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Tesi di laurea

AN AUGMENTED ENERGY POVERTY INDEX.

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Firma dello studente

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ABSTRACT

In questa tesi, preso atto dell'energia come bene essenziale alla sopravvivenza ed allo sviluppo umano, abbiamo considerato nella sua multidimensionalità la Povertà Energetica (PE) come derivata dalla stessa Povertà.

Siamo andati a valutare in letteratura degli indici per la misura della PE, in particolare Hills(2012) per un indice relativo e Miniaci, Scarpa, Valbonesi (2008) per un indice assoluto. Quest'ultimo è stato d'ispirazione per andare a creare un framework statico su cui costruire un nostro indice, che come in Miniaci, Scarpa, Valbonesi (2008) è basato sul Reddito residuo (il Residual Income, cioè il reddito al netto delle spese per utilities), ma che nel nostro caso, considera anche il risparmio. Lo stesso framework ci ha permesso di ipotizzare un ciclo dinamico che conduce alla Trappola di Povertà Energetica; ciclo che ci aiuta a supporre che l'indice di Hills (2012), che guarda ai bassi redditi e alti costi (LIHC, Low Income High Costs), sia un indice di lungo periodo mentre quello di Miniaci, Scarpa, Valbonesi (2008), che guarda non solo a chi ha basso reddito o alti costi ma anche chi sotto-consuma energia, sia un indice che include il brevissimo periodo. Nel mezzo poniamo il nostro indice che non considera i sotto-consumatori di energia in quanto li riteniamo difficili da discriminare se non sono a priori conosciuti gli assetti tecnologici della famiglia, ma che invece, come si anticipava, prende in considerazione il risparmio dove a livello Europeo viene visto come condizione di deprivazione ed esclusione sociale. Quindi, andremo ad utilizzare i dati dell'indagine Household Finance and Consumption Survey, (HFCS), di Banca d'Italia per confrontare i vari indici che vengono opportunamente modificati per essere resi confrontabili. Il nostro indice viene comunque studiato per essere resa agevole la computazione a livello Europeo se non addirittura a livello internazionale.

Summary

INTRODUCTION

We still have, imprinted in our memory, the terrible images of a wounded Europe. Rather than pursuing a Union of Peoples based on principles of brotherhood and solidarity with which to build a common culture, the Monetary-Economic Union has been founded without a sociological view, believing that from the underlying economic rule could emerge a form of society. We have continued, and actually we continue, to neglect the peripheral countries with respect to Germany, that are in difficulty, as it has been, and actually is, the case in Greece.

In the period 2010-2012, during the economic turmoil in Greece, images of Greek cities were shown on TV, with high level of pollution. A memorable article in *Il Fatto Quotidiano* of that period, titled: "Crisi Grecia, le conseguenze dei prezzi alle stelle: inquinamento e rischio salute", (namely, The crisis in Greece, the consequences of the high prices: pollution and health risk), which described that, due to the doubling of the price of diesel, because of heating needs, Greeks had come back to Wood-burning stoves. Greeks began to burn everything. The consequence was to emit polluting powders into the atmosphere that could potentially lead to increasing respiratory illnesses, if not the risk of lung cancer. The article reported an increase of 200% in the level of pollutant dust certified by the same Greek Health Ministry. Almost unbelievable for a European country, in a European economy that wants to be defined as advanced!

The example supplied, from recent history, is a case in point: it introduces us to this thesis on energy poverty. Energy is considered the main ingredient related to human development. We will show how energy can be seen from different perspectives, but basically essential for human life. Given the definition of energy poverty, despite the fact It is not universally recognized, we will try to understand the significance of the energy ladder that we will see as a support to focalize our energy analysis in the domestic environment: mainly electricity and gas, but we will consider utilities in general. Since there is no global index for a comparable estimation of Energy Poverty, we will take some estimation models proposed by different researchers, and we will evaluate how to position them in our hypothesis of static and/or dynamic analysis. Valuated, we will make our proposal to build our own indicator of Energy Poverty, paying attention to get an indicator useful for a possible comparison at least at European level.

CHAPTER 1

Energy

Energy

In this thesis we begin to say why energy is important. Before we will define what energy is in terms of its physical source, and how to classify it by its very nature, by its efficiency, and by the sustainability of its exploitation. So we will explain how to get a common metric for several kinds of energy sources. Getting a comparison among energy sources will help us understand the efficiency of the different sources.

Central in this chapter is the importance of energy: we will start adopting an historical perspective taking the point of view of economic development, the political economy aspect, and in the end from the unique point of view of economics, regarding the structure of supply and demand.

The physical nature of energy

Energy is found in nature. Sources can be of fossil origin like carbon, oil, natural gas, nuclear fuel (uranium), or from vegetal or animal origin as with wood or dung respectively, both also defined as biomass. Other natural sources are the sun, wind and water (this last one has been exploited for centuries using canals, rivers, basins, mountain lakes, but also tides), moreover, unbelievable until recently, among these sources we can find thermal variations, heat from the earth (geothermal energy) and lastly electromagnetic waves.

From the ENI Scuola website we find that the previous sources are defined as “primary sources” that we call energy carrier sources.

At the other end of the spectrum there are the “secondary sources”, because they are sources derived from the former, after a process of transformation. A clear example overall is electrical energy.

See Table 1.1, where we show energy carrier sources (or primary sources) and the sources derived (secondary sources) from them.

Energy Carrier Sources	Energy Sources derived
Fossil: carbon	Carbon for thermal and electrical energy
Fossil: oil	Gasoline and fuels derived from the treatment of raw oil to gain mainly mechanical energy (or others)
Fossil: natural gas	Thermal energy but also, from a transformation plant, electrical energy
Fossil: nuclear fuel (eg. uranium)	Electrical energy from nuclear plant
Biomass: wood	Wood, pellet, charcoal for thermal energy
Biomass: dung	Used to generate gas and so on for thermal energy. The dung in the poorest countries are used to cook (thermal energy).
Sun	From the sun we can get thermal energy throughout solar panels that pre-heat the water that goes into the boiler and permit notable savings on gas consumption. Moreover from the solar source we can also have electrical energy with Photovoltaic (PV) Panels and the necessary inverters that convey electric energy. Ceteris paribus of solar irradiation, it's worth remembering that from the solar thermal energy we can get 80% efficiency when PV energy hardly reach 40%.
Wind	We can obtain electrical energy through a generator today still called a windmill, but in the poorest countries windmills supply mechanical energy like in the past.
Water	From rivers, lakes, basins and from tides we can convert electrical energy, speaking in general about hydro-electric energy. To note that from basins, because of limitations for natural reasons, they have assumed an increasing meaningful role in terms of a change of paradigm: they have become energy accumulators.
Thermal variations, heating from the earth	Generically exploited for geo-thermic energy, but today thermal variations are used to generate electricity from TEG (Thermo-Electric Generator), e.g. we can think to the Peltier cells.
Electromagnetic Waves	As for TEG, these are harvested from the environment all around. It's a new technological paradigm that is being affirmed: from either electric or magnetic components of electromagnetic waves we are able to harvest electrical energy.

Table 1.1: energy carrier sources and energy sources derived from transformation. Source: our elaboration.

Efficiency

We need to spend some time to understand "efficiency". In relative terms we can define a higher efficiency system as one that is able to employ less energy to obtain the same amount of physical work. Reducing this definition into a domestic context, we can try to exemplify it. For instance we have a house where we employ 1600cubic metre/year of gas (or the equivalent of about 160kWh/sq. meter year) to get a certain level of comfort. For the same house, in the same place, but better thermically isolated, with the aim to obtaining the same level of comfort, we will consume only 160cube metre/year of gas (so translated that means around to 16kWh/sq. metres a year). In this latter case we can say we are more efficient because we have less thermal dispersion which means less energy consumption with an equal comfort obtained (less consumption ceteris paribus). Curiously, the two hypothetical houses, with the current law on energy classification would be respectively under the energy class F and class A.

So the example done is actually very concrete. Moreover we limited ourselves to a ratio between houses of 1:10 in consumption terms (16kWh/sq.meter year versus 160kWh/sq. metres a year). Defined as 100%, the consumption of the first house classified as F, the saving, compared to energy class A, is about -90%! But the differences could be even more relevant! We can take into consideration Table1.2, supplied by Professor De Carli (2016), of the Course of "Energy and Sustainability in the XXI Century" put in place by Padova University, and made available to his students, to realize the unbelievable divergences that can be recorded between different classes of buildings (to note that zero consumption buildings entail off-grid solutions).

	kWh/(sq.m year)
Stock Buildings	**220-250**
Buildings with medium level of insulation	**80-100**
Low energy buildings	**30-50**
Passive buildings	**< 15**
Zero energy buildings	**0**

Table1.2: Typical energetic needs of heating for residential buildings. Source: slides of Professor De Carli M. (2016), Course Energy and Sustainability in the XXI Century, put in place by Padova University in collaboration with UN-HESI.

