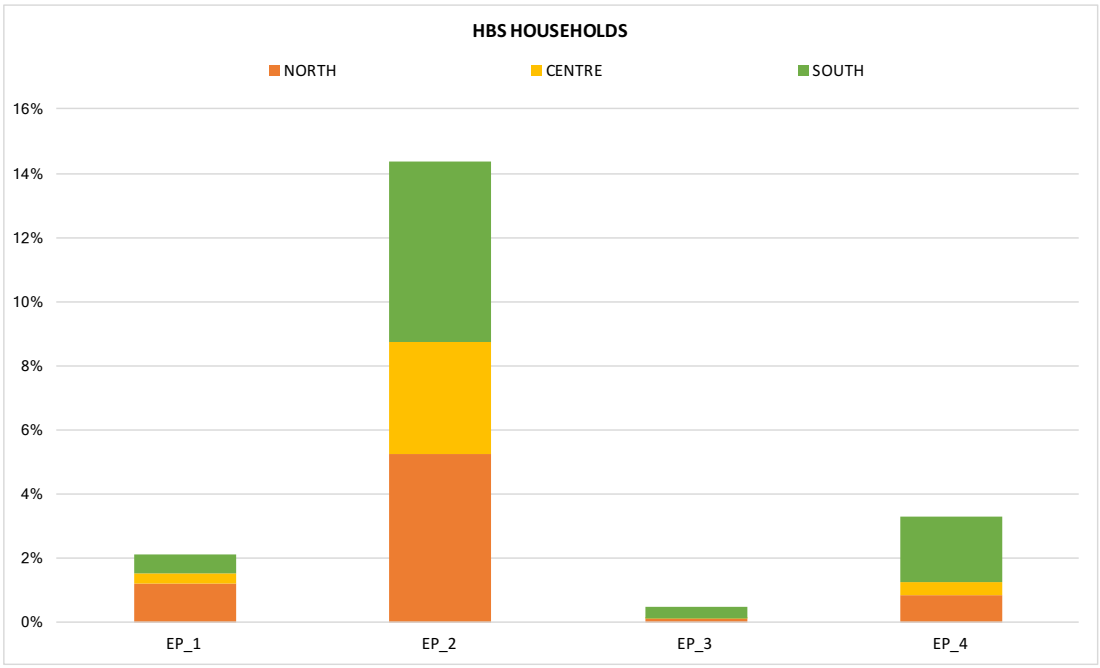

Figure 28. Ten Percent Rule vulnerable households for each subset calculated by examining the whole number of consumers of the survey.

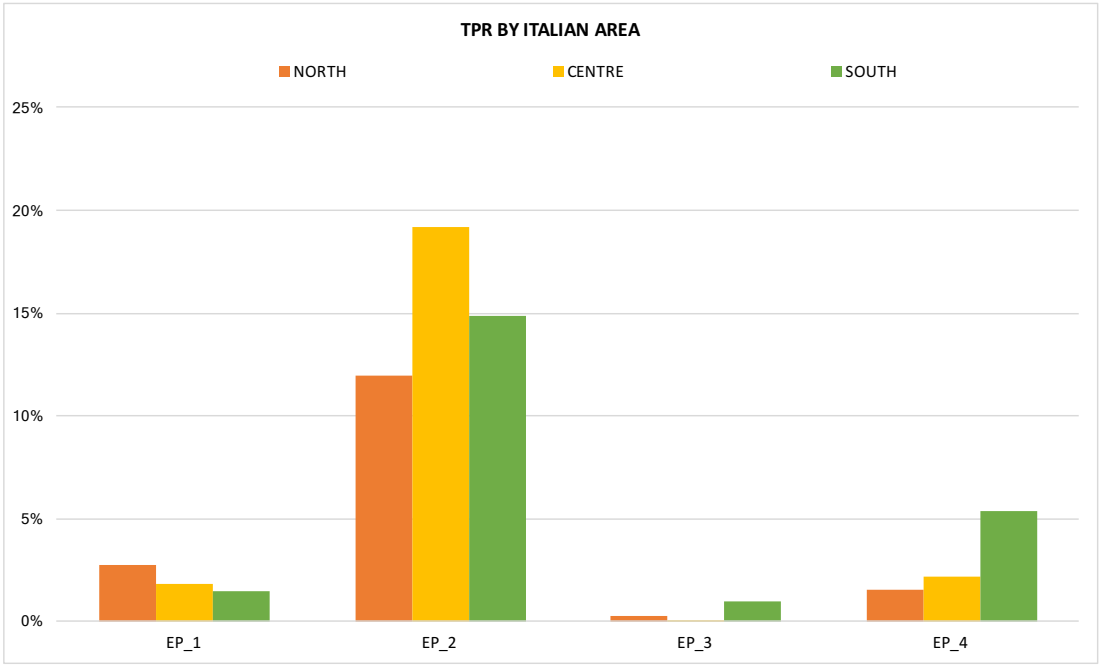

Figure 29. Ten Percent Rule vulnerable households for each subset calculated by examining the number of consumers of each area.

2.3.2 Conclusions of the TPR

From fig. 28 it's evident that among owners the most vulnerable consumers are in the South for both EP_2 and EP_4.

From fig. 29 it is interesting to observe the situation in southern Italy: although EP_4 is a low-populated subset, it takes on percentages of consumers in energy poverty rather high.
This shows that among consumers who do not use gas from the grid, energy poverty is more widespread in the South.
From this method, this work did not initially know what to expect because the TPR does not take into account many factors, but the results obtained are not so different from other methods.

2.4 Third approach

The third approach is based on the method of I. Faiella and L. Lavecchia published on the Occasional Papers of Bank of Italy.
This paper explains and analyses four different indicators, but while the first two are not meaningful because they are based only on the assessment of how much energy expenditure affects the total, the third and fourth ones provide some additional information.
In fact, the third indicator is the expenditure-based LIHC, while the fourth one tries to check which consumers have no heating costs and therefore are not taken into account in the first two approaches.
The approaches analyzed are as follows.

- *Incidence of Energy expenditures* $> 2 \cdot$ *Mean value of incidence of energy bills* of all the households (subdivided by number of members of the household and by geographical area);
- *Energy expenditures* $> 2 \cdot$ *Median value of energy bills* of all the households (subdivided by number of members of the household and by geographical area);
- *Residual expenditures* $<$ *ISPL* <u>*and*</u> *Incidence of Energy bills* $> 2 \cdot$ *Mean value of incidence of energy bills* of all the households (subdivided by number of members of the household and by geographical area). The residual expenditure is the total expenditure minus the energy expenditure;
- *Energy expenditures* $<$ *Median value of energy bills* <u>*and*</u>

Heating expenditure = 0 and Total expenditures < ISPL of all the households (subdivided by number of members of the household and by geographical area).

For the first two indicators, it is useful to note that the first one analyzes the impact of energy expenditure compared to two times the average incidence value, while the second one compares energy expenditure with twice the median value. It is also important to remember that the average value is always, in this specific context referred to energy bills, higher than the median value: therefore, by estimating the percentages of vulnerable consumers, there are different values between the two methods.

The third and fourth indicators are based on the simultaneous occurrence of two hypotheses.

The third one, as already mentioned, is the LIHC based on expenditure; indeed, ISPL, in the first condition that the third method imposes, is also based on expenditure and not on income.

Lavecchia and Faiella claim that an expenditure-based approach is more precise, as Atkinson also said in 2002, for the following reasons:

- The data are more accurate and precise;
- Expenditure-based consumption is more in line with household lifestyles;
- There is a lower risk of misreporting phenomena.

The fourth indicator is conceptually similar to that one for finding under-consumers because it aims to identify consumers who are not found with the other indicators. In this case, there is a greater focus on consumers who do not have heating at home: this is one way of excluding the possibility of including in this category of vulnerable energy-efficient consumers (excluding NZEBs that are not yet an established reality).

Other disadvantages to be considered in this fourth procedure are the following ones.

- No data on heating costs are provided in this study, only data on electricity and fuel costs are available. Therefore, it was decided to consider as heating expenses the costs of fuels (methane, LPG, kerosene, wood) as the most common heating methods.
- A zero-heating expenditure is not necessarily a real indicator of energy poverty because in many southern regions the need for room heating is very low.

To solve this problem this research added the condition that total expenses must be less than the value of ISPL. Furthermore, conclusions have been drawn for families living in northern and central Italy where the need for heating is constant throughout the winter months.

The values considered for ISPL are the same as those of tab. 16, while the average and median values of consumers' energy expenditure are given in the following tables.

MEDIAN VALUE OF MONTHLY ENERGY EXPENDITURE [€/month]			
Components	North	Centre	South
1	70	70	61
2	97	95	84
3	112	103	96
4	123	114	104
5	135	111	106
6	141	143	117

Table 24. Median value of monthly energy expenditure. Data source: ISTAT data revision.

MEAN VALUE OF MONTHLY ENERGY EXPENDITURE [€/month]			
Components	North	Centre	South
1	86	77	77
2	116	110	103
3	131	115	117
4	146	127	126
5	159	135	127
6	167	167	130

Table 25. Mean value of monthly energy expenditure. Data source: ISTAT data revision.

2.4.1 Results

The graphs below show the percentage values of vulnerable consumers according to this third method.

Fig. 30 represents the HIs values of consumers in energy poverty calculated with relation to the entire number of consumers in the survey (15 409).

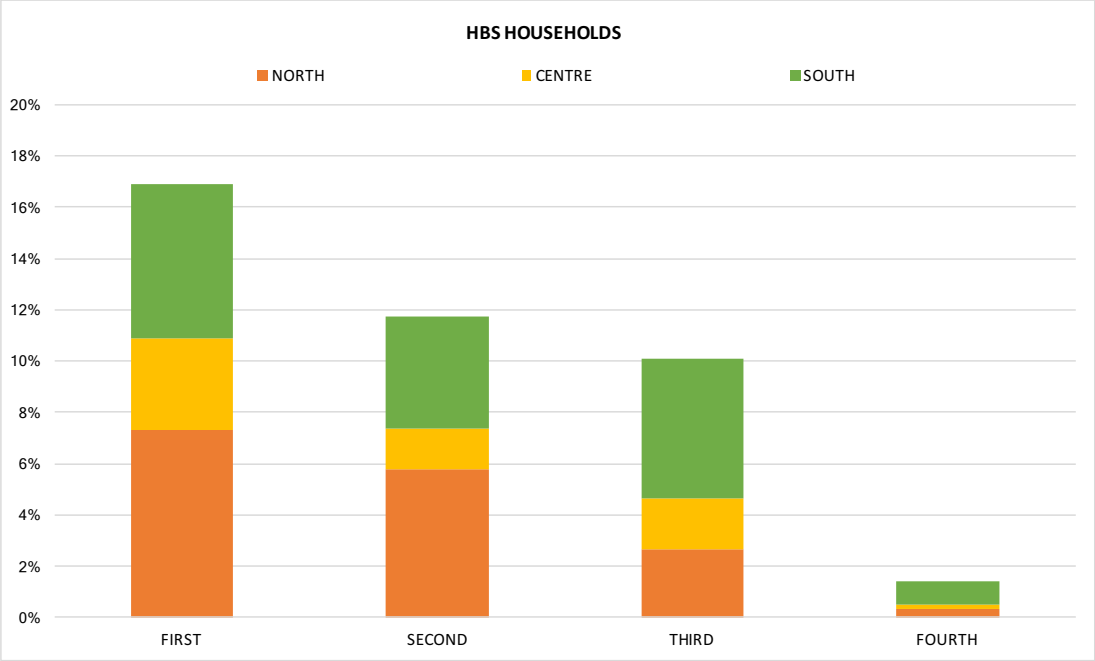

Figure 30. Households in energy poverty according to Faiella and Lavecchia's approach.

In fig. 31 it is possible to compare the values that each method assumes for each geographical area. In fact, *N* here is the number of consumers in each area (6 760 for the North, 2 825 for the Centre and 5 824 for the South).