A classification for sustainability

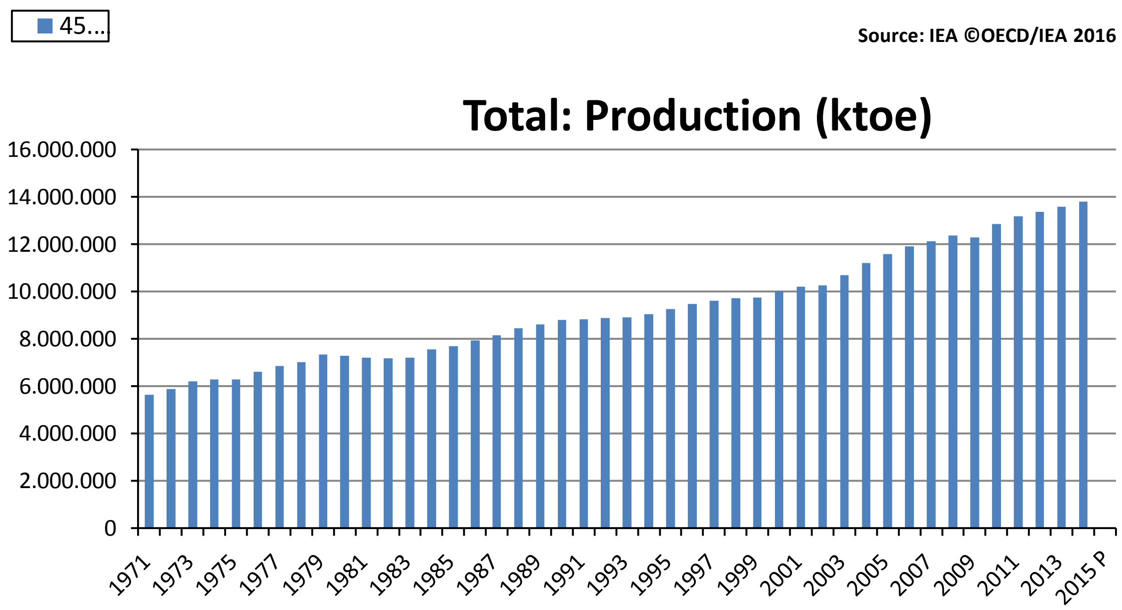
One more energy classification could be between renewable energy sources and non-renewable one. Respectively the renewables, supply energy that is able to be regenerated continuously and the non-renewables that are exploited are considered finished (or that would take millions of years to be reintegrated).

Examples of renewable sources are secondary energy related to the following sources: the sun, the wind, the water, the tides, the heating from the earth, biomass (with the exception of giving attention to the possibility of regeneration).

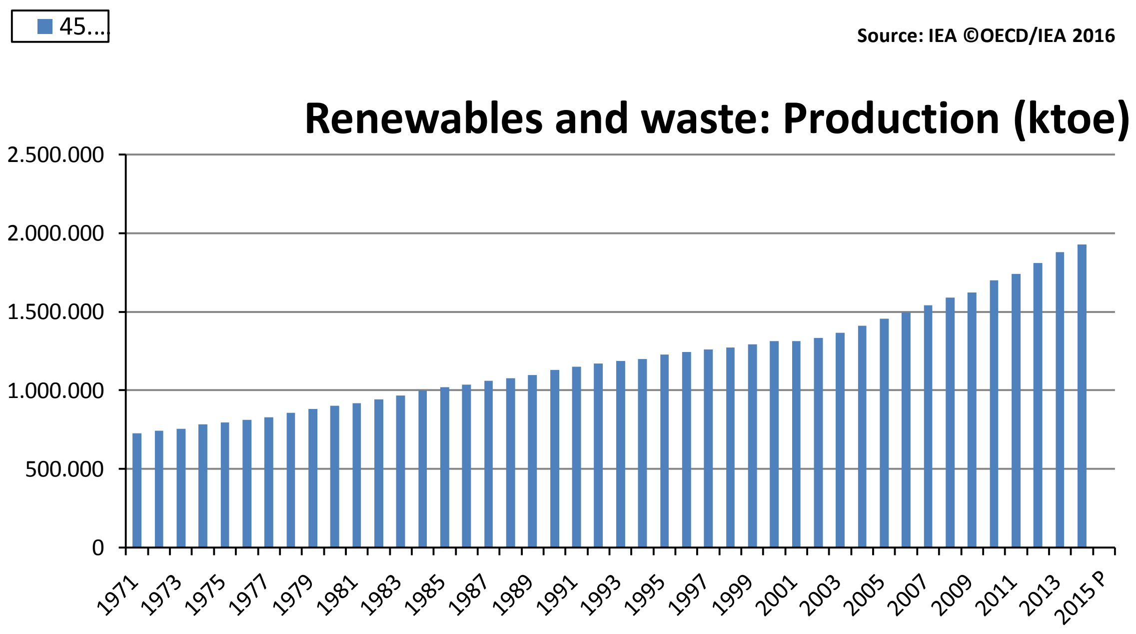
Contrastingly, examples of non-renewable sources come from the following: fossil fuels like oil, carbon, natural gas, and uranium.

Comparing different sources

Now, we can have a look into understanding among which sources distribute all the energy produced at a worldwide level. In 2014, around 14% of energy came from renewable sources, the rest came from fossil fuels, with a contribution of 4.8% from nuclear source, (IEA - Key World Energy Statistics 2016). Below, some graphs supplied by IEA. Graph1.1 shows us the worldwide production of energy. Graph1.2 shows us the part of energy produced by renewable sources.



Graph1.1: total production of energy from 1971 to 2014. Source: IEA.



Graph1.2: energy production from renewable from 1971 to 2014. Source: IEA.

When we speak about several energy sources, to obtain comparable measurements, statistics refer to units of measure that are unique: TOE (as we can see from the above graphs). Let's see what it is.

We know that the barrel is used like a measuring unit for oil, the ton for carbon and oil too, the cubic metre for gas, while the litre is used for gasoline. But to make a comparison between all these different measurements we need to take a common unit based in terms of energetic content or heat.

At a worldwide level the kilo-calorie (Kcal) is the unit of measurement of heat, like the BTU (British Thermal Unit). But because oil is the biggest source of energy at a worldwide level, the main measurement that normally prevails over all is the TOE, namely the Ton of Oil Equivalent (or KiloTOE, as adopted on the Graphs above).

The TOE represents the amount of heat one can obtain fron a ton of oil (petroleum).

The following equivalences are normally recognized:

1 Kcal = 4.186 J = 1.16 x 10-3 kWh = 1x10-7 TOE

So, to evaluate the equivalences in TOE of gas or carbon we need to know the calories. We know that 1 Ton of oil generates 10 million kcals, while one Ton of fossil carbon generates 7 million kcals. This means that:

1 TOE = about 1.43 Tons of fossil carbon

This example makes clear that with less tons of oil we can get the same energy (kCal) of carbon, so oil is a more efficient fuel compared to carbon!

To give another example, 1TOE is equal to 4Ton of vegetal fuel, because vegetal fuel contains 2.5millions kcal for each ton of material.

In this other case, the vegetal fuel is less efficient than carbon.

In the end, we learn that knowing the calories of the several energy sources, the TOE's are easily found, but also we can classify the energy sources by the kCalories per weight unit. This is important if we consider that pollution is proportional to the weight of material used.

If we consider the energy in a domestic context we'll speak about kWh per year (kilo-Watt-hour-year). The kWh is used for the measurement of electrical power per time unit.

However it is also used for general measurements in domestic environment: we need to think of the energy classification of buildings, as we have seen. In fact we don't speak about cubic metres of gas necessary per year for the heating of house but, instead, of kWh per year/sq.m necessary to obtain sufficient comfort.

The importance of energy

Adopting, for a while, a historical perspective, if we consider the different industrial revolutions, we find it coherent to re-think them as energetic revolutions.

We could identify three specific periods:

- Between the period of 1760-1780 and 1830 where the steam machine upset the textile and metallurgic sectors
- From 1870-1880 an on with the introduction of energy and oil
- From after the second world war with the introduction of electronics and information technology

From an energy perspective we can state the industrial revolutions took new forms of more concentrated energy, that we could store and transport in a different way.

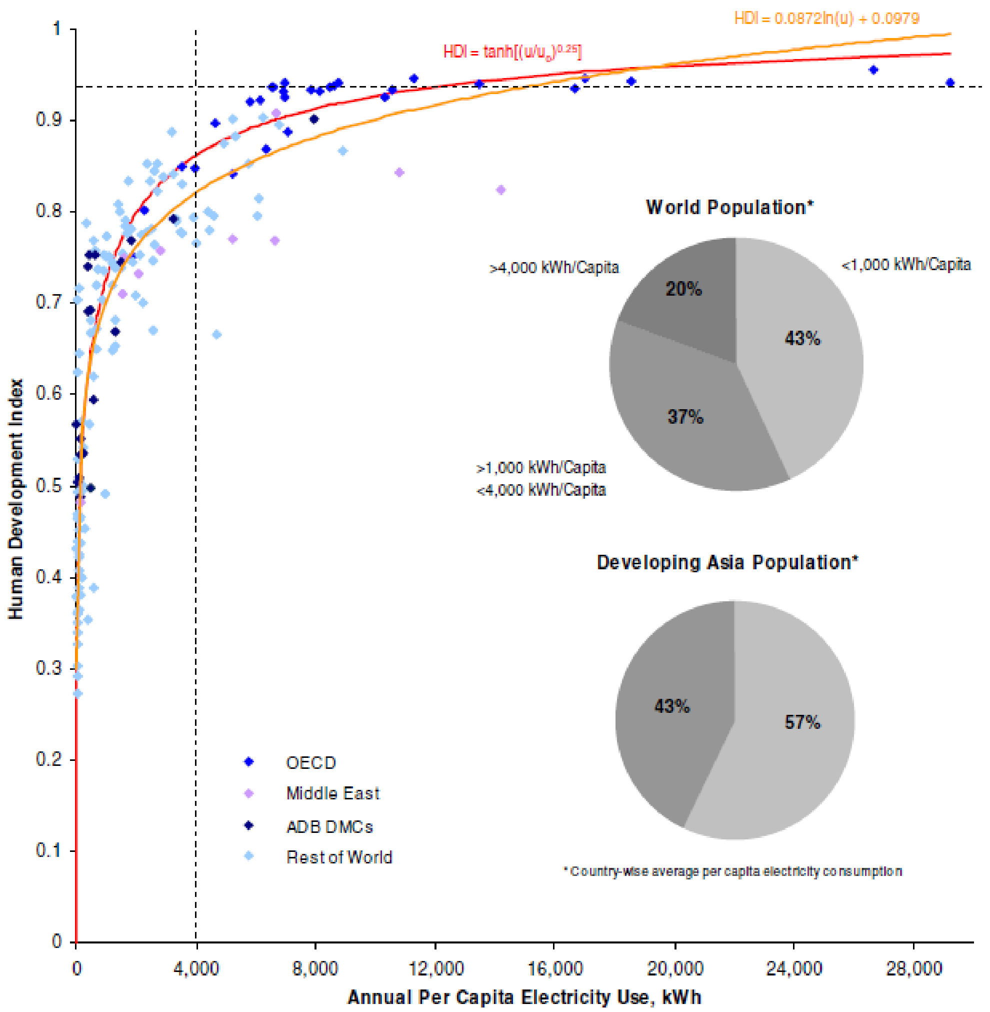
These changes took with them an increase of work productivity, which at the same time lowered costs of transportation and transitions.