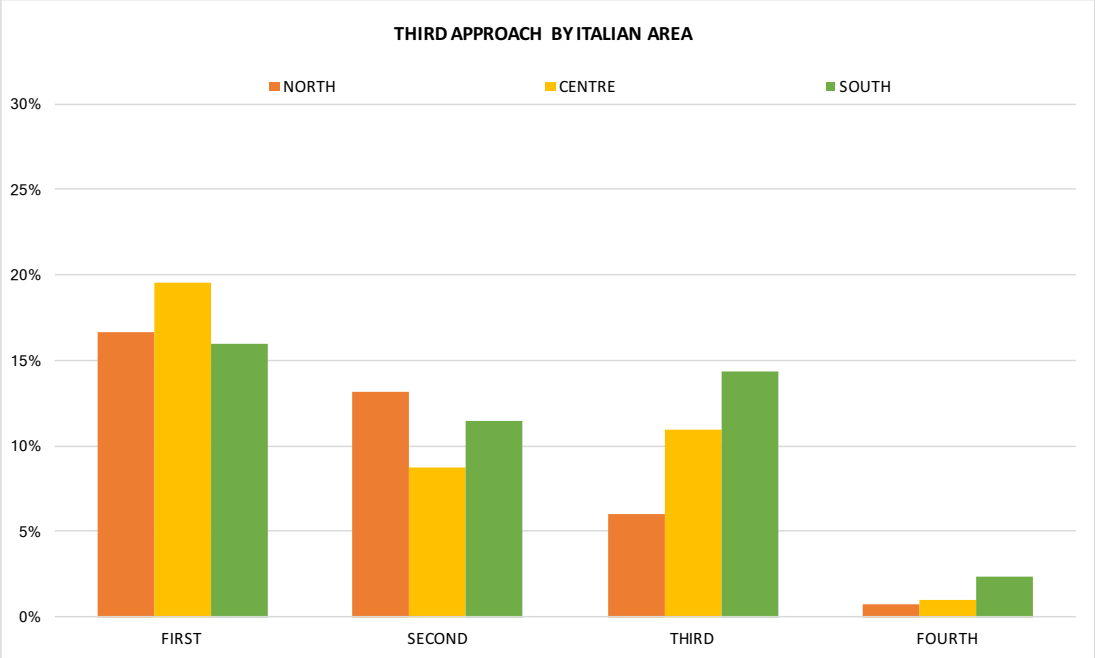

Figure 31. Vulnerable consumers differentiated by area in relation to their geographical area.

2.4.2 Conclusions of the third approach

The third procedure is the most significant and the one that reflects the LIHC indicator: the results that it provides are those expected, about 10% of the Italian population of the survey is in a situation of energy poverty. The most vulnerable consumers are those living in southern Italy.

It can be observed that for LIHC and the fourth approach, defined in this study as *zero-consumers*, the highest percentage of vulnerable consumers is in the South. This fact is due to two reasons:

- Lower residual expenditure compared to other Italian areas;
- Greater probability of finding zero heating costs due to a milder and warmer climate even in the winter months.

2.6 Under-consumers and Zero-consumers

Finally, the last comparison to be made between the indicators of Valbonesi et al. and of Faiella and Lavecchia, is that between under-consumers and zero-consumers.

Conceptually, these two indicators are very similar, but the one to identify zero-consumers is more limiting as it has to verify the hypothesis of zero energy expenditure.

Fig. 32 considers these consumers for each geographical area, adds the condition that they live in a house built before 1979 and then among these consumers it checks who is in absolute poverty.

The construction period was considered because in Italy the first law on thermal insulation of buildings dates back to 1976[24]: in this law, some guidelines for the construction of new buildings were laid down for the first time.

In addition, the 2014 Energy Efficiency Action Plan states that buildings built between 1950 and 1980 are not highly energy-efficient.

It was therefore decided to assess consumers living in buildings built before 1979 because they are less energy efficient.

[24] Law No. 373/76.

Of course, restructuring may have taken place over the years, but this work is considering these facts at the same time:

- Only under-consumers or zero-consumers are considered;
- These households live in houses that are certainly not efficient (the first step stops here);
- They are in absolute poverty so it is quite right to assume that restructuring cannot be allowed.

As a result of these considerations, the results are different:

- Under-consumers take on higher percentages in the North than in the South. This can be caused by increased energy efficiency in the North. In addition, the greater need for heating in the North means that those who cannot pay their bills under-consume.
- There are more zero-consumers in the South because they need less energy for space heating, especially in the warmer climate zone where the heating demand can be supplied using a simple electric heater.
- It is reasonable to assert after these considerations that the zero-consumers in the North and Central Italy are in energy poverty.

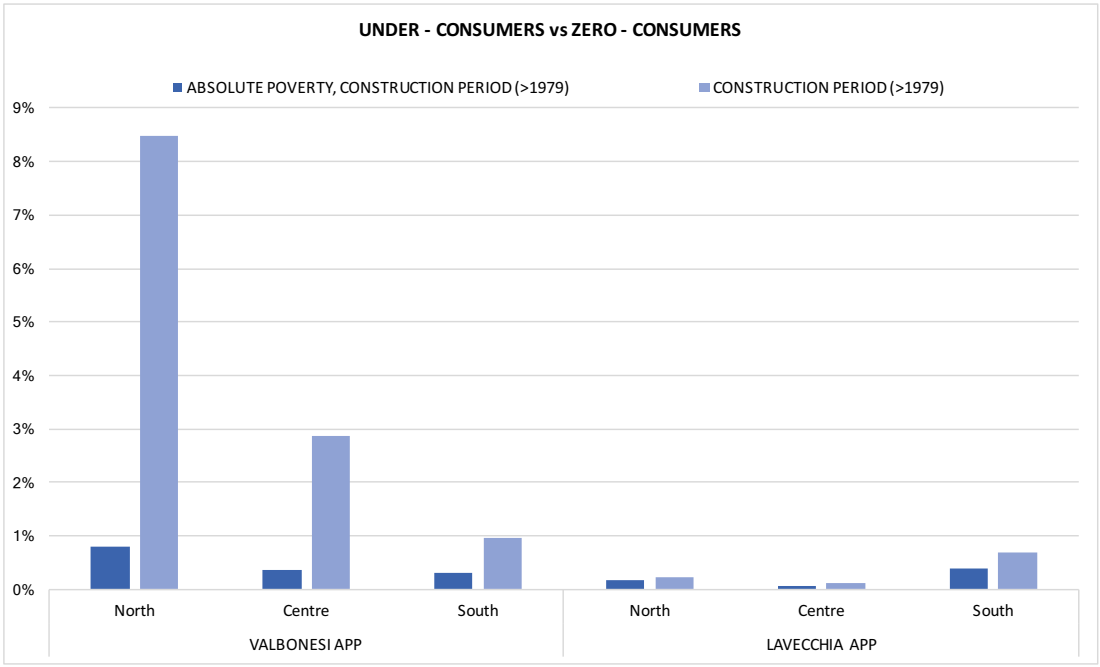

Figure 32. Comparison between under-consumers with different conditions.

2.5 Final conclusions of energy poverty in Italy in 2016

It is useful and necessary to compare all the percentages of consumers in energy poverty of all three methods examined.

The graph below shows the percentages of vulnerable consumers in 2016 for each indicator analysed: the different values that each method takes on according to the type of consumer considered can be distinguished.

Although consumer distributions among different household types (EP_1, EP_2, EP_3, EP_3, EP_4) are not homogeneous, they reflect the distribution of the Italian population in the four categories. In fact, for example, even at the Italian level, EP_3 group is very small compared to the categories of network gas consumers, so this study found interesting to show the following graph.

The normative indicator referred to electricity assumes an unrealistic value (as it can be seen in the figures 33, 34, 35).

As already mentioned, this depends on two factors:

- In the ISTAT document on the estimation of absolute poverty, dishwasher and air conditioning are not considered as electrical appliances that a *standard* household has. In the Italian household expenditure survey, 51% of the 15 409 households surveyed were equipped with dishwashers and 35% had an air conditioner, so that average consumption was higher and this made it possible to easily exceed the threshold set by ISTAT.
- In this analysis, only families are considered, broken down by family size and not by family type. However, it is well established that the presence of older people or children increases consumption because they spend at least half a day at home; or even it has been proven that an elderly person tends to spend more on energy than a young person in a single household.

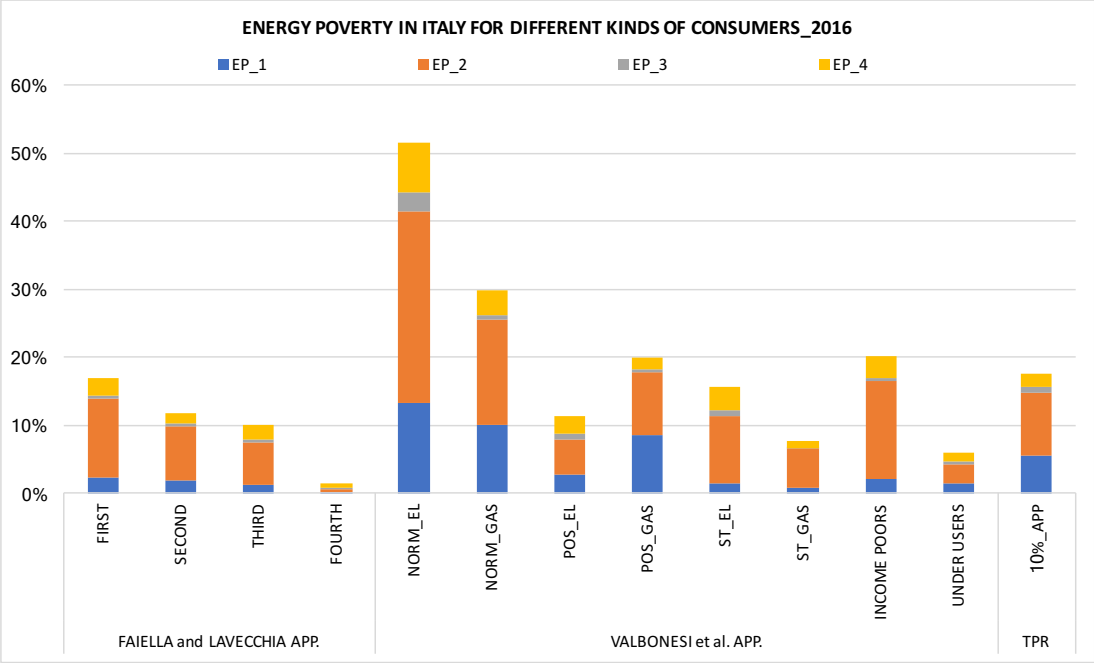

Figure 33. Vulnerable consumers divided by different types.

An interesting fact of the HBS analysis in order to comprehend better the results, is given by the following data:

- Among the HBS' gas consumers in absolute poverty:
  - 246 are tenants;
  - 48 have a mortgage to pay;
  - 332 are owners.
- Among the HBS' other fuels consumers in absolute poverty
  - 91 are tenants;
  - 16 have a mortgage to pay;
  - 195 are owners.

What can be seen from these values is that the number of owner consumers who are in absolute poverty is greater. Assuming that consumers in absolute poverty are also in energy poverty, it can be said that the indicators correctly show that vulnerable owner consumers are more than tenants.

However, it is necessary to consider that the ISTAT survey has included more owner families than rented ones: this fact is on one hand in line with the real Italian situation, but on the other hand it makes possible that there may be a greater probability of meeting owner families in absolute poverty as a larger set is being considered.

Fig. 34 shows vulnerable consumers for each indicator considered, distinguishing for each indicator the percentages of consumers belonging to the three geographical areas.

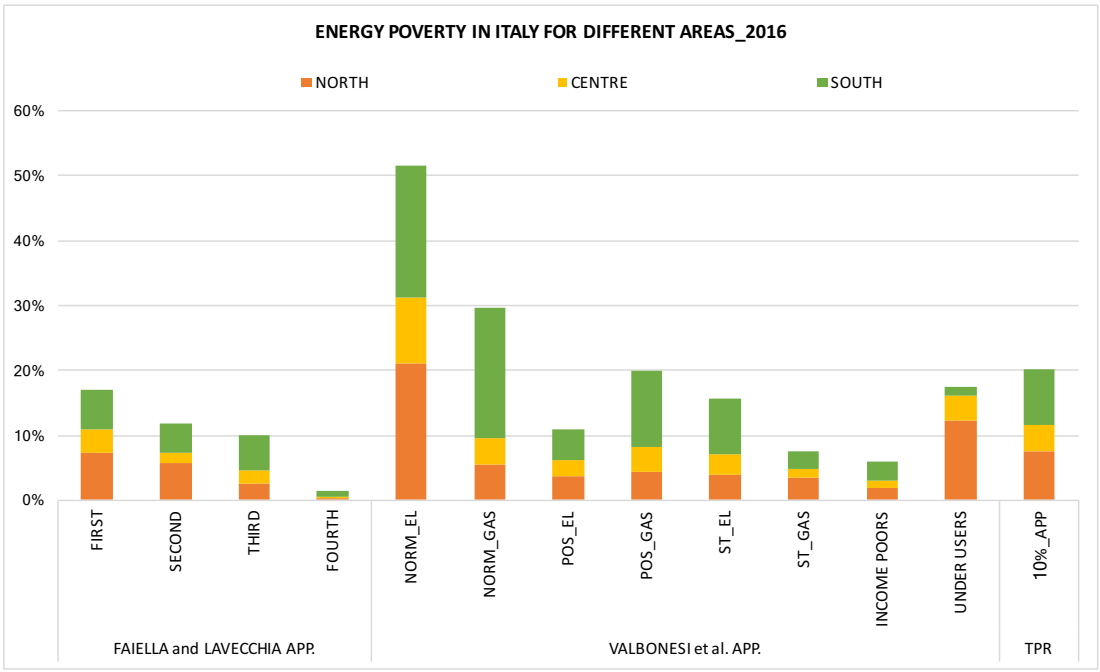

Figure 34. Vulnerable consumers divided by geographical area.

Finally, the following graph resumes the situation of energy poverty in Italy in 2016 for each considered indicator.

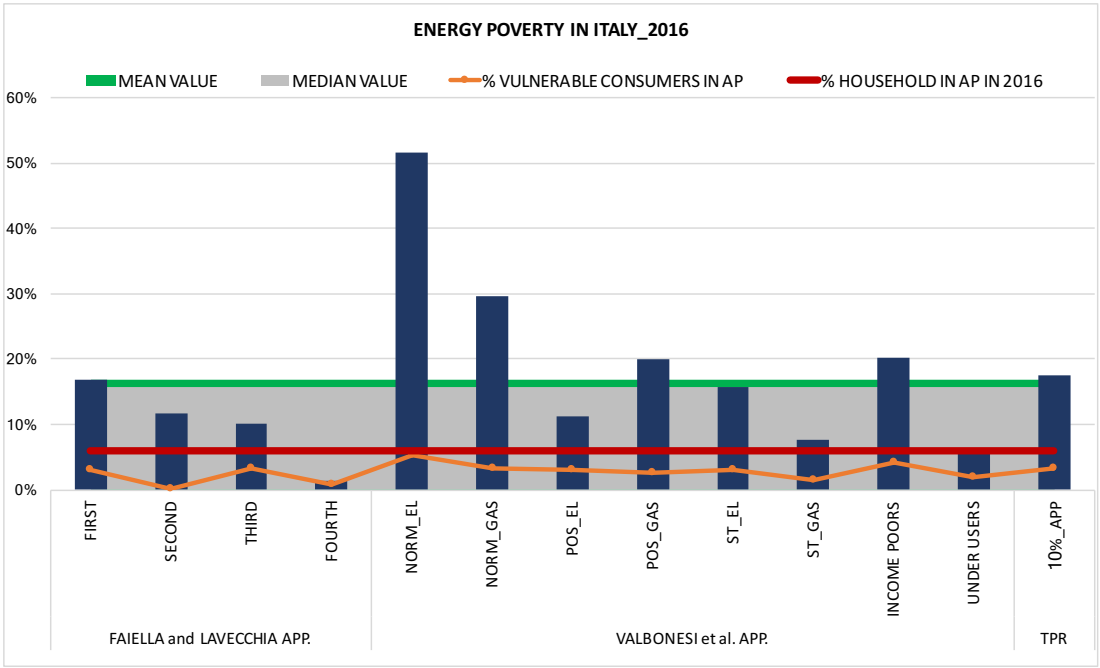

Figure 35. Energy poverty in Italy in 2016.

Some considerations about Fig. 35:

- The average value between the absolute poverty indicators is 17% and the median value is 16%, including the values of the normative indicators that cannot be considered reliable because they are too high;
- The average value of energy poverty achieved without taking normative indicators into account is 13%;
- The red line represents the absolute poverty line evaluated as the percentage of consumers in absolute poverty among all households in the survey. The exact value is 6%;
- The orange line shows the percentage of vulnerable consumers who are also in absolute poverty for each indicator studied;
- Households in absolute poverty are also considered in energy poverty by this study, but absolute poverty is not the only factor that determines energy poverty. Therefore, some consumers may be in energy poverty even though they are not in absolute poverty;
- Families in both energy poverty and absolute poverty are those who must be helped promptly because they find themselves in a situation of serious hardship.

Chapter 3

Analysis of energy savings

In this chapter, the European directive on energy efficiency and a brief overview on energy efficiency in Italy are discussed.
Finally, this work assessed the energy savings that can be achieved with different solutions for space heating and domestic hot water.

3.1 2012/27/EU EED - Energy Efficiency Directive

Energy efficiency is defined as the ratio between outputs of energy efficiency, services and energy and an energy input.
European Directive 2012/27/EU makes a very effective reference to the concept of energy efficiency:

> *"The European Union must tackle energy dependence on other countries, scarcity of energy resources, the need to limit climate change and the economic crisis. Energy efficiency is a powerful means to face all these problems."*

Therefore, a list of ways in which this invisible energy can help to solve these problems has been drawn up in the legislation. It is interesting to mention this short passage of the EED because in a single sentence the main problems on energy, the environment and modern society are mentioned.
This Directive is a reference for all the states that are members of the European Union and that should commit themselves by 2020 to reducing emissions and part of them also through energy efficiency. The main points are as follows:

- Introduction in a European level white certificates;
- Smart metering until the end of 2020;
- Energy audits;
- Financing methods;

- Objective of 20% of energy efficiency until the end of 2020;
- Demand Responde;
- High efficient CHP plants.

3.2 Energy Efficiency in Italy

Energy efficiency is an important issue in Italy: the first law on thermal insulation of buildings dates back to 1976, in which some guidelines were defined on how to build them.

After the European Directive on energy efficiency, the Government has drafted Law 102/2014[25] on energy efficiency in which the 2012/27/EU targets have been regulated at Italian level.

Italy aims for a primary energy reduction of 20 million toe by 2020, calculated from 2014 onwards.

An important action to promote energy efficiency is the Energy Efficiency Fund for companies and public administrations regulated in 102/2014 and explained in more detail in the Energy Efficiency Action Plan in 2014.

The fund comes from:

- Ministry of Economic Development providing 15 million €/year for the period 2014-2020;
- Ministry of the Environment providing 35 million €/year for the period 2014-2020.

The Fund was established by the Ministry of Economic Development and its main objective is to promote and support energy efficiency on buildings.

In the 2017 National Energy Strategy it is also called Ecoprestito.

The Fund operates on a revolving basis and finances energy efficiency measures in two ways:

- Provision of guarantees;
- Provision of funding either directly through the Fund or through banks (including the European Investment Bank).

[25] Legislative Decree No. 102/2014 art.15.

The other objectives of the Energy Efficiency Action Plan are the creation of new professional figures, the promotion of NZEBs and seismic protection measures for buildings.

The main obstacles identified in the Action Plan are banks and credit institutions' unwillingness to finance energy efficiency projects: this is due to long investment times, high risk due to innovative projects and the lack of competent persons who can evaluate innovative projects within banks or institutions.

One of ENEA's[26] main objectives is to inform the citizens about what energy efficiency is and how it can be achieved; this is in line with the Action Plan because information is one of the pillars of achieving the objective of reducing emissions through energy efficiency.

Another effective measure has been the Covenant of Mayors for Climate and Energy: this is an agreement that some cities have signed spontaneously to achieve a 40% reduction in CO2 emissions by 2030 and to take measures to combat climate change.

In Italy, 2 731 cities have joined the Covenant of Mayors.

State measures to economically support energy efficiency in the private residential sector are mainly government measures:

- Conto Termico which is an incentive for renewable thermal energies, regulated in 2012[27];
- Tax deductions on IRPEF, which is the Italian Personal Income Tax.

3.2.1 Conto Termico

Conto Termico was introduced in Italy in 2012 with the Ministerial Decree of 28/12/2012 concerning incentives to produce thermal energy from renewable sources and the improvement of energy efficiency.

The latest draft of the Conto Termico has been published in the Ministerial Decree of 16/02/2016, in which it is specified that the Conto Termico is a non-repayable loan for specified categories of interventions amounting to 40-65% of the eligible expenditure.

This incentive is addressed to private households and public administrations, but the interventions for which these two categories have access to credit are different: in fact,

[26] ENEA is the Italian National Agency for New Technologies, Energy and Sustainable Economic Development.
[27] Ministry Decree of 28/12/2012.

the eligible interventions for private costumers are renewable thermal installations (solar collectors, heat pumps, biomass stoves, hybrid systems), but not thermal insulation measures on buildings.

The regulations define them:

- Eligible subject, the person who owns and benefits from the installation;
- Responsible subject, the person who pays the intervention, requests and benefits from the incentive;
- Delegate subject, the person who can apply for incentives instead of the responsible person on the Portaltermico.

If the private household or public administration avail themselves of an ESCO[28] with UNI CEI 113 52 certification, the ESCO becomes the responsible subject and the private/public administration maintains its role as an eligible subject.

The Portaltermico is a tool of the GSE (Energy Services Manager) which is the site through which the request for incentives must be completed.

To simplify the process, the GSE has published a catalogue of devices already approved and in conformity with emission and efficiency standards.

The private household interested in the incentive can only apply through the portal: it has to fill in the request within 90 days from the date of completion of the work, then an evaluation is carried out and no more than 30 days after the two-month period in which the request was submitted, the GSE gives the incentive.

For expenditure values of less than or equal to 5 000 €, the incentive is given in a single solution, while for higher expenses the cash consideration is divided into equal annual instalments for *n* years depending on the solution chosen:

- For 2 years, substitution of traditional gas boiler with gas or electrical heat pumps (geothermal too) with nominal thermal power lower than 35 kW;
- For 5 years, substitution of traditional gas boiler with gas or electrical heat pumps (geothermal too) with nominal thermal power higher than 35 kW;
- For 2 years, substitution of traditional gas boiler with biomass boiler with nominal thermal power lower than 35 kW;

[28] Energy Service Company.

- For 5 years, substitution of traditional gas boiler with biomass boiler with nominal thermal power higher than 35 kW;
- For 2 years, installation of solar thermal power with gross solar surface lower than 50 m^2;
- For 5 years, installation of solar thermal power with gross solar surface lower than 2 500 m^2;
- For 2 years, substitution of electrical water heater with heat pumps water heater;
- For 2 years, substitution of traditional gas water heater with heat pumps hybrid systems with nominal thermal power lower than 35 kW;
- For 2 years, substitution of traditional gas water heater with heat pumps hybrid systems with nominal thermal power higher than 35 kW.

In any case, the incentive may not exceed 65% of total expenditure.

The Conto Termico cannot be added to other government incentives (such as tax deductions), but can be added to other private incentives.

The incentive is not only given for the cost of the equipment chosen but also includes manpower, masonry, electrical and hydraulic works.

In the case of a second request for an incentive before five years, the actual need for improvement or a higher rated power plant must be demonstrated.

3.2.2 Ecobonus or Tax deductions on IRPEF

Tax deductions are allocated for the following types of interventions:

- Improvements of energy efficiency in the buildings;
- Substitution of traditional gas boiler with a more efficient one (as for instance condensing boiler, heat pump)
- Installation of solar thermal panels;
- Improvements of thermal building insulation.

The 65% deduction was postponed until the end of 2018 following the approval by the Chambers of the 2018 Budget Law[29], for these interventions[30]:

- Substitution of traditional gas boiler with A class condensing boiler (with thermostatic valves);
- Substitution of traditional gas boiler with hybrid systems (heat pump integrated with condensing boiler);
- Substitution of traditional gas boiler with condensing air generator;
- Substitution of traditional gas boiler with low enthalpy geothermal heat pumps with a maximum deduction of 30 000 €;
- Substitution of traditional water heater with heat pump water heater with a maximum deduction of 30 000 €;
- Energy efficiency improvements with a reduction of 20% of heating primary energy (maximum 100 000 €);
- Other equipment for energy efficiency with a transmittance value [W/(m^{2}K)] lower than the standard values on a table (reported in the act);
- Solar thermal panels to produce DHW[31] (maximum incentives 60 000 €).

The deductions are only 50% for the following interventions:

- The substitution of windows;
- The substitution of traditional gas boiler with A class condensing boiler (without thermostatic valves);
- The biomass boilers with a maximum reduction of 30 000 €.

Finally, interventions in common areas of apartment blocks can achieve a reduction of up to 70% for thermal insulation and up to 75% for the replacement of summer/winter air conditioning systems until 2021.

Earth-quake areas can also benefit from deductions for the reconstruction of buildings and the application of anti-seismic measures.

There is also the possibility of assigning the deduction credit to third parties.

[29] Law No. 205 of 27/12/2017.

[30] Only the improvements that interest this analysis are mentioned.

[31] Domestic Hot Water.

What is more important is that only private households belonging to the no-tax area, who therefore do not benefit from deductions because they do not pay taxes, can also transfer credit to banks or financial institutions.

3.3 Analysis of energy consumptions

The analysis began to consider the different Italian climatic areas: in fact, in Italy there are six climatic areas (A, B, C, D, E, F where F is the coldest one) that differ according to the degree days. A very useful study by ISPRA[32] divided each province according to the degree day range in the corresponding climatic area and divided Italy only into three climatic areas:

- Area B that is the sum of area A and B in which DD[33]>2 100;
- Area D that is the sum of area C and D in which 900<DD≤2 100;
- Area E that is the sum of area E and F in which DD≤900.