This interested not only the technological side of the development with a direct impact on industrial and agricultural environment, but also from a social point of view, of health and well-being (intended as life extension and diminishing premature death), of education, of opportunity of employment and generation of income. The connection of Community to the economy and commerce has been, and is today more evident, among the consequences.

Masud et Al. (2007), in Energy for All promoted by ADB, shows that the energy consumption per head in technologically advanced countries is hundreds of times higher than in developing countries. Empirically the comparison with the HDI, (Human Development Index), established by the United Nations, is absolutely unrelated to the statistics on energy. Results are strongly correlated with the annual use of electricity per head.

Graph1.3 shows the HDI (Human Development Index) versus the use of electricity by country.

The HDI takes into consideration life expectation, education and the standard of life (through the income by person). It's estimated that a minimum quantity of 4000kWh/person is required to obtain a decent level of human development marked by the HDI, Masud et Al. (2007).



ADB = Asian Development Bank; DMC = developing member country; HDI = human development index; kWh = kilowatt-hour; OECD = Organisation for Economic Co-operation and Development.

Graph1.3: Human Development Index vs. use of electricity by country. Source: Masud et Al. (2007).

Of note is that this energetic development during the history of the most advanced countries (but also in developing countries), didn't miss leaving negative effects: both in terms of unequal distribution and in terms of the degree of pollution.

The point of view of developing economics

The just discussed correlation with the humand development index, (HDI), should be sufficient to understand the importance of energy. Nevertheless meaningful is the central aspect of development economics: the sustainability.

The term “sustainability” helps us in the understanding of Energy Poverty.

In the chapter 7 of “Economia dello Sviluppo”, on page 51, D’Antonio, Flora, Scarlato, speak about *“sustainable development as a tendency of the economic growth to self-supply, under different aspects: institutional sustainability… social sustainability… environment sustainability”.*

We know that institutional sustainability is correlated at the role that the institutions cover, while social sustainability is more connected to the question of redistribution of the wealth, where, instead, environmental sustainability concerns the opportunities and the restrictions on the exploitation of resources.

These three different aspects related to energy, become the focus of our discussion, and are recalled from the World Energy Council.

The World Energy Council (WEC), created in 1923, and based in London, is considered the main network of leaders and experts that offers to promote an energy system that has to be affordable (in terms of access), stable and that takes in consideration the environment for the best benefit of all. Recognized by the United Nations, it has the aim of encouraging policies in the energy area of interest.

The WEC defines the energy trilemma as the simultaneous pursuing of electric certainty, of environmental sustainability and of social equal access to energy.

WEC is oriented to the definition of policies and for electric certainty, the capability of the supplier and of the energy infrastructures, is also intended to satisfy the current and the future demand of a Country (Faiella, Lavecchia, 2014). This last trilemma corresponds, contextualizing everything into a vision where energy is central to the economic process, exactly to the three principles of development economics cited previously.

In the end, we can add that in “Verso la definizione e la misurazione dei concetti di affordability nei servizi elettrici” Miniaci, Scarpa e Valbonesi, speak about sustainability from the point of view of: the expenditure of the households, (the social dimension), and of the access of the electric energy consumption and gas throughout the definition of opportune policies (the institutional dimension).

The political economy side

From the perspective of the political economy we could state that the energy has the characteristics of a commons described in Mattei (2011) in his “Beni Comuni un manifesto”. Mattei (2011) states the necessity of an ecological dimension where a community structured and organized is in equilibrium: in harmony it is able to satisfy the common needs. This is a society oriented on the “being” instead of the “having”. In this way Mattei speaks about a third way to manage the commons with the necessary creation of a third space of Right based on Commons, today occupied entirely from either the Private Right or the Public Right.

On the same view, Farley et Al., 2014, in their Ecological Economics paper, state where the public administration fail and where the private sector fail, another way is necessary: “the commons refers to resources collectively owned by all and managed by mutual agreement” (Farley et Al., 2014).

But theoretical evidence of a possible failure of the private sector is supplied from Professor Arturo Lorenzoni, the current political Mayor of the City of Padova, and responsible for the Course of Energy and Sustainability in the XXI Century, put in place by Padova University in collaboration with UN-HESI.

Professor Lorenzoni (2016) states the impossibility of Coase theorem to find the optimum point when in presence of the commons (example of more subjects involved). More in general, the Rights that determine the sense of justice cannot undergo the need of economic efficiency so appreciated from the Chicago school (Mattei, 2011).

But the Private sector hasn’t encountered only theoretic failures.

Chester and Morris (2011) have demonstrated, with effective data, the energy-impoverished population of Australia, seen as an exemplar of electricity sector liberalisation. Moreover they posit that new forms of energy poverty are rising from the privatisation of the energy sector in general.

Less evidences of failure come from the Public sector: some, the most polarized, criticize its lack of flexibility which leads to inefficiency, so they push for a market-like behaviour of the institutions. This often means mechanism like taxation and marketable propriety right. So the most of times we assist to fails on implementing policies due to lobbies connected to the private sector (Farley et Al., 2014).

Farley et Al., (2014), propose the institution of a Common Asset Trust based on principle of sustainability, justice and efficiency.

A possible third way, theorized by Mattei, to fulfil the minimum necessary basket of needs for the commons.

Supply and Demand of Energy

It’s worth, in the end, saying a few words about the structure of the supply and demand of energy.

From the demand side, several authors report a demand of energy almost inelastic to the price. An example is Faiella-Lavecchia, (2014) in “La Povertà Energetica in Italia”, page 15, where they derive the consideration that, because demand is inelastic, valuating the price variation dynamic for energy expenditure and/or households income, the incidence measured as the ratio of expenditure over income could be an interesting indicator. But we will look at this discussion later in speaking about indices.

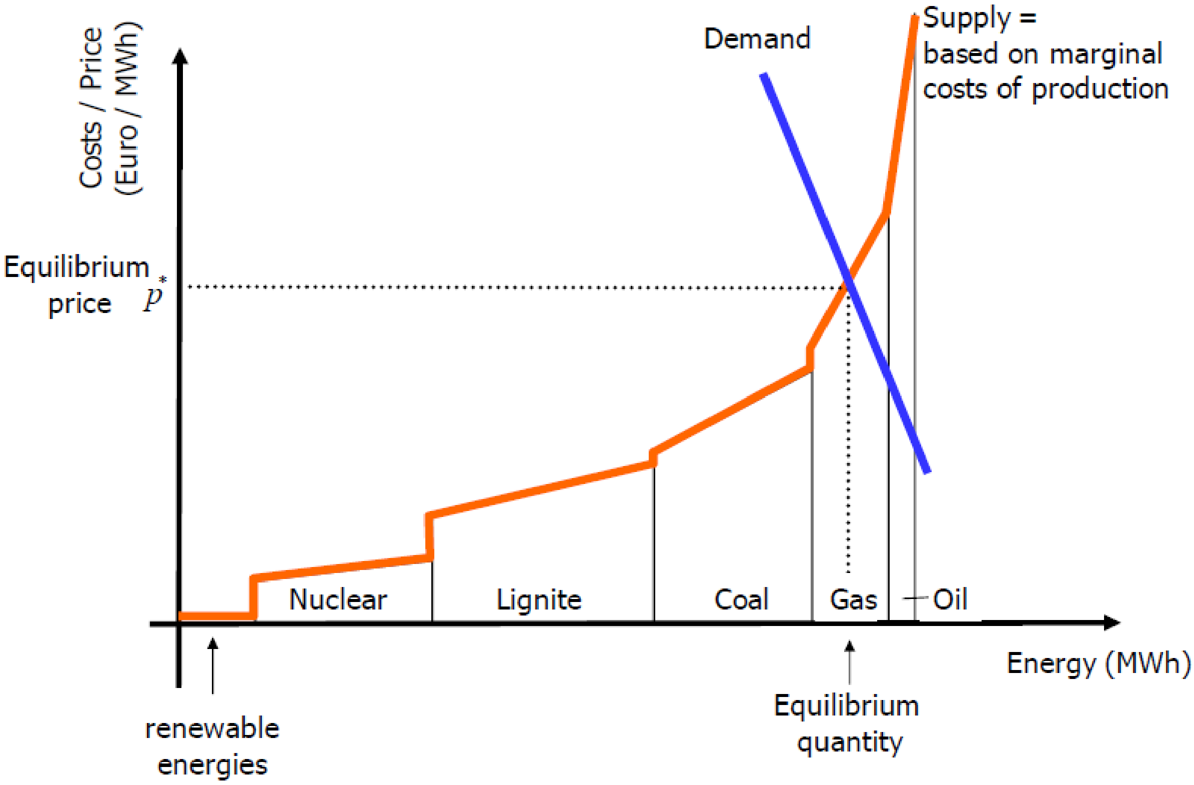
Instead another example is the interesting study coming from a Korean University about electric energy, that concludes:

<<based on the bivariate model, the price and income elasticities were estimated to be -0.2463 and 0.0593, respectively, implying that household electricity demand in Seoul is price- and income-inelastic.>> Yoo et Al. (2007)

So not only a demand of energy inelastic to price but also to income.

One additional piece of supporting evidence to the fact that demand (in this case gas and electrical energy) is almost inelastic to income and to price is supplied by Jamasb T., Meier H., (2010) in their Report that looks at Great Britain valuating the elasticity for 5 different groups divided by income (quintiles).