In the image of Italy from the ISPRA studio, you can see the HDDs (Heating Degree Days); it is clear that there are also different climatic conditions in the South and in the Centre for the Apennine Mountains. Some regions belong to two different climatic areas as shown in the tab. 26.

[32] Higher Institute for Environmental Protection and Research.
[33] Day Degree.

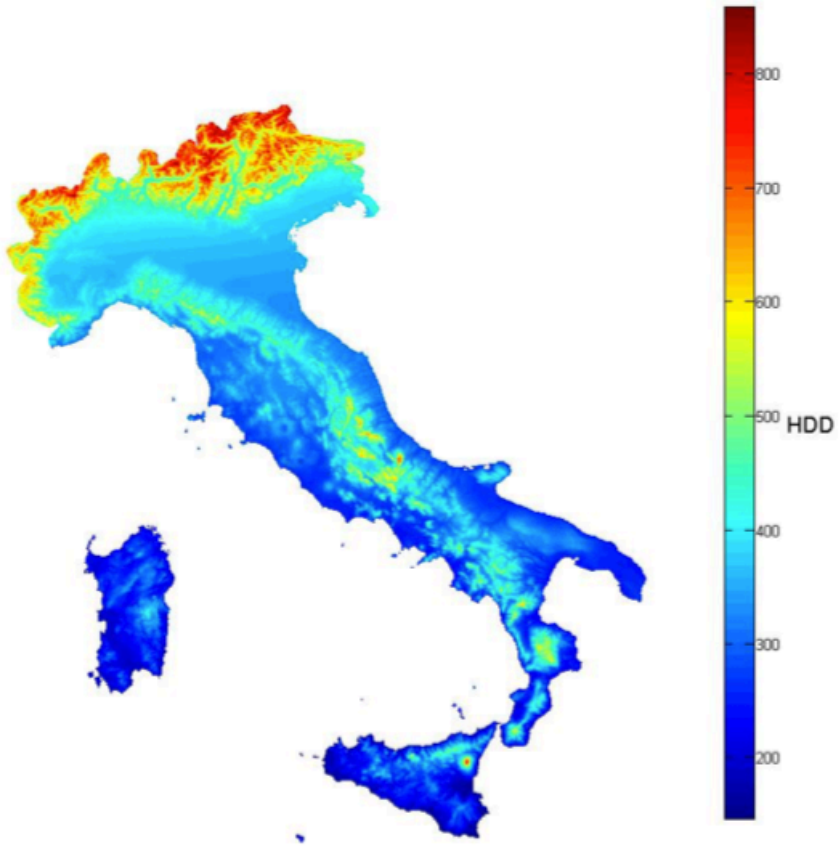

Figure 36. Italy colored by different climatic areas in HDD (Heating Degree Days). Data source: ISPRA.

This analysis makes a further simplification as it aggregates the provinces in their respective regions and then it divides regions into climate zones.

Zone B	**Zone D**	**Zone E**
Apulia	Liguria	Piedmont
Calabria	Tuscany	Lombardy
Sicily	Friuli Venezia Giulia	Veneto
Sardinia	Marche	Trentino Alto Adige
	Sicily	Emilia Romagna
	Lazio	Friuli Venezia Giulia
	Campania	Molise
	Sardinia	Umbria
	Basilicata	Abruzzo
	Apulia	Basilicata
	Calabria	Marche
	Umbria	Valle d'Aosta
	Molise	Lazio
	Abruzzo	

Table 26. Regions divided per climatic areas. Data source: ISPRA data revision.

It should be noted that the grey regions are those belonging to two different climatic areas.

The ISPRA document defines the gas consumption per capita in [Smc], but this analysis aims to estimate the consumption of a family of four members.

Other data have been found from sufficiently consistent websites, because multiplying per capita consumption by the number of family members is not the right strategy to estimate consumption.

The gas consumptions for a four-component household (100 m^2 of surface area of the house, which is the average value of the size of the Italian houses) with an average thermal insulation and a boiler of at least 10 years, are:

Areas	Heating [Smc]	Cooking [Smc]	DHW [Smc]
B	296	16	56
D	640	16	120
E	752	16	141

Table 27. Median value of annual gas consumptions. Data source: Kilowattene for cooking consumptions, website luce-gas data revision for the other ones.

As regards the value of the consumption of cooking gases, this study used an ENEA tool, Kilowattene, sharing information on gas uses.

The following table (tab. 28) shows the same results as the previous one.

The only difference is that in the following table the results are converted to [kWh] using methane LHV equal to 8 250 kcal/m^3 as ENEA[34] reports and an average value of factor C (really this factor changes depending on the location because it depends on pressure, altitude and temperature) to convert [Sm^3] to [m^3].

From here on, the analysis has available the value of the gas demand for a typical family, so considering different solutions for space heating and the production of DHW through their efficiency, it is possible to evaluate the different consumptions.

The gas demand for a household is divided in the following way:

- 80-85% for heating;
- 5% for cooking;
- 10-15% for domestic hot water (DHW).

[34] http://old.enea.it/produzione_scientifica/volumi/REA_2007/Appendice.pdf

As far as cooking is concerned, gas consumption was taken into account, as the survey on energy consumption of Italian households[35] showed that among the 20 000 households questioned, the source of power for the cookers is:

- Methane for 14 410 households;
- Electricity for 873 households;
- LPG for 4 386 households;
- Biomass for 83 households.

		Heating [kWh]	Cooking [kWh]	DHW [kWh]
Area B	Apulia	2 830	150	531
	Calabria	2 830	150	531
	Sicily	2 830	150	531
	Sardinia	2 830	150	531
Area D	Liguria	6 118	150	1 147
	Tuscany	6 118	150	1 147
	Friuli Venezia Giulia	6 118	150	1 147
	Marche	6 118	150	1 147
	Sicily	6 118	150	1 147
	Lazio	6 118	150	1 147
	Campania	6 118	150	1 147
	Sardinia	6 118	150	1 147
	Basilicata	6 118	150	1 147
	Apulia	6 118	150	1 147
	Abruzzo	6 118	150	1 147
Area E	Piedmont	7 189	150	1 348
	Lombardy	7 189	150	1 348
	Veneto	7 189	150	1 348
	Trentino Alto Adige	7 189	150	1 348
	Emilia Romagna	7 189	150	1 348
	Friuli Venezia Giulia	7 189	150	1 348
	Molise	7 189	150	1 348
	Umbria	7 189	150	1 348
	Abruzzo	7 189	150	1 348
	Basilicata	7 189	150	1 348
	Marche	7 189	150	1 348
	Valle d'Aosta	7 189	150	1 348

Table 28. The gas demand divided per heating, cooking and DHW demand. Data source: tab.28's data revision.

[35] Energy Consumption Households Survey (2013) published by ISTAT.

From the catalog of GSE of the approved appliances for the Conto Termico, the following installations are selected:

- Immergas Victrix 24 kW TT plus, as a condensing boiler;
- Immergas Audax Top 18 ErP, as a heat pump air/water;
- Immergas Rapax 300 V2, as a heat pump water heater;
- Dal Zotto Malika Idro 24.7 kW, as a pellet stove;
- Dal Zotto Diletta 11.7 kW, as a pellet stove.
- As a traditional gas boiler, it is considered one with an efficiency of 80% like is mentioned in Enea site[36].

		E	D	B
Traditional boiler [Sm^3]	Heating	940	800	370
	DHW	176	150	69
Condensing boiler [Sm^3]	Heating_HT	706	601	278
	DHW_HT	132	113	52
	Heating_LT	666	567	262
	DHW_LT	125	106	49
Heat pump [kWh]	Heating	1 753	1 492	690
Heat pump [kWh]	Heating	395	336	156
	DHW	475	404	187
Pellet stove [10^3 kg]	Heating	1.65	1.40	0.65
	DHW	0.31	0.26	0.12
Pellet stove [10^3 kg]	Heating	1.69	1.44	0.67

Table 29. Consumptions for heating and domestic hot water.

Finally, the electrical consumption of all household appliances should be accounted for: AEEGSI states that the average value of a household's electrical consumption is 2 700 kWh/year, so this value was used in the analysis.

3.3.1 Analysis of the annual energy cost

After the energy consumption assessment, this study started to calculate energy expenditure.

The AEEGSI, that since 2018 becomes ARERA[37], defined the prices of electricity and gas and their taxes.

[36] http://www.acs.enea.it/calcoli/

[37] Arera is the Italian Regulatory Authority for Energy Networks and Environment.

Gas price

The price of gas is the same for energy matter, but it is different for the share of transport and meter management. The areas, where prices vary, are:

- Valle d'Aosta, Piedmont, Liguria;
- Lombardy, Trentino Alto Adige, Friuli Venezia Giulia, Veneto Emilia Romagna;
- Umbria, Tuscany, Marche;
- Abruzzo, Molise, Puglia, Basilicata;
- Lazio, Campania;
- Calabria, Sicily.
- Sardinia is not considered.

For each category of precedents there is an energy quota [€/m^3] and a fixed quota [€/year].

In addition, it is also necessary to add taxes consisting of an excise duty [c€/m^3] and a regional surcharge (of which Lombardy and the regions with special status are exempt) and the VAT (22%).

Electricity price

The study aims to analyse only resident users and does not consider the special price regime for heat pumps as it no longer applies to new heat pump systems.

The price of electricity is divided into energy, transport and management of the meter and system charges: each category is divided into energy quota [€/kWh], fixed quota [€/year] and power quota [€/$kW_{installed}$].

In addition, the energy tariff can be mono-hourly or two-hourly.

For the two-hourly rate, there are time slots:

- F1 lasts 8-19 from Monday to Friday and it is the most expensive one;
- F2 lasts 7-8 and 19-23 from Monday to Friday, 7-23 on Saturday;
- F3 lasts 00-7 and 23-24 from Monday to Saturday and all day on Sunday and on festivities.

F1 is the band with the highest price.

This analysis has calculated the energy expenditure both with the mono-hourly tariff and with the two-hourly tariff; however, the comparisons between the different

systems shown in the following graph refer to the two-hourly tariff with F1=10% and F2=90%.

The price of the energy quota is not that provided by the AEEGSI because it is much higher than other offers. It was decided to use the energy price of an ENEL offer[38], where:

- 0.125 €/kWh for F1;
- 0.055 €/kWh for F2;
- 0.076 €/kWh for the single-price tariff.

Finally the VAT (10%) is added.

Pellet price

The price of the pellet[39] is 229 €/ton that becomes 279.4 €/ton when the VAT (22%) is applied.

Combined solutions

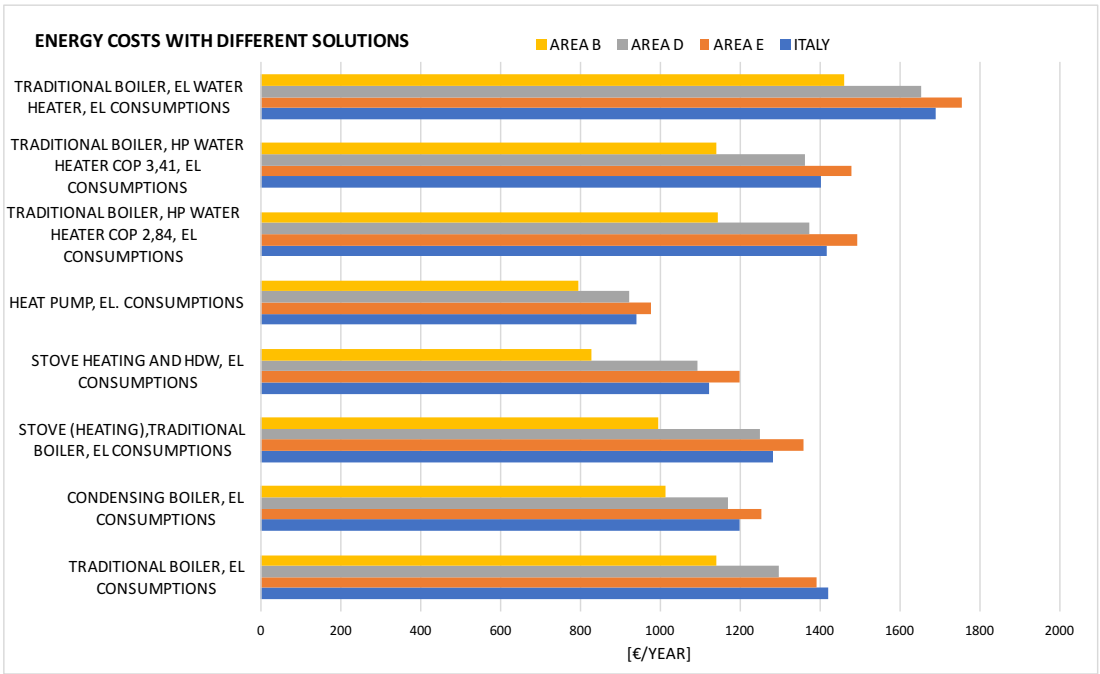

Figure 37. Energy costs of diverse solutions (without considering the investment cost of this installations).

The graphs show total energy expenses including electricity and gas expenditure.

[38] https://www.enel.it/it/luce-e-gas/luce/casa. The offers are for the mono-hourly tariff *Energia Pura Casa*, for the two-hourly tariff *Energia Pura Bioraria.*

[39] D. Thrän, D. Peetz, K. Schaubach (2017). *Global wood pellet industry and trade study 2017.* IEA Bioenergy.

It is clear that the electric water heater is very expensive, although the investment cost for this system is very low.
The heat pump is a very useful solution for areas where there is no gas network and especially in warmer areas as heat pumps work better with small temperature gradient.

3.3.2 Payback times

The next step is the analysis of the return on investment times of the analyzed systems. The return time is calculated according to the incentive received (Conto Termico or Ecobonus) and the annual economic savings in the bill.
The investment cost and installation cost here are provided by ENEL's offer, which also allows the total cost to be paid in installments.

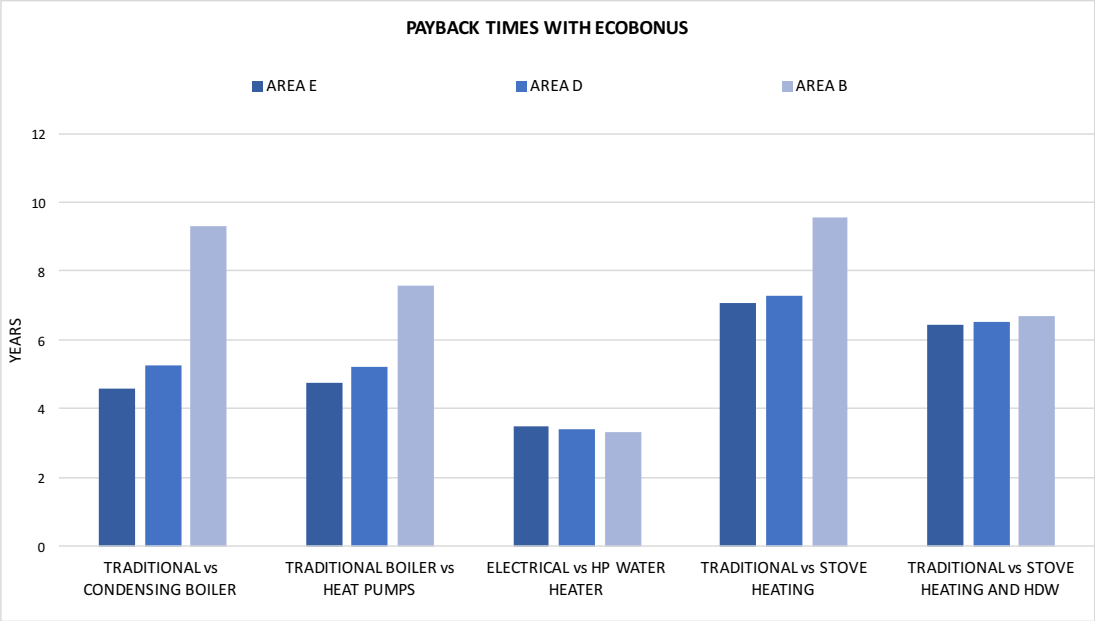

Figure 38. Pay back times with Ecobonus based on the energy cost savings for the substitutions of the old installments.

Fig. 37 represents the pay back times of different installations; the most convenient one seems to be the heat pump instead of the electric water heater. In fact, although the price of the heat pump system is high, consumption decreases considerably.
The advantage of the electric water heater is only the investment cost factor that in the past encouraged consumers to buy it.

It has been decided to compare the traditional gas boiler with all other installations with regard to space heating systems, because it has been assumed that a household decides to replace the boiler only if it has an old equipment that is probably a traditional (non-condensing) gas boiler.

In the South of Italy the payback times are highest than in the North due to:

- Highest cost of transport and management of the meter;
- Less savings because of the less energy supply for heating and lighting.

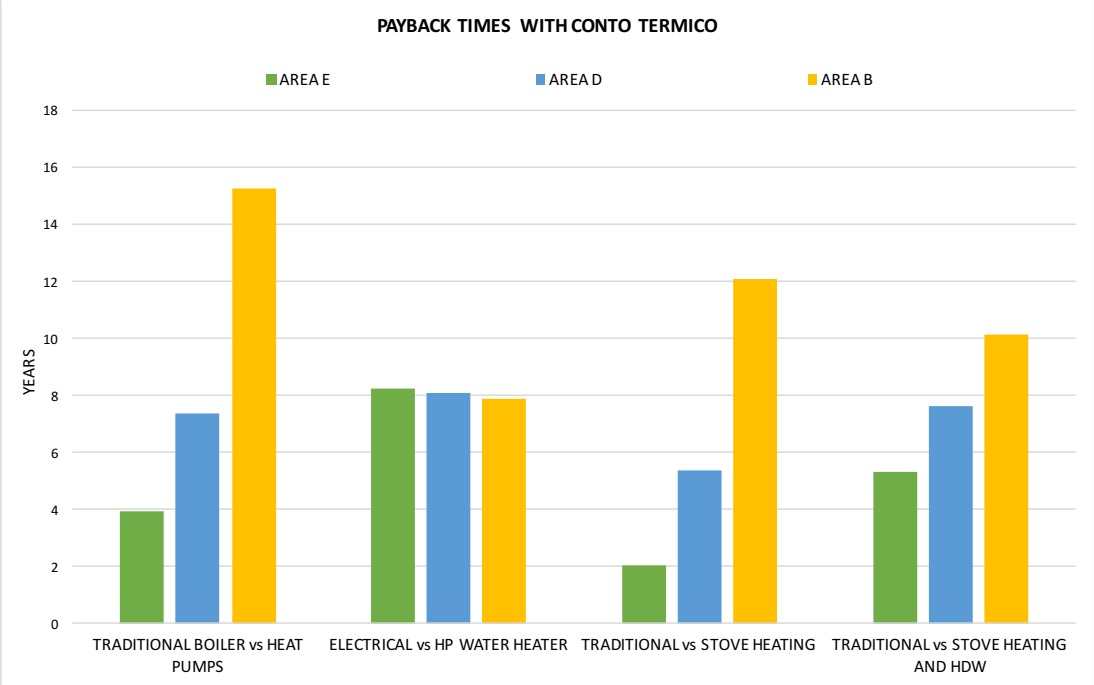

Figure 39. Pay back times with Conto Termico based on the energy cost savings for the substitutions of the old installments.

Fig. 38 shows different return times, but this is considered the Conto Termico and not the Ecobonus. It is clear that certain solutions are really convenient in the North: for example, the stove is a good option for space heating especially if the cost of pellets does not increase much.

The heat pump also seems a good alternative, the problem is that it works better at small temperature gradients, so in mountainous areas or in very cold areas is not the best option. However, there are also areas in the North where it can be a possible alternative because they are milder areas belonging to zone D, such as Liguria and the coastal part of Friuli Venezia Giulia.

The condensing boiler is not considered among the payback times because with the Thermal Account it does not receive incentives.
Heat pump water heaters receive incentives only depending on the tank capacity and regardless of the climatic zone.

3.3.3 Solar coverage factors

The graphs below show the solar coverage factors in Milan, Florence and Palermo that belong to the E, D and B areas respectively.
The monthly solar coverage factor is the ratio of the average monthly solar energy compared to the average monthly heat demand for heating/DHW.

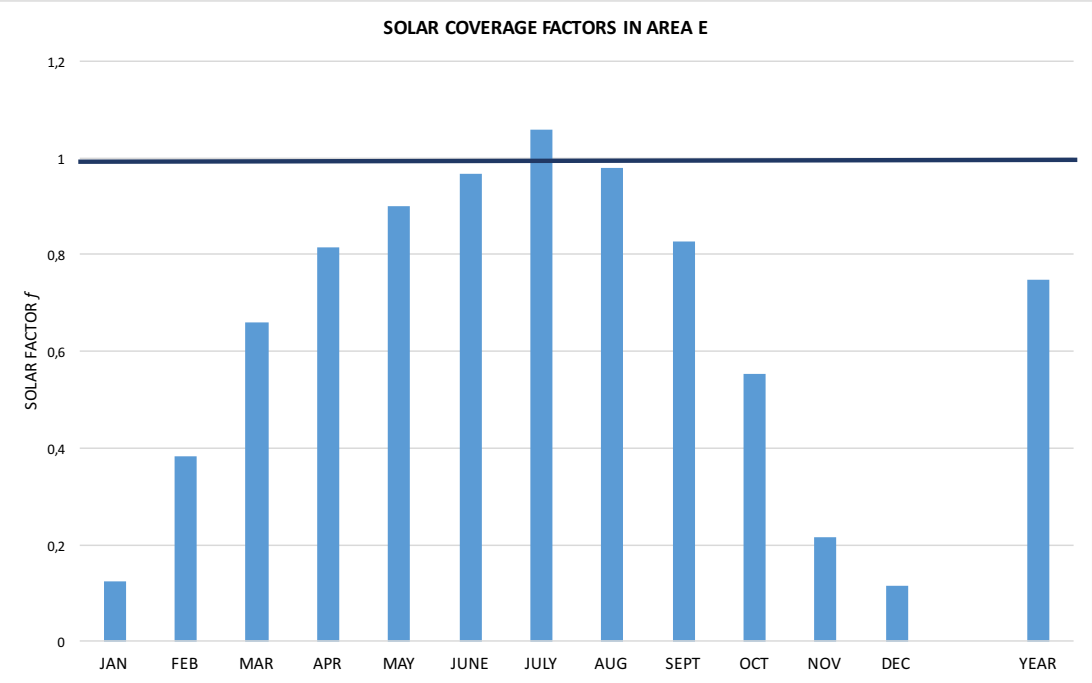

Figure 40. Monthly and annual solar coverage factors in Milano (area E).

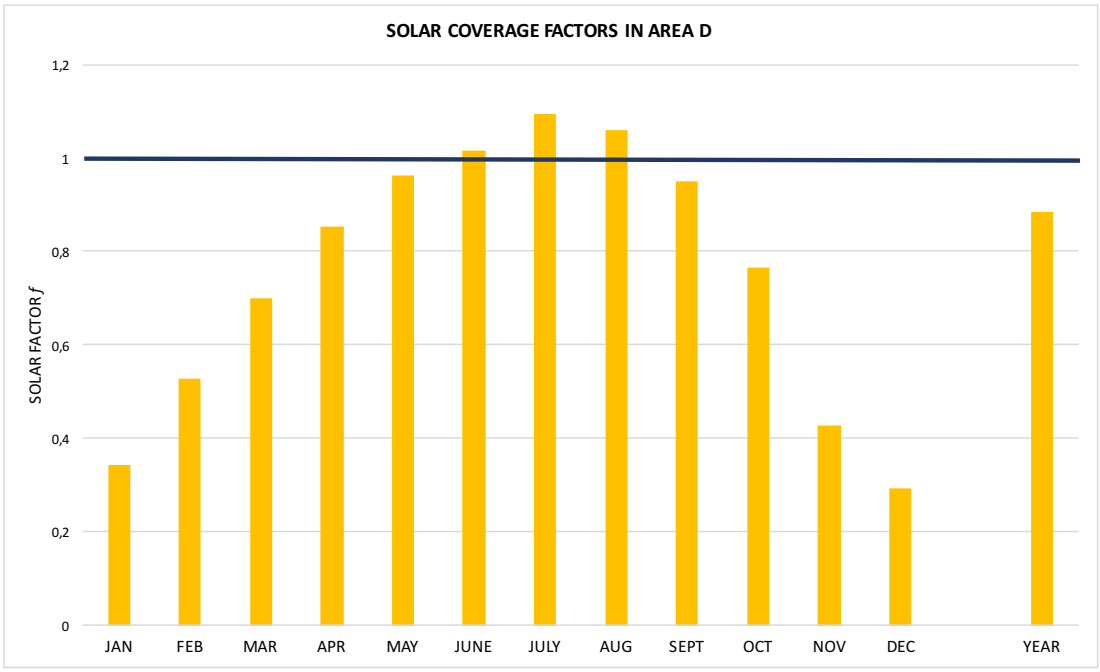

Figure 41. Monthly and annual solar coverage factors in Firenze (area D).