From the supply side, we find, in general, what is defined as “Merit-Order-Effect”, namely the ways which the different supplies of energy are disposed on the market. Generically based on the costs of the energy supplied and, more specifically, on the marginal cost of production. So we can assist the substitution effect of the energy produced from systems at lower costs to the detriment of that produced at higher costs. The below Graph 1.4 shows (in orange) the curve of electrical energy supply based on marginal costs of production by different sources of production.



Graph1.4: in orange color the electric energy supply curve based on marginal costs of production by different sources of production. Source: Bode S., Groscurth H.-M., (2010).

We can observe, how on the right side of the graph there are the fuel sources of electric energy power station which are more costly, and on the left side are the cheaper ones. However these costs are based on production, but don't take into account environmental damage as a direct consequence of more CO_2 emissions into the atmosphere, or in terms of weak radiation spread into the environment as in the case of nuclear plants or deposits, or indeed the costs of maintaining safe places to store the refuse from nuclear plants forever.

Note, shown in blue, the almost inelastic demand.

CHAPTER 2

Energy Poverty

Energy Poverty

To get the full understanding about the meaning of Energy Poverty (EP), necessarily we have to clarify the meaning of Poverty, and to include on the EP the explicative concepts of Energy Ladder and Energy Equity.

Poverty

In the introduction of “Debates on the measurement of global poverty”, Anand S., Segal P., Stiglitz J. E., (2009), begin from the definition of poverty throughout a threshold on the monetary income per head (the income poverty line) established from the World Bank being of 1$PPP per day at the prices in 1985, but on which more authors make adjustments that are different among them. From here, Anand, Segal, and Stiglitz recall the Srinivasan reasoning, which affirms that poverty should be a multi-dimensional concept and if we would necessarily consider it in monetary terms it should be defined uniquely at national level as a basket of basic need and specific services of each Country.

The United Nations, speaking about Poverty, in their Human Development Report del 2010, write:

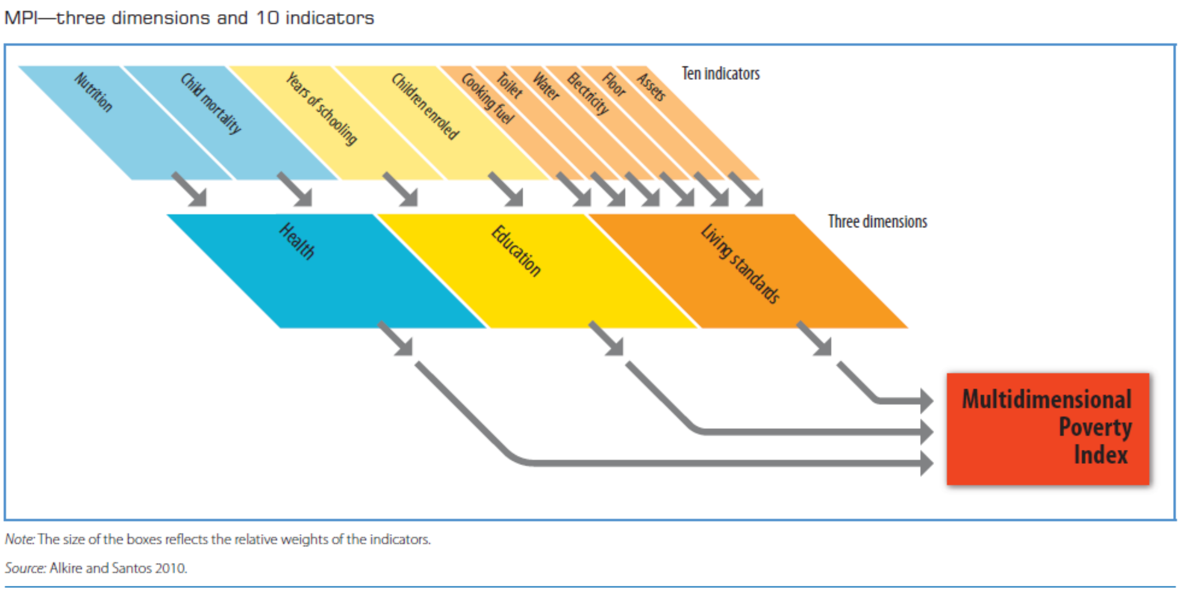
<<A focus on deprivation is fundamental to human development. The dimensions of poverty go far beyond inadequate income—to poor health and nutrition, low education and skills, inadequate livelihoods, bad housing conditions, social exclusion and lack of participation.

... poverty is multifaceted and thus multidimensional. Money-based measures are obviously important, but deprivations in other dimensions and their overlap also need to be considered, especially because households facing multiple deprivations are likely to be in worse situations than income poverty measures suggest.>>

Source: Human Development Report, (2010), page 104.

The multi-dimensions of poverty

In the Human Development Report of 2010 cited above, contains the following Graph2.1 elaborated from Alkire and Santos, where they show the determinants of the Multi-dimensional Poverty Index (MPI). Poverty is shown as a multi-dimensional concept. Today this multi-dimensionality is largely recognized; we will see more in detail this Graph 2.1 later.



Graph 2.1: determinants of the MPI elaborated from Alkire S., Santos M. (2010).

Absolute and Relative Poverty

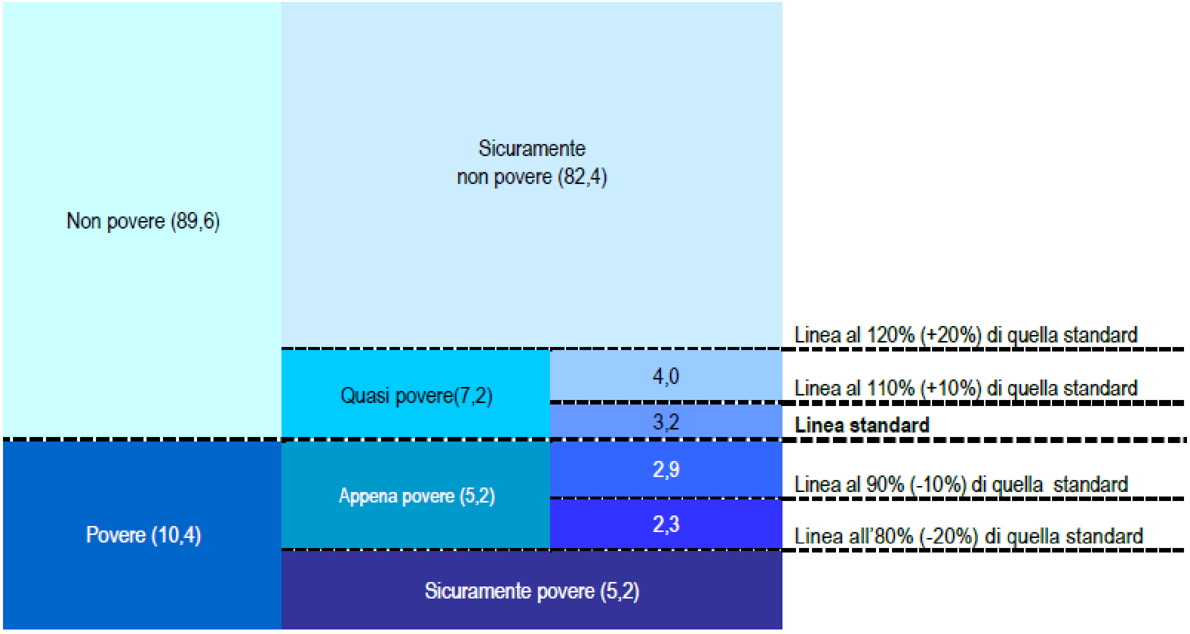
ISTAT with the Survey on Italian Household Consumption (ICF, Indagine sui Consumi delle Famiglie), describe Poverty distinguishing between Absolute Poverty and Relative Poverty: <<The survey represents, moreover, the informative base for the official estimations of Relative and Absolute Poverty in Italy, thank you also to the contribution of the Commission of Investigation on Social Exclusion (Commissione di indagine sull'esclusione sociale, Cies). The measure of Relative Poverty identifies the disadvantaging condition for some subjects (household or individuals) compared to others and refer more to the concept of inequality. The measure of Absolute Poverty instead is based on the definition of a minimum basket of goods and services necessary to satisfy a set of essential needs and so is defined as the inability to acquire goods and services that permit one to reach a standard of life considered the "minimum acceptable" on the reference context>> (Source: ISTAT website, our translation).

Since 2014 ICF is not available anymore and in accordance with Eurostat, has been operating a harmonization so that a survey is conducted on the expenditure of a household on specific harmonized expense items, (through COICOP, namely a Classification of Individual COnsumption by Purpose). This has the aim of getting a comparison between European Countries.

The COICOP survey is important because ISTAT establishes Relative Poverty taking the threshold International Standard of Poverty Line (ISPL) defined as: poor, is <<household of two components with an expenditure for consumption either lower or equal to the average

consumption per capita>> (ISTAT website, our translation).

In the following Graph 2.2, supply by ISTAT, we can see how the distinction from poor households and non-poor households, done by the ISPL (international standard poverty line), but we also see additional groups of households classified, identified by the distance of their expenses from the poverty threshold.



Graph 2.2: poor households and non-poor households, distinction done by different lines with respect to the standard poverty line. Source: ISTAT, (2015b).

Contrastingly, Eurostat define the people at risk-of-poverty: <<At risk-of-poverty are persons with an equivalised disposable income below the risk-of-poverty threshold, which is set at 60% of the national median equivalised disposable income (after social transfers).>> (Eurostat website)*[1].