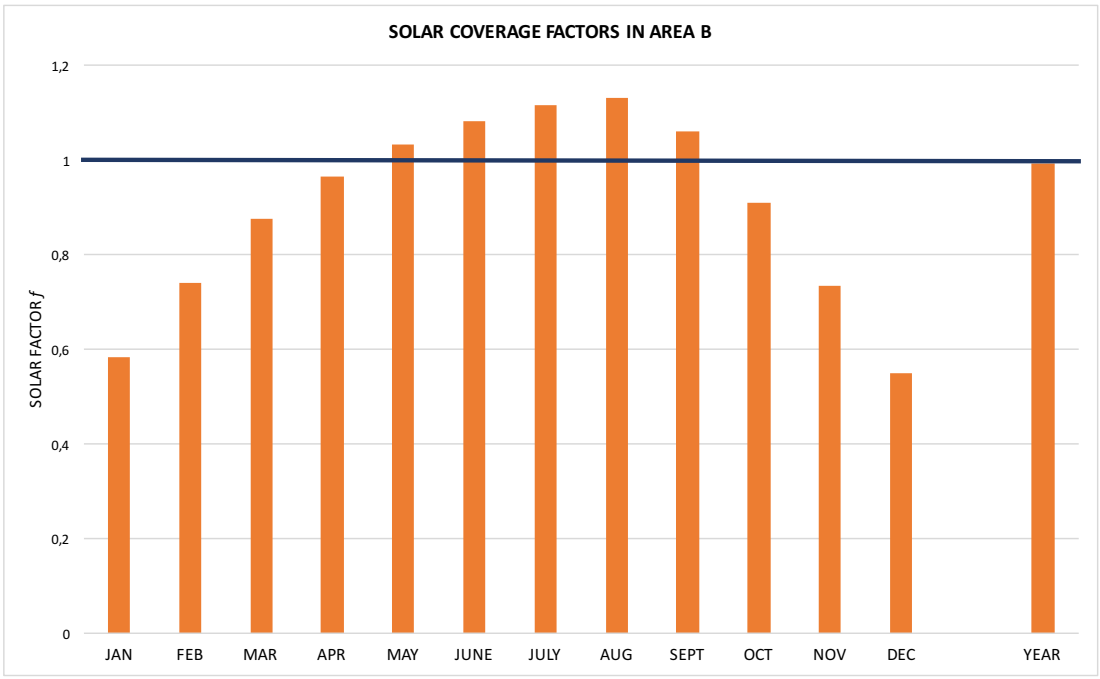

Figure 42. Monthly and annual solar coverage factors in Palermo (area B).

These solar roofing factors were derived from a system consisting of two flat glazed solar collectors with a gross area of 1.852 m^2 for each panel and an angle of tilt of 60°. These factors were calculated according to the UNI EN 1516-4-3 normative for a plant producing only DHW.

The results with this type of system (2 glazed flat solar panels) are clear:

- In Northern and Central Italy, the solar coverage factor does not reach the unit, so demand cannot be met. In southern Italy, the annual value reaches the unit;
- Monthly factors are less than 0.5 in November, December and January in area E, the months when the need for DHW is higher;
- In area D the values are slightly higher but not enough to exceed 0.6;
- Only in area B the values are higher than the unit from April to October, but in the other months it is not possible to cover the entire demand for energy.

The consequence is the impossibility of having only one solar thermal system to cover the entire demand for hot water; hybrid systems or solutions with more than two thermal solar panels must be adopted.

The only possible solution for this type of installation is their use for summer DHW production only in hot areas for homes used only as summer residences. However, this is not the case for vulnerable consumers.

Hybrid systems are, for example, combined solutions of solar collectors and condensing boilers or solar collectors and heat pumps.

Hybrid systems are not considered in this work because they are expensive solutions. However, some studies[40] have shown that hybrid solar plants can lead to 20-30% savings in the heating/DHW consumption of a family.

Furthermore, no solutions with more than two solar thermal panels have been considered, as the cost is increasing and it should be considered that installations for low income families only are being considered.

[40] Müller-Steinhagen H. (2008). *Applications of solar heat for temperature ranging from 50-2000° C.* 5th European Thermal-Sciences Conference, The Netherlands.

3.4 Some other works about energy savings

ENEA in the section dedicated to energy efficiency has published some useful tools for technicians:

- Docet which is a software capable of drawing up an EPC[41] which is the energy performance certificate for buildings with a surface area lower than 200 m^2;
- The transmittance values for window frames, roofs and walls;
- Evaluation of thermal bridges;
- Assessment of energy savings.

For example, for a condensing boiler the annual energy savings [kWh/apartment/year] are:

- 163 for heating and 466 for heating and DHW concerning area B;
- 378.5 for heating and 669.5 for heating and DHW concerning area D;
- 919 for heating and 1 220.5 for heating and DHW concerning area E.

ENEA[42] also provides information about the energy savings achieved with the use of heat pumps for heating and DHW replaced by a boiler.

Another interested study group on energy efficiency and renewable energy is Energy and Strategy Group[43]: this team is made up of professors and researchers from the Politecnico di Milano, which provides registered users with many reports on the topics it deals with.

A presentation[44] of the GSE on the Conto Termico sets the acceptance threshold for return on investment times at 4-6 years for the residential sector.

For example, the lighting has a return time of less than one year with the support of tax deductions while heat pumps and solar thermal systems have return times of up to seven years with the support of the Conto Termico.

A good solution is the installation of the condensing boiler, which has a maximum return time of 4.5 years with the economic help of Ecobonus.

[41] Energy Performance Certificate.
[42] http://www.acs.enea.it/calcoli/
[43] http://www.energystrategy.it
[44] Di Giamberardino L. (2017). *Il meccanismo del Conto Termico.*

3.5 Conclusions about energy savings

This chapter analyzes some possibilities to save energy.

There are many alternatives, but each of them is a too expensive solution for consumers in energy poverty and with low incomes.

In fact, the problem is that those suffering from energy poverty cannot afford an initial investment which, even if reduced by incentives, is still high for households with total spending below the relative poverty line.

In Italy, as explained above, there are two kinds of incentive, Ecobonus and Thermal Account, which are very useful to help consumers save energy through energy efficiency and use of renewable thermal sources, but some problems can be found:

- They do not aim at helping those in energy poverty;
- They return part of the investment cost, but in many years or after a few months (not immediately and before installation);
- They are not destined to solve the problem of split incentives between owner and tenant to promote energy efficiency even among those consumers who are renting.

Chapter 4

Analysis of possible solutions

This chapter presents some very interesting Italian projects and some possible solutions to tackle energy poverty.

4.1 Objectives

The solutions to tackle this form of poverty are distinct in:

- Solutions to combat energy poverty;
- Solutions to help vulnerable consumers and try to get them out of this situation.

In the first case, the solution adopted today by the Italian State is the Social Bonus; however, one of the objectives of the national energy strategy is to reform the Bonus. In fact, the Bonus is an effective instrument, but it is necessary to simplify the procedure in order to be able to request it, and it must be provided in accordance with an energy poverty indicator and not according to the value of the ISEE attestation.
In the latter case, strategies can be created to help vulnerable consumers get out of this condition.
This work is aimed at addressing vulnerable consumers by trying to envisage joint solutions to the Italian projects that have seemed more interesting in order to achieve this objective.
Energy efficiency is certainly the solution from an energy point of view.
The economic solution for achieving energy savings is analysed in the following paragraphs.

4.2 Energy Service Companies - ESCO

Energy service companies are an effective means of achieving energy savings.

In Legislative Decree 115/2008, ESCO is defined as the physical or legal person that implements the energy saving measure and assumes at least part of the financial risk. In addition, the payment for the energy service provided is paid in whole or in part based on the economic savings obtained from the intervention clarified in the contract signed.

The categories of contract that a private party can sign with an ESCO are based on what GSE says about the Conto Termico:

- Energy service contract: it is defined in the Presidential Decree 412/1193 and subsequently in Legislative Decree 115/2008, it is a contract that under defined requirements regulates the supply of goods and services necessary for the improvement of the process of transformation and use of energy.
- Energy plus service contract: this is a variant of the previous contract and has been regulated in Legislative Decree 115/2008. It is an energy service contract that is classified as a special case of an energy performance contract and therefore aims to bring energy savings to the supply with which the agreement is concluded.
- Energy performance contract: it has been regulated in Legislative Decree 115/2008 and subsequently in Legislative Decree 102/2014. It is an agreement between the company implementing the energy saving measures and the beneficiary of them. Investments shall be repaid according to the energy savings achieved, which shall be fixed before intervention in the drafting of the contract.

The energy service contract and the energy plus service contract are special forms of energy performance contract as explained below.

There are two possible ways of financing via the EPC contract:

- Funding by ESCO, however, it is not easy to find a company that decides to take over all the investment risk;
- Financing through third parties, banks or credit institutions finance the investment through a loan. Third-party financing (TPF) has been regulated in Legislative Decree 115/2008, which defines it as a contract between the investment beneficiary, the energy supplier and a third party that finances the investment cost and then charges the beneficiary as a rent on part of the saved energy expenditure. The third can be an ESCO (and in this case you return to the first point where it is the same ESCO that finances).

Third-party financing is not consistent with the definition of ESCO as it does not take the financial risk in the project through this type of financing. However, the TPF is permissible in the EPC contract and also widely used.

The types of EPC contracts are the following:

- First out: a contract between ESCO and the customer where ESCO finances with equity or applies for financing through third parties, receives 100% of the savings for the duration of the contract and the installed systems are its property. At the end of the contract, ownership of the investment passes to the customer; the average duration of the contract is 3 to 5 years.
- Shared Savings: a contract between ESCO and the client where ESCO finances with equity or applies for financing through third parties; during the duration of the contract, a savings percentage is fixed that goes to the client and a savings percentage goes to ESCO. The ownership of the plant initially belongs to ESCO and ultimately passes to the customer. In this case, the average contract duration is a little longer because ESCO does not immediately recoup the entire investment, so the average is around 5-10 years.
- Guaranteed Saving: a contract between ESCO and customer where the customer asks for financing through third parties and ESCO guarantees a level of energy saving. With the guarantee of an ESCO, the bank will be more likely to provide the loan. The customer pays ESCO for its management services through energy savings, so this contract continues to be an EPC. The average contract term is 4-8 years.
- Four Steps: contract between ESCO and customer where the customer pays a fixed fee to ESCO.

  The ESCO pays the funding in these four steps:

  - Optimisation of the system's O&M, from savings achieved to phase 2.
  - Low-investment innovations, thanks to the energy savings achieved, we move on to phase 3.
  - Innovations at average cost and more intensive, so you get enough savings to move on to the last stage.
  - Innovations with long investment times.

  The average contract duration is variable and depends on the savings achieved.

- Build - Own - Operate & Transfer (BOOT): a contract between ESCO and the customer in which ESCO finances, builds and manages the plant for a period of time in which it also owns the plant. The financing can be done by ESCO itself or by a bank, however it is contracted by ESCO.
- Pay from Savings: is a contract between ESCO and client where the customer finances the investment or applies for financing through a third party. This type of financing means that the bank does not grant the loan with repayment at fixed prices but is indexed based on savings.

  This contract has a maximum duration of 20 years.
- First in: contract between ESCO and client where ESCO finances the intervention through equity or third party financing. The customer pays the energy bills to ESCO with a minimum discount on the bill, so that the ESCO has a return on investment and the customer immediately receives a saving. If there is more energy recovery than agreed, this benefits the customer.

  The average duration of the contract is 7-8 years.
- Chauffage or energy service contract: is a contract between the ESCO and the end customer where the ESCO provides a service for an agreed number of years and the customer pays a fixed fee with a discount decided upon signing the contract. ESCO is responsible for financing, managing and paying bills. They are long contracts with a duration of up to 20 years.
- Energy plus service contract: is an energy service contract with certain requirements, in fact for example it must achieve a percentage of primary energy savings over the years for winter air conditioning.

All types of energy performance contracts have pros and cons, but some of them are better suited to the situation of vulnerable consumers.

The most interesting ones are Shared Savings and First out as well:

- For a vulnerable consumer, it is necessary for the ESCO to borrow or invest in financing;
- The First Out has short contract times and the ESCO has a greater incentive to conclude such a contract because vulnerable consumers are high-risk customers, but the consumer does not see any economic savings in his bill for the first few years;

- Shared Savings has relatively short contract times and both parties immediately gain an economic advantage from the investment made.

However, the ESCO needs to be prepared to take on a greater financial risk with a low-income client.

4.3 European projects

At European level, there are many projects concerning the energy efficiency of buildings, the battle against energy poverty and information among European citizens on the issues of energy efficiency and energy poverty.

In this work it seemed important to cite some of them in order to understand what has been done so far and to disseminate information.

They refer in particular to the European Energy Efficiency Directive (2012/27/EU):

"The common framework should allow Member States to include in their national schemes requirements with a view to achieving social objectives, including in particular ensuring that vulnerable consumers have access to the benefits of increased energy efficiency."

Subsequently, the directive also refers to the landlord/tenant dilemma (theme addressed by the guarantEE project and the LEMON project) by saying that states can address the issue of the separation of incentives between landlord and tenant in order not to give up energy efficiency measures because one of them does not personally benefit from them.