But there are also other differences, for ISTAT <<to define the threshold of Relative Poverty for household of different sizes, corrective coefficients are used (Carbonaro equivalising scale) that take in account different needs and economies/dis-economies of scale which is possible to realize, despite the variability of the components of the family. To summarize, the information on several aspects of poverty (diffusion, gravity) two indices are calculated: the first is the proportion of poor (incidence), namely the ratio between the household (or individuals) in condition of poverty and the number of households (or individual) resident; the second is the gap mean (intensity), that measure 'how much the poor are poor', namely,

*[1] The European target is based on this threshold established by EUROPE2020 (see Eurostat website) and consider people at risk-of-poverty or social exclusion (AROPE).

how much, in percentage terms, the mean of monthly expenditure of the poor household is below the poverty line>> (Source: ISTAT website, our translation). These last indices can be defined as gap indices, we will see later on just how.

It's opportune, to point out that Carbonaro's equivalising scale (Carbonaro, 1985) born as coefficients which act to correct and make comparable income and expenditure among households of different size. Carbonaro's Scale follows the law of Engel (1895) and expresses the changing amount of expense of an household in order that in case of a variation of a component, the ratio between the expense for food and the total expense remains constant. But, others use different scales, an example is the OECD (1982), which consider not only the components of a family but also the distribution of ages. So, we can say that the OECD (1982) acts with families of different sizes and composition. Later, in chapter 3, we will see that we will choose a unique scale to get the indices comparable at international level.

Energy Poverty and the Energy Ladder

Back to the Graph 2.1, we can note how two out of ten indicators, referring to the living standard, are connected directly to the energy, in detail: electricity and cooking fuel. It's clear that Energy Poverty, like even Poverty, both, derive from a multi-dimensional concept.

Is not chance that the United Nations adopt a definition of Energy Poverty (EP) that capture these two last dimensions. UNPD defined It as the "inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset" (Gaye, 2007/2008).

The Asian Bank, enlarged this vision without conflicting it, with respect to the United Nations, and defined the EP as "the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development." (Reddy and Reddy, 1994, in Masud, Sharan, Lohani, 2007). This last sentence takes us directly to the definition of the *Energy Ladder*, because when we speak about "absence of sufficient choice" we are saying that some people, normally the poorest, rely on proportionally cheaper energy carriers. In this sense those richer will be able proportionally to get access to energy carriers of quality and in a quantity to get a better living condition.

<<Households use fuel for a variety of activities, including cooking, water heating, lighting, and space heating. Different energy carriers can be used for each of these activities. For instance, firewood, dung, charcoal, coal, kerosene, electricity, and LPG can be used for cooking; and kerosene and electricity for lighting. These carriers (for a particular activity)

form what is commonly referred to as an ‘energy ladder’ for that activity. Each rung corresponds to the dominant (but not sole) fuel used by a particular income group, and different income groups use different fuels and occupy different rungs>> (Hosier and Dowd, 1987; Reddy and Reddy, 1994).

We can associate to different income groups, different Countries: from the poorest and less developed, to the richest and more developed. We can observe as the domestic energy services for several categories of Country can be disposed in a continuum coherently and logically from the energy carriers easier and cheaper to the more complex (also in terms of managing and distribution).

In Table 2.1, for instance, we find the Energy Ladder, organized horizontally, where the lower level is in the left side and is occupied by the lower income households, that use energy carriers sources like wood, biomass, charcoal but also agricultural residues and even, incredibly, dung to burn for cooking or heating, all low efficiency elements very polluting.

If we move toward the right side of Table 2.1, in a higher rung of the Energy Ladder, we find energy carriers that give us an higher living standard in terms of quality defined as less pollution and higher efficiency; e.g. kerosene is from three to five times more efficient to cooking (Sovacool B.K., 2012).

Energy service	Developing countries			Developed countries
	Low-income households	Middle-income households	High-income households	
Cooking	Wood (including wood chips, straw, shrubs, grasses, and bark), charcoal, agricultural residues, dung	Wood, agricultural residues, coal, kerosene, biogas	Wood, kerosene, biogas, liquefied petroleum gas, natural gas, electricity	Electricity, natural gas
Lighting	Candles, kerosene (sometimes none)	Kerosene, electricity	Electricity	Electricity
Space heating	Wood, agricultural residues, dung (often none)	Wood, agricultural residues	Wood, coal, electricity	Oil, natural gas, electricity
Other appliances	None	Electricity, batteries	Electricity	Electricity

Table 2.1: Energy Ladder based on domestic use of energy. Source: Halff et Al. (2014), Energy Poverty Global Challenges and Local Solution

From the Table 2.1 we show developed Countries use more energy carrier sources which are cleaner as electrical energy and natural gas.

Note, there is not a full agreement on literature about the Energy Ladder. Kroon- van der B., Brouwer R., Beukering-van P., (2011), state that energy ladder is a myth. They sustain that the Energy Ladder that show a transition of the energy carrier sources is not in realty so clear defined by discrete steps. It's understandable their position, having them the aim to research the policies to support the processes of energy transition. But, they assume, an extreme position. Moreover this question doesn't cover any interest from our side, and it doesn't damage the concept of development based on an evolution of the energy carriers and energy resources available connected to dynamics of social innovation.

The United Nations (2010), instead, have tried to establish a scale based on level of needs of energy measuring it by kWh or kOE (kilogram of Oil Equivalent) necessary. In Table 2.2, supplied by the United Nations Report of 2010, we show the classification by levels of needs. We see that to satisfy the basic needs are essential from 50 to 100kWh per person, that's equivalent to 50-100kg of Oil Equivalent (kOE); for productive use, instead, we move to, respectively, 500/1000kWh per year and 150kOE; and, in the end for an use that require more modern needs we get 2MWh and 250/450kOE per year, per person. This data is substantially equivalent to that in the threshold reported from the Asian Development Bank in the Graph 1.3, previously examined.

Level	Electricity use	kWh per person per year	Solid fuel use	Mobility	Kilograms of oil equivalent per person per year
Basic human needs	Lighting, health, education, communication	50 to 100	Significant	None, walking or bicycling	50 to 100
Productive uses	Agriculture, water pumping for irrigation, fertilizer, mechanized tilling, processing	500 to 1,000	Minimal	Mass transit, motorcycle, or scooter	150
Modern society needs	Domestic appliances, cooling, heating	2,000	Minimal	Private transportation	250 to 450

Source: UN 2010

Table 2.2: energy services and levels of access. Source: UN-Energy 2010

It's clear how there is difference between who has more and who has less in terms of quality of sources available but also in terms of the amount that are available.

REGIONI	Spesa media per famiglia (b)	Spesa totale per fonte energetica (composizioni percentuali)				
		Energia elettrica	Metano	Gasolio	Gpl	Legna o pellets (c)
Piemonte	1.821,6	27,9	57,6	5,4	5,2	3,9
Valle d'Aosta/Vallée d'Aoste	2.000,0	26,1	20,7	29,1	15,9	8,2
Liguria	1.505,4	30,3	56,9	4,6	4,9	3,3
Lombardia	1.823,4	29,6	62,9	3,8	1,5	2,3
Trentino-Alto Adige/Südtirol	1.673,2	30,9	38,5	18,5	4,9	7,2
Bolzano	*1.575,5*	*33,9*	*33,1*	*20,9*	*3,2*	*8,8*
Trento	*1.763,0*	*28,3*	*43,0*	*16,5*	*6,4*	*5,8*
Veneto	1.897,6	32,5	50,3	6,3	5,4	5,5
Friuli-Venezia Giulia	1.780,4	29,5	50,3	7,8	5,6	6,8
Emilia-Romagna	1.916,2	30,9	61,4	1,3	4,0	2,4
Toscana	1.666,8	34,5	50,4	4,6	4,9	5,7
Umbria	1.673,0	34,8	41,3	3,6	8,4	11,8
Marche	1.640,7	33,8	52,4	1,9	7,0	4,8
Lazio	1.391,2	39,8	47,1	2,7	6,0	4,5
Abruzzo	1.601,6	34,4	50,8	0,3	4,8	9,8
Molise	1.564,2	35,5	51,1	0,5	2,9	10,1
Campania	1.355,7	45,9	33,3	1,3	11,0	8,5
Puglia	1.401,3	42,2	47,9	2,4	4,5	3,1
Basilicata	1.503,0	34,3	45,1	2,1	5,8	12,8
Calabria	1.453,6	43,9	32,0	0,9	10,9	12,3
Sicilia	1.259,4	53,2	35,0	0,8	8,4	2,5
Sardegna	1.494,6	49,3	0,0	15,4	24,5	10,8
Nord-ovest	**1.789,9**	**29,1**	**60,4**	**4,6**	**3,0**	**2,9**
Nord-est	**1.872,4**	**31,4**	**53,8**	**5,4**	**4,8**	**4,5**
Centro	**1.527,0**	**36,8**	**48,4**	**3,3**	**5,9**	**5,5**
Mezzogiorno	**1.386,5**	**45,5**	**35,3**	**2,6**	**9,6**	**7,0**
ITALIA	**1.635,1**	**35,5**	**49,8**	**4,0**	**5,8**	**4,9**

Fonte: Istat, Indagine sui consumi energetici delle famiglie (R)
(a) I dati si riferiscono ai consumi degli ultimi dodici mesi.
(b) La spesa media per consumi energetici è calcolata dividendo la spesa totale delle famiglie per il numero di famiglie residenti in Italia.
(c) I dati si riferiscono alla totalità dei consumi di pellets e alla sola quota di consumi di legna derivanti dall'acquisto.

Table 2.3: average expenditure and total of the households by energy consumption by Regions, year 2013, monetary values are in euro currency. Source: Annuario Statistico Italiano 2015

From the ISTAT survey, taken from the Annuario Statistico 2015, in Table 2.3 are showed the average expenditures of energy by Italian Regions, sustained by households and the relate distribution of the energy expenditure in percentage among the several energy carrier sources. It's curious to note how, for instance, Region Valle d'Aosta, has the highest average expenditure per household (€2000) of Italy, and, at the same time, it makes use, with respect to the others Regions, of energy fuels lower positioned in the Energy Ladder, like wood (legno o pellets) and diesel (gasolio).

At the same way, we can highlight how Region Basilicata has an average energy expenditure per person of €1503, that is very high respect to the average of that Regions positioned in the south of Italy (Mezzogiorno) where the average expenditure per person is €1386.50. Also in this case, Basilicata Region makes an intensive use of biomass: wood (legna o pellets).

Energy inequality

<<Access to modern energy services is fundamental to fulfilling basic social needs, driving economic growth and fueling human development. This is because energy services have an effect on productivity, health, education, safe water and communication services.

Modern services such as electricity, natural gas, modern cooking fuel and mechanical power are necessary for improved health and education, better access to information and agricultural productivity.

There are wide variations between energy consumption of developed and developing countries, and between the rich and poor within countries, with attendant variations in human development. Furthermore, the way in which energy is generated, distributed and consumed affects the local, regional and global environment with serious implications for poor people's livelihood strategies and human development prospects.>>. (Gaye A., 2007/2008).

Energy is the engine of the development. At the same time richer can have the access to the more expensive, more efficient and cleaner energy carrier sources. This is the foundation and the reason of inequality between rich and poor. In this way the question of energy become a question of social justice. Justice is a question of put all in the condition to access to energy services, and possibly to put them in the condition to make a choice among these services.

CHAPTER 3

Indices

Indices

We have seen Energy Poverty (EP), like poverty, appears in its multi-dimensional aspect. Because of this multiple dimension there isn't a unique definition of EP that follow a specific logic. This is, also, evident from the recent report Rademaekers k. et Al, (2016), commissioned by the European Commission, which was unable to find a coherent logic. But this question emerges even from several countries of the European Union that have attempted to address the problem. The multidimensional nature of energy poverty (EP), however, doesn't have to distract us from the terms by which EP has to be measured.

So which is the possible index to capture energy poor households?

We talk about evolution of indicators of PE because, in history, a refining and developing methods, have always been imposed that most effectively and efficiently have led to a clearer phenomenological definition of events. We now have huge databases of data that refer to surveys which were unthinkable a while ago with traditional methods. The same indices have undergone a deep evolution so today they are able to convey a remarkable capacity of information.

In the literature, you normally distinguish between **subjective** and **objective** indicators. The former are representative of the perception that people have of themselves and of their own condition. Instead, we are more interested in the latter, the **objective** indicators, based on considerations to identify persons or social groups that find themselves in specific situations. Among the **objective** indicators, commonly, we discern between **absolute** and **relative** indicators.

From the chapter two, talking about poverty, we have considered the measure of absolute and relative poverty provided by ISTAT. Transposing that definition of ISTAT in terms of energy poverty, we can say that an index of energy poverty in relative terms refers to an index that measures individuals or families versus a set of other individuals or families in comparative terms: the principle that underlies the concept of inequality; while an absolute energy poverty index considers a minimum basket of essential energy goods and is compared with the basket of the subject considered to establish whether he does or doesn't have energy poverty status. Evaluating an essential minimum basket means aiming to determine a concept of an acceptable standard of living. Table 3.1 summarizes the two types of indices explained so far, but it adds others indices: the Headcount Index, the Gap Index, and the Intensity Index.

The Headcount Index, the Gap Index, and the Intensity Index

The Headcount Index and the Gap Index are like those taken into consideration by ISTAT with regard to Poverty (already seen in the Chapter two).

The Head-count Index and the Gap Index are indices that abstract themselves from absolute or relative measures. In detail the Head-count Index counts which is the incidence of the phenomenon with respect to the entire population. Contrastingly the Gap Index, generically, measures the gap distance regarding the threshold. This distance can be determined in absolute or relative terms.

In addition, it should be noted that a Gap Index could be an average of the distances or an average of the root of squared distances, to give coherence to the underlying concept of intensity that the index is meant to represent. The Gap Index give a sense of the “gravity” of the situation of the energy poor, in fact they build the average based on the whole population.

In opposition to the Gap index, the Intensity indices capture the average distance of only the subjects that are under the specific threshold. Such an index has not to be taken into account alone: in fact, if we assume that a family escape from energy poverty status, the intensity index averaging between those that are in the PE condition, may record an increase in PE when in reality it is not. This situation makes us say that the index is not monotonic. (Sen, 1976)*[1].

Alternatively if we analysed series of historical data to understand the average gravity of the event considered year-over-year, we would use a Gap index. In this way the monotonic property is respected and we avoid not understandable distorted conditions.

We want our indices be comparable over time, and at an international level, so, we will take into consideration more the Gap Indices than the Intensity Indices.

Indices	**Motivation underlying**
Head-count Index	Measure the Incidence
Gap Index	Measure of the gravity
Intensity Index	Measure the Intensity of the phenomenon but cannot be used alone in historic series or for comparison.
Relative Index	Inequality Concept
Absolute Index	Concept of minimum acceptable living standard

Table 3.1: Possible Indices and reasons underlying. Source: our elaboration.

*[1]: We have just realized that one’s desirable properties of an index is the monotonicity. Sen (1976) established the monotonic axiom at poverty level. Is possible translate that axiom to the Energy Poverty. Put it easy, Sen says, considering an individual that is below the poverty line, a reduction of its income, ceteris paribus, should increase the measure of the poverty.

Relative Indices

From the first paragraph of this chapter we know that these are relative indices which all have the reference threshold defined in comparative terms. An easy example of relative indexes came from the UK. The UK were, likely, the first country to consider the problem of energy poverty. In fact they have adopted and used for several years an index that considers a fuel poor household, one that would need to spend more than 10% of its income on energy. Substantially they consider the ratio between the energy expenses and the income when the 10% threshold is exceeded. That threshold was fixed over time but at the beginning was defined as double the median incidence of expenditure on energy (and for sure this is a relative threshold).

In this case, as Hills (2012) said, “it is fundamentally flawed because it misrepresent trends, and includes some household that are not low income”.

A fruitful example that made things clear was when the Financial Times (October 22-23, 2010) in an article titled “They are changing bulbs at Buckingham Palace, The Queen heads for fuel poverty as price rises nudge bills close to 10% of royal income”. And a poor Queen is something that makes us smile because it cannot be true!

Now, let’s go on to consider a relative index, proposed by Hills (2012), that we should better define as a composite index.

Professor Hills suggested to the UK Government the Low Income High Cost (LIHC) index.

We can find the LIHC index of Hills in Faiella-Lavecchia (2014) with the following formula:

$$\eta = \frac{1}{n}\sum_{i=1}^{n} w_i \left\{ I\left[s_{ie}^{eq} > P50_t(s_{ie}^{eq}) \right] * I\left[(y_i^{eq} - s_{ie}^{eq}) < y_j^* \right] \right\} \quad (3.1)$$

Where:

w_i = weight for the composition of the household

$P50_t(s_{ie}^{eq})$ = equivalent expenditure median: adjusted for household size and composition

s_{ie}^{eq} = equivalent expenditure of the i-th household

y_i^{eq} = Income equalized of the i-th household

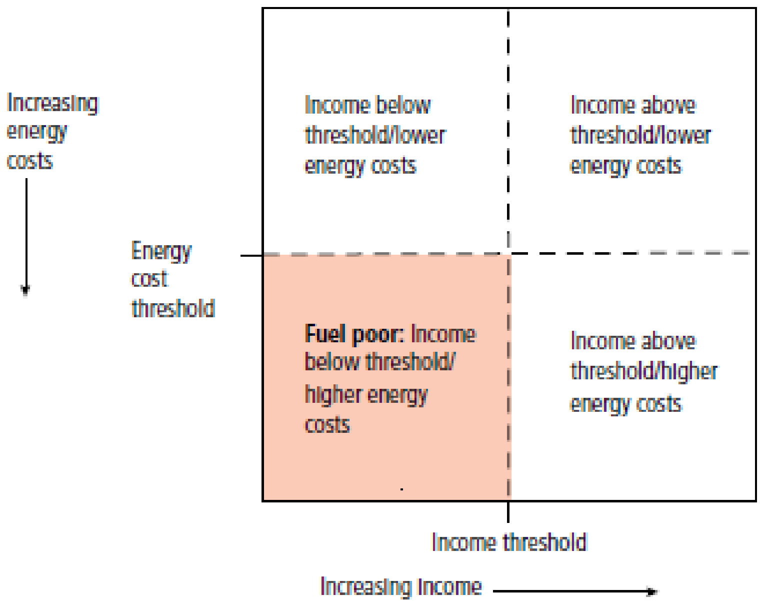
y_j^* = poverty line threshold as defined by Eurostat

The indicator function *I* returns either one, if the underlying condition is verified, or, in the opposite case, zero. In the specific case of 3.1 we have two indicator functions: the first one valuates that equivalent expense of energy of i-th household is higher than the median expenditure (P50), the second assesses that the i-th equivalent income after expenses (Y-S) will be lower than the poverty line as defined by Eurostat (the income threshold that locates a family in poverty, is at 60% of median of equivalent income).