The European funds that finance these projects are the Cohesion Policy Funds, divided into: Cohesion Fund (CF), European Regional Development Fund (ERDF) and European Social Fund (ESF).

The objective of all is to reduce economic and social disparities between Member States and European regions and to promote sustainable development.

In the case of the European Social Fund, its objectives are to improve employment and education opportunities and the situation of the most vulnerable consumers at risk of poverty. Some of its main priorities are social inclusion and poverty reduction.

In the 2014-2020 period, this funding was used to meet the above-mentioned objectives:

- For CF, 8 billion € for projects with the objective of low-carbon economy.
- For ERDF:
  - 31.6 billion € for projects with the objective of low-carbon economy.
  - 11.9 billion € for projects with the objective of supporting social inclusion.
  - 6.3 billion € for projects with the objective of education and training.
- For ESF:
  - 21.2 billion € for projects with the objective of supporting social inclusion.
  - 27.1 billion € for projects with the objective of education and training.

For the Horizon 2020 Programme, 1 billion € has been financed with the objective of secure, clean and efficient energy.

4.3.1 ELIH-MED Project

Elih-Med means Energy Efficiency in Low-Income Housing in the Mediterranean: it is a European project carried out from 2011 to 2014 in some of the northern Mediterranean countries, in fact Cyprus, France, Greece, Italy, Malta, Slovenia and Spain participated.

This project was fully funded by the European MED programme, which has now become an Interreg Mediterranean programme in the period 2014-2020.

The project envisaged improving the energy efficiency of some buildings inhabited by low-income households.

In Italy, three places were selected to implement the project: one in Sardinia, one in Campania near Naples and one in Liguria in Genoa.

Once the sites were selected, the first action was an information and awareness campaign to citizens who would enjoy the benefits. All the improvements that would have been made were explained in detail, and technicians also tried to teach the beneficiaries of the intervention new habits to ensure that the interventions were more effective.

After the information phase, work began.

In Sardinia, for example, in order to isolate the buildings, goat wool was used, so using a local resource (Sardinia is in fact known for sheep breeding and sheep farming) has achieved economic savings and an increase in the local economy.
For example, in Genoa the work lasted only six months because the time needed to be short due to the inconvenience faced by tenants.
In addition to replacing or installing systems and thermal insulation of buildings, there was also the replacement of meters with smart meters to monitor actual energy savings.
The interventions were made on different types of houses, in fact in the Italian case they were part of the project both blocks of apartments and single houses.
The funds for the project did not derive entirely from the Med programme, but each area in which the interventions were made sought ways to receive other funding; for example, in Liguria the Genoa City Council (since these were social housing) paid the compensation for the work of the technicians.
In Campania, as additional means of financing, recourse was made to the Conto Termico and the Scambio sul Posto (an incentive for domestic producers of electricity).
In Sardinia, no ESCO or private company wanted to support the project with funding because low-income households represent a high financial risk.

4.2.2 ASSIST 2GETHER Project

ASSIST 2GETHER is a European project of the Horizon 2020 Programme aimed at combating energy poverty, including Belgium, Finland, Italy, Italy, Poland, the United Kingdom and Spain.
The project was launched in May 2017 and aims to tackle energy poverty on the one hand by making consumers more aware of how energy efficiency measures are implemented and how habits can be changed to achieve it more effectively, and on the other hand by changing energy policies for energy poverty.
The project will have a duration of three years.
The main activities of the project are as follows:

- An analysis of energy poverty at European and national level for the states participating in the project; all measures implemented at national level for vulnerable consumers will be classified and recorded.

In this way, all Member States will have a clear idea of energy poverty in Europe and the measures implemented, which meets the objectives of the European Energy Poverty Observatory;

- Creating the role of Household Energy Advisors (HEAs) as new competent figures who can teach vulnerable consumers to change habits regarding energy consumption and who can explain what energy poverty is;
- Creation of advisors who can help families affected by energy poverty to receive state support for this type of vulnerability. They can also help the state itself to implement policies in support of vulnerable consumers.
- Assist Actions are activities aimed at supporting vulnerable consumers, such as a change of supply, changing habits.
- Policy orientation towards strategies to combat energy poverty.

The Italian project partners are RSE (Research of the energy system) and AU (Single purchaser).

4.2.3 FIESTA Project

The Family Intelligent Energy Saving Targeted Action project is a European project co-funded by Intelligent Energy Europe (IEE) which ran from October 2014 to September 2017.

The project was aimed at families and in particular the most vulnerable families. Six members of the European Union of Southern Europe, Bulgaria, Cyprus, Croatia, Italy and Spain participated in the project.

The aim of the project was to carry out energy audits of the homes by means of energy counters. Subsequently, it aimed to help families to reduce energy consumption based on a change in behavioral habits and awareness of savings as a result, for example, of better use of household appliances or the purchase of energy class A+++ appliances.

The targets set by the project were a saving of 328 toe/year of primary energy and a reduction in greenhouse gas emissions of 1 130 tons of CO_2 equivalent.

4.2.4 Energy Ambassadors

Energy Ambassadors is a European project within Intelligent Energy Europe.

It started in May 2009 and was completed in October 2011. Nine European Union countries were part of the project: Bulgaria, Denmark, France, Greece, Italy, Romania, Spain, Sweden and the United Kingdom.

The aim of the project was to teach vulnerable consumers efficient use of energy for energy saving purposes. This work was done through groups of social workers previously trained and educated on the subject.

The main target groups of the project were therefore vulnerable consumers (18 000) and social workers (300).

At the end of the project 4 500 MWh, 51% from heating/DHW and 49% from electricity consumption were saved, and 1 451.5 tons of CO_2 equivalent per year were avoided.

Among the keywords of this project are certainly education and integration: energy saving education for those who need to be trained and for those who benefit from it, integration between the various municipal social bodies and health social partners to achieve the set goal.

4.2.5 SMART – UP Project

The Smart - up project is part of the Horizon 2020 programme and was launched in March 2015 and runs for three years.

The main objectives of the project are as follows:

- Increase the use of smart meters among vulnerable consumers;
- Help consumers to change their consumption patterns according to the data provided by the smart meter;
- Let consumers realise by saving energy and saving bills on the efficiency of smart meters.

However, the project also outlines the obstacles it faces:

- Consumers do not know how to read the meters and are not aware of the importance they have in energy saving;
- For vulnerable consumers, any changes that result in even very high energy savings (like the replacement of some household appliances) are exacerbated because they lack sufficient economic resources.

The solutions to these obstacles are also here the training of specific professionals who teach consumers how to use meters efficiently, tools that always help consumers (telephone assistance services).
An important consequence of the use of this type of meter is the in-depth and detailed analysis of consumption, which is particularly important in various surveys in the energy sector.

4.2.6 GuarantEE Project

The guaranteed energy efficiency project in the public and private sector is part of the Horizon 2020 Programme. The project duration is April 2016 - March 2019.
GuarantEE aims to encourage the development and dissemination of energy performance contracts. This should be achieved through the development of more flexible contracts targeted at the private sector, through a strategy for dealing with the tenant/owner dilemma, through experts who carry out pilot projects.
The solution to split incentives dilemma is the triple - win approach: costs and benefits are shared between ESCO, owner and tenant.
The solutions that this approach proposes are the following:

- EPC savings transfer agreement, the owner concludes the contract with ESCO and the tenant pays the landlord the fixed rent and consents to the transfer of savings.
- EPC contract at the owner's expense, the landlord signs a contract with ESCO and the landlord will charge him a higher rent when he has new tenants.
- Progressive regeneration of neighbourhoods, social housing of neighbourhoods. The owner and ESCO will sign the contract.
- EPC Agreement with the consent of the owner, the tenant signs the contract with ESCO and the owner agrees. This type of contract is more suitable for long-term lease contracts.

In order to make the EPCs more flexible the actions taken by the GuarantEE project are the early termination clauses by both parties, simplification of initial measures to make the contract less costly and the possibility for ESCOs to access public funding.
In achieving these goals, the EPC facilitator, a competent professional figure, is needed.

4.4 Independent projects of European countries

This section shows some independent projects (not funded by the European Union) dedicated to vulnerable consumers.

Projects that were considered more interesting and in line with the issue of energy poverty are divided into short-term projects aimed at helping vulnerable consumers in the immediate future and long-term projects aimed at eradicating energy poverty from the roots.

Short-term projects are:

- Disconnection protection: this is a method of preventing vulnerable consumers from being disconnected from the grid and remaining without heating, hot water and/or electricity. It was adopted in Catalonia (Spain), the Netherlands, Cyprus, Romania, Slovenia, Hungary, Greece, United Kingdom. Disconnection protection measures are different: in the United Kingdom, for example, there are three protection services, one for the winter months only (Priority Service Register), one in which are only the six largest distribution companies that guarantee continuity of service also free of charge for vulnerable consumers (Energy UK Safety Net), one for vulnerable consumers at risk of disconnection (Extra Help Unit). In Greece, however, with the project Measures against humanitarian crysis, the disconnection protection measure guarantees a certain level of continuous energy (300 kWh).
- 2017 Energy Best Deal Project: is a UK project that has benefited 600 000 consumers between England, Scotland and Wales. It is a project started in 2008 thanks to private funding from Citizen Advice. The aim is to make vulnerable consumers aware of their situation and to help them find cheaper and more suitable offers for their energy bills. Vulnerable consumers are also informed about government aid, the most cost-effective energy efficiency measures and are taught to change consumption habits with more efficient behaviors.
- EDF projects: EDF (Électricité de France, France's largest energy distributor and producer) has promoted services for consumers in energy poverty Vous aider dans les moments difficiles (Helping you at a difficult time) which provides information on payment methods, energy savings and access to support services; EDF et moi (EDF and I) is an app that helps the consumer to reduce consumption in both [kWh] and [€].

Long-term projects are:

- Energy Audits that accompany renovations: this is a French project that is financed by private funds. By the end of 2018, around 200 000 consumers will be identified and recommended with advice on energy efficiency and possible thermal refurbishment following an energy audit.
- SLIME (Service Local d' Intervention pour la Maîtrise de l' Energie) is a project financed by the French Government. The project aims to facilitate the identification of vulnerable consumers, to support them and to coordinate the organizations involved.
- ECO (Energy Company Obligation) is a project promoted by the British government, the latest ECO2t version was drafted in 2017. One of the main objectives is HHCR (Home Heating Cost Reduction Obligation), which requires suppliers to promote measures that improve the ability of vulnerable consumers to adequately heat their homes (among these measures is also the replacement of the boiler).

  The obligated parties are companies that supply energy to more than 250 000 consumers, have an obligation to supply more than 400 GWh of electricity and more than 2 000 GWh of gas.
- Warm Homes Nest Scheme project funded by public funds from the Welsh Government since 2011. Advice and free help is provided to reduce energy costs. Eligible consumers (in energy poverty) are offered a free package of energy efficiency improvements, such as new boilers, thermal insulation.

These projects clearly show the difference between the UK and other European countries. The United Kingdom was in fact the first to start studying energy poverty, so today it has a much more reliable database with more reliable data than other countries. The projects promoted by the United Kingdom are at a later stage than those of the other countries, the aim is to find new solutions and provide permanent aid to eradicate this particular form of poverty.

Initiatives by other countries are aimed at identifying vulnerable consumers, obtaining stable data and organizing follow-up projects to address the problem of energy poverty.

4.5 Italian projects

This paragraph explains some interesting initiatives at Italian level that can lead to a reduction of vulnerable consumers.

4.5.1 Protocol of agreement between ENEA and Fratello Sole

The protocol was signed by ENEA and Fratello Sole in February 2018 and aims to find solutions to combat energy poverty.

Fratello Sole is a society that wants to support the social institutions that support people in need. Specifically, the help that this company offers is towards the energy saving of the social organization to make it sustainable.

In November 2017, Fratello Sole won the Ashoka Award as one of 15 European best practices in the fight against energy poverty.

The company operates as an ESCO, makes an energy audit of the institution's building, invests capital, manages the plant and when it has depreciated the investment cost it passes ownership of the installed systems to the entity itself.

The protocol signed by ENEA and Fratello Sole is aimed at the Third Sector Entities, but it is interesting to report its objectives as it studies solutions to combat energy poverty.

The objectives are the study of new technologies, the study of fiscal, incentive and financial solutions.

4.5.2 Rete IRENE

IRENE Network is the network of companies for the energetic rehabilitation of buildings whose objective is to spread the energy efficiency of buildings.

The network has proposed three types of guarantee contracts to improve energy performance:

- Contract works with guarantee of energy class improvement: this type of contract guarantees the improvement of the energy class of the building following an energy efficiency intervention of the building.
- Works contract with management and maintenance of plants and guarantee of reduced consumption: this agreement provides not only for the intervention of

energy efficiency, but also the management and maintenance of plants. Here the improvement of the energy class is not guaranteed (even if that is what follows), but a reduction in consumption.