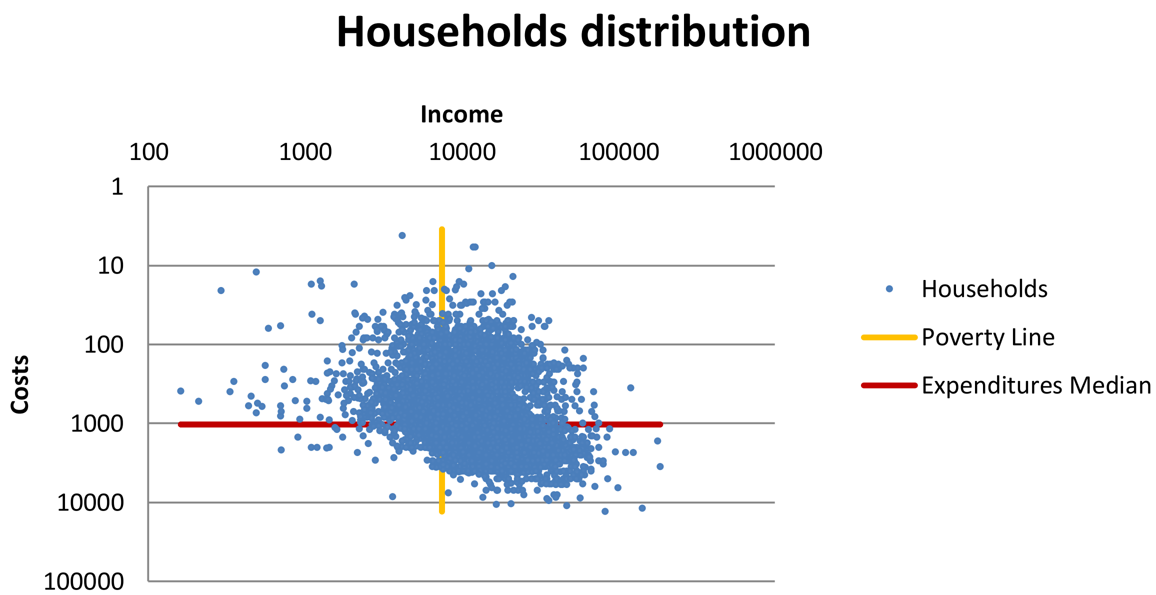
The index compares two absolute terms: the expense and the net income after expenses with two thresholds absolute per se, but, in fact, relative, respectively to the median expenditure and the poverty line defined by Eurostat. In essence the two thresholds compared are relative thresholds. So this index can be considered a relative index.

But it is of interest to observe the graphical example of the meaning of LIHC indicator showed in the Graphic 3.1a, takes from Hills (2012).

Even more interesting the Graphic 3.1b where we show data taken from Banca d'Italia (we will discuss later the HFCS dataset) some early "raw" results.



Graphic 3.1a: Graphical example of the meaning of LIHC indicator. Source: Hill J. (2012)



Graphic 3.1b: Graphical raw example of distribution of households in LIHC indicator with real data taken from Banca d'Italia (we will discuss later the HFCS dataset). Source: our elaboration.

We have defined the graphed data as "raw" results in Graphic 3.1b for at least two reasons: firstly we consider the adjustment of expenses or income, based on OECD's scale, we didn't follow the Hills equivalisation.

Secondly when Hills in Graphic 3.1a shows Income, actually he intends net income (after housing costs while Faiella excludes just the energy costs).

Especially for this last point we need to rise an important question: Hills make a comparison between a relative poverty line threshold, that can be seen as a minimum quantity of expenses for goods and services that a household needs to avoid the deprivation and social exclusion status (so here the costs for energy are included), and the net income, obtained from income after energy costs/housing costs. In our opinion there is no congruence on this comparison, so later we'll adjust this LIHC index opportunely.

Going back to discuss about the function proposed by Hills/Lavecchia et Al. with formula 3.1, we can note that the index, due to the first indicator function, doesn't include the low income households that have lower expenses on energy. This is in our opinion the biggest problem we see in the LIHC index.

Of the same opinion, Miniaci, Scarpa, Valbonesi (2014) speak about the LIHC index proposed by Hills, and "deviate from this definition in at least three directions: (i) we consider actual energy expenditure; (ii) we set the income threshold based on the absolute poverty approach rather than the relative one, as in the Minimum Income Standards (Hills, 2011); (iii) we consider consumption under the minimum standard as a possible source of deprivation".

In the end we believe it to be definitely incorrect not to include as energy poor the people or households with income below the Poverty Line (despite the fact they might or might not face lower energy costs).

Absolute Indices

As we stated just before, the absolute indices contain a comparison with a reference threshold that is based on a minimum basket of essential goods (that include all the expenses for consumption that a household needs to get a minimum decent quality of life).

The absolute index, we are going to treat, is based on the approach of the Residual Income.

As we have pointed out from the first chapter, we believe that the EP is linked to an issue of sustainability. From the definition of sustainability, which we fully agree with Miniaci, Scarpa, Valbonesi, we can state that it is a question of "Affordability – namely the sustainability of consumer spending on essential levels of utility – " (page 456, Miniaci, Scarpa, Valbonesi, 2014).

Considering the issue in terms of family budget, I would have trouble sustaining a dignified life with a certain basket of consumption if my energy basket was excessive in relation to a basket of minimum consumption: that is, if I see my energy costs are eroding resources they could be allocated to other consumption. Basically, from my income, I can allocate the economic resources for consumption, which can be divided into energy consumption and consumption for other goods, as necessary for energy (e.g. food, clothing etc.). So, we will have an energy basket and a consumption basket for others goods, when the energy basket erodes the consumption basket we speak about "public utility services induced poverty" (Stone 1993; Kutty 2005). Clearly when we talk about an energy basket we allude to the expenditure for utilities.

These expenditures for utilities for the specific household h is assembled by a specific quantity q_h^u multiplied by the price p_u.

Now, let's define the Residual Income as:

$$RI_h = x_h - p_u q_h^u \qquad (3.2)$$

Where:

x_h is the income of the household h, instead,

$p_u q_h^u$ is the expenditure for utilities of the household

But Residual income (income after consumption for utility), cannot be less than a basket of standard consumption ($p_c q^{pc}$) that allows a decent standard of living.

$$x_h - p_u q_h^u < p_c q^{pc} \qquad (3.3a)$$

Where:

x_h is the household income

$p_u q_h^u$ is the expenditure for utility of the household

$p_c q^{pc}$ is the minimum expenditure basket for consumption to get a decent standard of life

The formula 3.3a is exactly that one we find in Miniaci, Scarpa, Valbonesi (2014b, page 460). And from 3.3 we can have:

$$RI_h < p_c q^{pc} \qquad (3.3b)$$

Where:

RI_h is the Residual Income of the household

The Head-count Index is built on 3.3 through the indicator function:

$$I_h^u = 1(x_h - p_u q_h^u < p_c q^{pc}) \qquad (3.4)$$

This Indicator Function valuates the RI of the households (Income less Utility expenditures) when below the minimum consumption basket; valuating if the utility expenses erode the consumption basket.

So, the Head-count Index is based on the previous Indicator Function 3.4 and is:

$$H_u^{RI} = (\frac{1}{N})\sum_h I_h^u \qquad (3.5)$$

While the Gap-Index is:

$$PGI_u^{RI} = (\frac{1}{N})\sum_h I_h^u \times (p_c q^{pc} - p_c q_h^c) \qquad (3.6)$$

But Miniaci, Scarpa, Valbonesi (2014) also consider the Under-Consumption case taking into consideration an Indicator Function, I_h^c, that looks at the Residual Income obtained from income after household consumption compared with a basket of expenditure for the utility standard ($p_u q^{up}$):

$$I_h^c = 1(x_h - p_u q_h^c < p_u q^{up}) \qquad (3.7)$$

Where,

$p_u q_h^c$ is the expenditure for consumptions of the household

$p_u q^{up}$ is the minimum expenditure basket for utilities to get a decent standard of life

So, the Head-count Index is:

$$H_c^{RI} = (\frac{1}{N})\sum_h I_h^c \qquad (3.8)$$

Formulas 3.4 and 3.7 are the core of the index proposed by Miniaci, Scarpa, Valbonesi (2014b): they are able to capture people or household that are Under-Income (lower than a std. x_h) or Over-Consumption of utility (higher than a std. energy consumption basket), and Under-Consumption of utility (the need to make savings on energy).

In the end, they go to build a composite Head-count Index based on the previous I_h^u summed to I_h^c, so, the composite Head-count Index becomes:

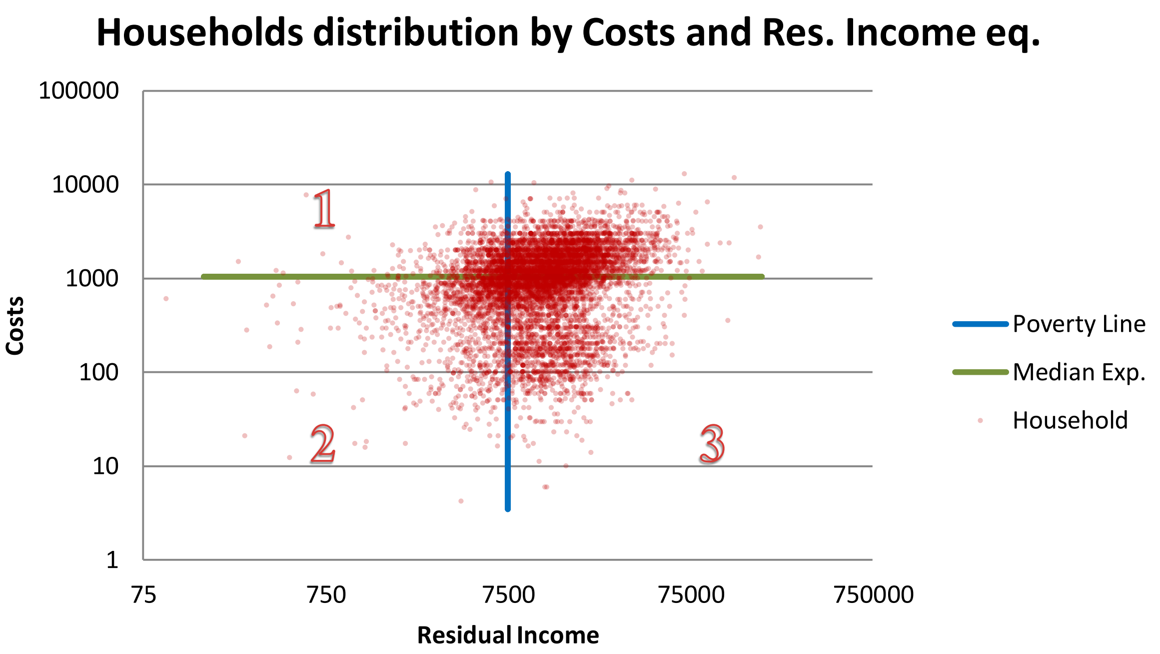
$$H^{RI} = \left[\sum_h I_h^u + I_h^c - I_h^u I_h^c\right] / N \qquad (3.9)$$

Despite its seductive appearance, the Under-Consumption condition in our opinion needs more investigation. For this reason we first need to understand the logic that drives our thinking: we’ll see later our static and dynamic framework.