- Work contract with energy service and guarantee of reduced consumption: this contract ensures the investment, management and maintenance of the plant, but also the supply of energy to the user. Therefore, the user receives all the costs in the bill, and a guarantee of the installed system is also guaranteed for the duration of the contract.

Irene Network also organized for March 2018 an event called Say Do Requalify (Dire Fare Riqualificare) to disseminate and propose new options for the energy improvement of buildings.

4.5.3 Banco dell'energia

Banco dell'energia is a non-profit organization founded by A2A together with the AEM and ASM foundations, whose aim is to obtain funds for vulnerable consumers.
In fact, the funds raised will be allocated to a series of nonprofit organizations that have participated in the call established by the Cariplo Foundation.
A2A's customers can donate directly to their bills if they join the project; in addition, A2A and Cariplo foundation have each committed themselves to double the amount of donations. The objective is in fact to reach the 2 million € quota for households in conditions of energy poverty.
The benefits will go not only to A2A users, but to all distribution companies; however, to begin with it was decided to confine the project to the Lombardy region only.
The project does not only seek help from private users, but also from companies that can contribute more donations and become energy partners.
It is a project that aims to integrate non-profit associations, businesses, users and energy supply companies.

4.5.4 Italia in classe A

Italia in classe A is an ENEA's project that aims to promote energy efficiency.
ENEA's researchers have made an on the road trip to Italy to spread this important topic and help understand how energy can be used more effectively and efficiently.

Each stage of the trip was informed about the following five themes:

- Energy Efficiency: small gestures, great results. This theme explains the daily gestures that can be made every day to reduce energy consumption and save money in your home.
- EE Factor: use your energy well. Here, it is explained to citizens how to become passive consumers, low-emission consumers.
- Public Administration (PA) energy efficiency objective.
- More efficiency, greater competitiveness for small and medium-sized enterprises (SMEs).
- The vital energy of art.

It is an important project in which surely the key word is information.

4.5.6 LEMON Project

LEMON means Less Energy More OpportuNities, is a European project, funded by Horizon 2020, whose partners include Italy, which started in February 2016 and will end in May 2018.

Lemon is a project that aims to find solutions for tenants to benefit from the advantages of energy efficiency while not owning a house.

The project aims to upgrade 622 apartments of social buildings in the provinces of Reggio Emilia and Parma in Emilia Romagna.

Integration is also an essential word for this project, because it aims to involve:

- Citizens and tenants of social buildings;
- Public administrations;
- ESCO;
- Financial institutions.

The project model once completed with the joint action of all these parties can be replicated.

The main objectives of the project are as follows:

- Experimentation of financial models through the EPC contract, in fact, investments of up to 15 290 million € are aimed at reducing primary energy.
- Energy efficiency in 622 homes leading to primary energy savings of 5.74 GWh and a reduction in emissions of 1 159 tons of CO_2 equivalent.

- Experimentation of a new model EPC contract called EPTA (Energy Performance Tenancy Agreement) based on the energy performance of the apartment. In fact, after the investment the energy expenditure decreases, but the tenant continues to pay the same monthly amount: the bills decrease but the rent is increased by the same amount of rent of which the bills decrease. The owner can therefore recover the investment cost and the tenant enjoys the benefits of greater living comfort.

EPTAs are expected to last about 15 years. This does not create problems for the landlord as the investment recovers it on the rental contract so, even if the tenant is changed, the contract remains.

4.6 Some solutions

The above mentioned projects have shown that there is still no single solution to help vulnerable consumers.

All the projects agree that energy efficiency is an optimal solution for economic savings and this is the way to combat energy poverty, but energy efficiency is still a very expensive tool today.

Projects also converge on two other key issues: the need for information and the joint action of different financing and incentive schemes.

Vulnerable consumers are consumers who live in energy inefficient homes and have a very low income.

In the ELIH - MED project there were cases in Italy where families did not have heating at home or had heating at home but did not work for years.

These are really serious cases in a state of European Union.

The first action is therefore the information, as in the case of the Energy Ambassadors project, through the establishment of a call center that is competent and ready to answer questions about energy savings and to teach families how to change consumption habits.

This initiative, although free of charge for consumers, needs national or European funding.

All the projects mentioned so far are pilot projects with substantial European funding, but when long-term solutions are adopted there will be a need for internal funding.

The solutions that can be adopted are certainly combined solutions that benefit from government incentives, social bonus, but also private financing.

In fact, it must be remembered that for a vulnerable consumer, even the expense of replacing an appliance with another one of superior energy class, represents an expense that he can hardly afford.

ENEA's *Italia in classe A* campaign was very important, not only to spread knowledge and culture of energy efficiency, but also for having (maybe) sensitized private individuals and citizens to the topic.

In this sense, it is also important to carry out an awareness campaign for energy poverty, because apart from those affected by it and those who belong more to the scientific world, they are mostly unknown. A2A has taken important steps in this direction: billing, the involvement of companies and other foundations. The key word at this stage is not only to inform, but above all to raise awareness; private individuals and companies must be involved in the problem in order to involve themselves financially.

One of the major problems in identifying and establishing a common method for reducing energy poverty is the diversity and complexity of the cases where actions should be taken, i.e. the particularities of vulnerable consumers.

In order to obtain financing and/or a bonus, it is necessary to consider the factors:

- Family size;
- Type of household (children, pensioners, workers, unemployed);
- The type of house in which the consumer lives (size, energy class, etc.);
- The climate zone to which the family belongs.

These are just some of the main factors that need to be taken into account if we really want to contribute to the eradication of this specific form of poverty.

The bonus cannot be based only on a given income and financial situation of the family, because it is not sufficient; energy poverty is not income poverty.

A household may be in energy but not economic poverty, although very often vulnerable consumers also have an income below the poverty line.

ESCOs and EPC contracts play a key role in this situation, as they have a great deal of experience in the sector, they are familiar with plants and strategies for energy

improvement, but a solution must be found so that they have an incentive to enter into contracts with this type of consumer, who certainly represent a high financial risk.
This can be the result of state support, as a guarantor for vulnerable consumers.
Solutions need to be found in this direction, since while ESCOs have no incentive to invest (no ESCOs were interested in the ELIH-MED project, which had anyway guaranteed European funding), they could be a good intermediary between banks and vulnerable consumers.
The LEMON project, together with the guarantEE project, are also very effective in supporting rented households and resolving the landlord / tenant dilemma.
The energy performance rental contract is a very interesting project and could be implemented nationally also in order to achieve the primary energy savings targets through energy efficiency.
Results are expected by June 2018, when the pilot project should be completed.
What all these projects represent is the willingness to take a direction in order to find a solution for energy saving and energy poverty.
Finally, there are also other bio-sustainable and very interesting projects that still need to be implemented.
The Green Walls and Green Roofs systems consist of growing certain types of plants (rampicants in the case of walls) on walls and roofs of houses.
It is proved by many studies that they thermally insulate buildings: there is an average reduction in the building's air conditioning cost of around 3-10% in winter and 8% in summer.
However, account must be taken of the climate zone to understand which plants are the best and how much water they need. For now, the most relevant studies come from areas in the north (England, Canada, North America), but ENEA is carrying out studies[45] to develop guidelines for the use of these biosystems in urban areas.
These solutions could lead to cheaper solutions than others such as the outer coat of buildings.

[45] Campiotti et al., RT/2014/19 ENEA.

Conclusions

Energy today is a primary commodity that must be accessible to all consumers, including those who cannot pay for the supply.

Energy poverty is an important issue that has a social, economic and human health impact.

Once these fundamental points have been clarified, it is necessary to find and implement strategies that lead to its eradication.

This has been the main focus of many studies, projects and initiatives at both public and private level.

The first major objective highlighted by the European Union, by this and many other work is data retrieval.

This step is essential if you want to find accurate and reliable indicators. The necessary data are mainly needed:

- Income data [€/month];
- Energy expenditure data (fuels, electricity) [€/month];
- Energy consumption data [kWh/month], [Smc/month];
- Verified data on housing conditions (energy class, types of installations, etc.);
- Fuels used by households;
- Heating expenditure [€/month].

And many more data according to the specific needs of the applicant.

National Statistical Institutes must agree to the full dissemination of data in compliance with privacy laws so that in-depth studies can be carried out.

Furthermore, it is important to define the thresholds with which to compare consumer data in the various methods: it has been seen how the indicator regulations provide very high values of energy poverty because the thresholds on which they are based do not take into account current electricity consumption that is higher than 15 years ago because more appliances are used.

This makes one perceive how important it is to set standard and/or minimum thresholds for consumption, expenditure and consumer needs in each country, but also how important it is to keep them up with current lifestyles.
Technology is advancing faster and faster and the thresholds must also be checked to ensure accurate measurement.
As already pointed out, it is essential that each country sets its own thresholds and then makes them available to the European Observatory on Energy Poverty.
Another factor to be taken into account is that the data for estimating thresholds must be differentiated by family size, geographical area and family type.
The family typology is also a very important factor because families with the same number of members have different consumption levels because of the family typology.
The first step is to standardize the family typologies according to their percentages and characteristics, then it is necessary that all the thresholds are distinct for the same family typologies: this is a problem that particularly affected this study because there were some different expenses for family typologies (but the typologies were not standardized so for different data there were different typologies) and others only for numerousness. As a result, in this work it was decided to assess families only by area and family size, but this has made work more limited than it could have been.
Italy does not yet have an official measure of energy poverty. I. Faiella and L. Lavecchia calculated a measure, as explained in this work in chapter 2, and this was also reported in the National Energy Strategy of 2017.
It is precisely in the National Energy Strategy that it is said that Italy will adopt as an indicator of energy poverty the Low Income/High Costs indicator.
This study considers that surely with the current data[46] available to the state LIHC indicator is the most suitable criterion, however the MIS indicator could provide a more complete statistic of the percentage of energy poverty in Italy.
From the point of view of using the MIS indicator, it is necessary to establish what the needs and the minimum expenses that families have to bear in order to be integrated into society.

[46] The micro data on income are not provided to citizens, but of course the Italian State has them at its disposal.

Among the indicators studied in this work, what seemed to be the best and most accurate identification of vulnerable consumers is the third indicator of the methodology in agreement with the study by Faiella and Lavecchia:

Residual expenditures < ISPL and Incidence of Energy bills > 2 · Mean value of incidence of energy bills

This method is the one that comes closest to the LIHC indicator, which is precisely the indicator that the Italian State would like to adopt as an official measure of energy poverty.

This indicator shows that the percentage of vulnerable consumers in Italy is 10% of the total number of consumers in the survey.

10% of energy poverty in Italy is a realistic value, however it could have some fluctuation once extended to the entire Italian population.

This indicator is based on relative measures, so as already mentioned, it is not very sensitive to price changes.

Certainly, once complete data have been obtained, this analysis can also be differentiated according to the different family types; moreover, it would be better to check how much the results of the indicator vary if, instead of the residual expenditure and the expenditure-based poverty line, the residual income and the income-based poverty line are taken into account. In fact, even if income and expenditure very often coincide, this is not always the case.

Once an indicator has been defined, the social bonus must be assigned on the basis of this indicator and no longer on the basis of the value of the ISEE attestation.

Vulnerable consumers should be identified and informed about the possibility of receiving aid, as they do not always have the necessary information about the procedures to follow in order to receive the bonus.

In addition, by identifying consumers in energy poverty in this way, there is no longer the problem of those who do not make the ISEE attestation: only those who receive the bonus, but a part of the population is excluded which, due to lack of knowledge or other reasons, avoids doing so.

However, there is still the problem of those who are not connected to the network, the Bonus is a discount in the bill, but in areas where there is no methane network,

for example, it not possible to receive the bonus even if there may be families in energy poverty. In this case, only substantial reform can lead to a solution.
As far as the assessment of consumption is concerned, the right strategy is the one that the Smart-Up project is driving forward. It is necessary to learn how to use smart meters that, in addition to evaluating actual consumption (very important factor for analysis), can teach consumers to change their consumption habits based on meter readings.

The aim of this work was to understand which indicators could be used, and a further objective was to compare the different percentages of vulnerable consumers that the indicators themselves determined.
What was achieved was quite satisfactory, despite the lack of complete data.
From the analysis of energy efficiency, the reader has understood that energy efficiency is the most effective solution for improving the thermal properties of buildings, but it is too expensive for consumers in energy poverty.
The solution is therefore, according with European objectives, an Observatory of energy poverty in which, once a complete database on consumer spending and consumption has been obtained, reliable indicators can be calculated and more targeted solutions can be found.
Pilot projects are working well to date and awareness of this problem is spreading.
The answers we can give today to the question of how to solve this form of poverty for this study are: data collection, awareness and financing.

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