A small comparison between indices

Let's go on to see in graphical terms the household captured by the Residual Income Index proposed by Miniaci, Scarpa, Valbonesi (2014b) compared with the LIHC indicator of Hills J. (2012).

In Graph 3.2 we have followed Miniaci, Scarpa, Valbonesi (2008, pag. 207) where they chart the absolute poverty line and the residual income approach: but we have used real data from the HFCS survey. So, we are going to show the household distribution by residual income and costs for utilities, namely the amount of utilities consumed in the y axis and the amount of other goods consumed (the residual income) on the x axis.



Graphic 3.2: Distributed households captured by the Residual Income Index proposed by Miniaci Scarpa, Valbonesi (2014b) roughly compared with the LIHC indicator of Hill J. (2012). Source: our elaboration.

If the scale of the axes of the Graph 3.2 would be linear (actually we set them in log.) we could place a line in the graph that represented the absolute poverty line*[2] ($x^p = p_u q^{pu} + p_c q^{pc}$) the sum of the minimum basket of utility and the minimum quantity of other consumption basket.

*[2]: the absolute poverty line (x^p) is supplied by Miniaci, Scarpa, Valbonesi (2008, pag. 201-202) where the minimum basket of utility ($p_u q^{pu}$) is described by the median of expenditures, and the minimum quantity of other consumption basket ($p_c q^{pc}$) is described by the poverty line.

Thanks to the value of the minimum basket of utilities (that's the median) and the minimum value of the basket of other consumption (we can define it as 60% of the median of the income) we can divide Graph 3.2 into several quadrants, we've enumerated three out of four.

The first represents the household captured from the LIHC index (with low costs and high income), while the households captured from the RI index of the Miniaci, Scarpa Valbonesi are in the first, second and third quadrants.

This graphical division by quadrant to explain the differences between the population captured is clearly approximate. In fact, we have to observe that Miniaci, Scarpa, Valbonesi (2014), consider the minimum basket of consumption at the level of the **absolute poverty line** calculated in coherence with ISTAT disposals. So, while Hills considers the **poverty line** based on Eurostat (60% of median of income of the household under survey and this is an absolute value but is based on a relative computation), Miniaci Scarpa, Valbonesi (2014b) take the absolute poverty line defined by ISTAT (2009).

We remember that ISTAT define the poverty line in two ways: as an absolute poverty line ISTAT (2009), and as a relative poverty line (that's, actually, the ISPL, International Standard Poverty Line, based on the average of consumption for a family of two components).

The Absolute Poverty Line, measures a specific basket of necessary goods. Included in this basket of necessary goods there are three main components: dietary, housing and residual (maintenance of house). Several items are important to underline: the main ones are the inclusion in the basket of electric energy, the heating, the replacement of fridge every 10 years, and of the washing machine every 15years.

The computation of this absolute poverty line is very critical: mainly for complexity.

Now, if we solve this question, and we would make a comparison between the two indices proposed, it could appear easy, because we just need to understand the difference between the relative threshold calculate by Hills for LIHC index and the Absolute Poverty Line of Miniaci, Scarpa, Valbonesi, based on ISTAT.

But, actually, Hills (2012) to establish the income threshold takes the standard poverty line (defined by Eurostat as 60% of median of income) after housing cost plus household modelled bill, adjusted for household size and composition. So the line has a slope evident from the following picture in Figure 3.3.

Moreover LIHC index, so calculated by Hills (2012), has used a non-standard scale of equivalence to adjust both costs of bills for household size and composition and to establish the income threshold (for the income and household modelled bill equivalisation).

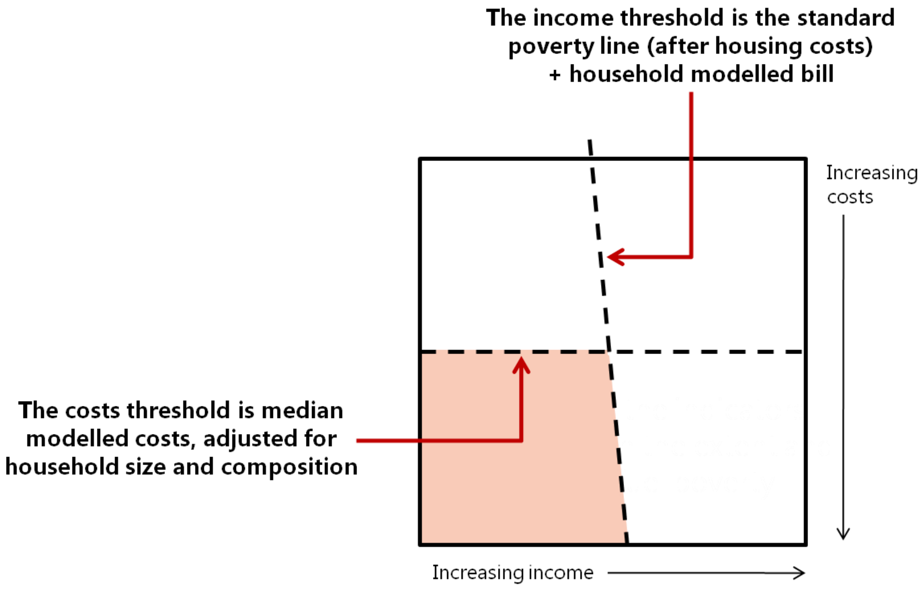


Figure 3.3: How threshold are set. Source: Hills J. (2012b)

The problem of equivalised income and costs without following an international standard doesn't give us the possibility to make a comparison between indices and among different countries.

Regarding the equivalising scales

The Miniaci, Scarpa, Valbonesi index, that is based on a comparison with the ISTAT absolute poverty line follows the indication of ISTAT based on the Carbonaro's scale of equivalence. Let's see in deep the differences using some international scale of equivalence. For instance, ISTAT, the famous Italian institute of statistics, uses Carbonaro's Scale (Table 3.2).

Members	Carbonaro Scale	
1	1.000	0.559
2	1.669	1.000
3	2.229	1.335
4	2.725	1.632
5	3.180	1.905
6	3.589	2.150
7 or more	4.008	2.401

Table 3.2: Carbonaro's scale for equivalisation

But we can look more in detail at other scales too. From the OECD website we can see the weight assigned by family composition in Tab. 3.3.

Household size	Equivalence scale				
	per-capita income	"Oxford" scale ("Old OECD scale")	"OECD-modified" scale	Square root scale	Household income
1 adult	1	1	1	1	1
2 adults	2	1.7	1.5	1.4	1
2 adults, 1 child	3	2.2	1.8	1.7	1
2 adults, 2 children	4	2.7	2.1	2.0	1
2 adults, 3 children	5	3.2	2.4	2.2	1
Elasticity[1]	1	0.73	0.53	0.50	0

Table 3.3: OECD equivalent scales. Source OECD website.

An interesting graphical view of the comparison between equivalising scales is reported in Figure 3.4. Important to note and consider, if not specify, are that the first two elements of the family are both adults, and all the rest are children (this consideration influences in particular the OECD scales that, in this last case, should increase their elasticity).

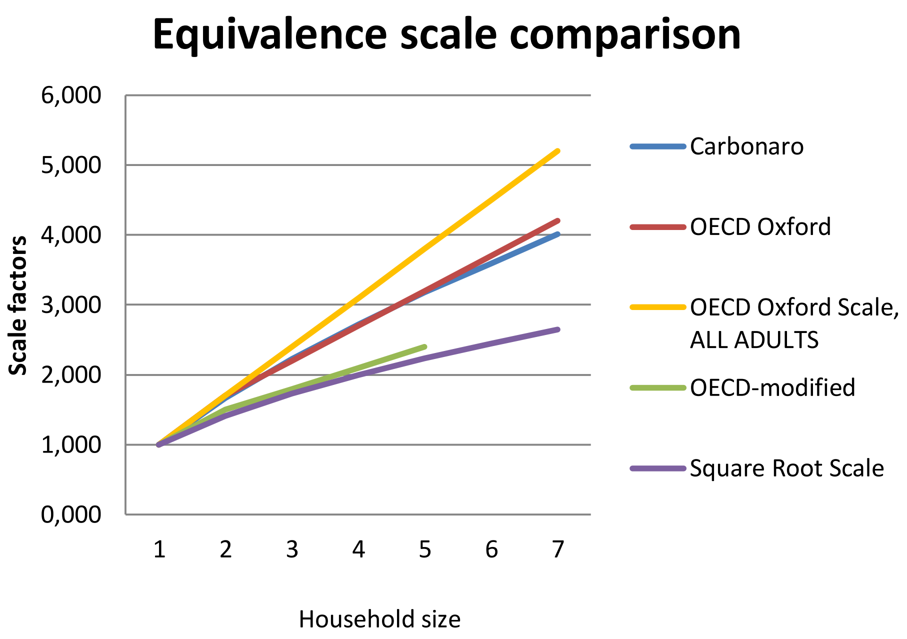


Figure 3.4: different equivalence scale comparison. Source: our elaboration.

We can add a couple of considerations to Figure 3.4. We have the maximum elasticity with the OECD Oxford's scale considering the family is composed of all adult elements. This is clearly unrealistic so the OECD Oxford is also the equivalence scale that is closer to Carbonaro's scale.

But what about the effects of using different equivalence scales? Again from the OECD

website we can find that “The choice of a particular equivalence scale depends on *technical assumptions* about economies of scale in consumption as well as on *value judgements* about the priority assigned to the needs of different individuals such as children or the elderly. These judgements will affect results. For example, the poverty rate of the elderly will be lower (and that of children higher) when using scales that give greater weight to each additional household member (Förster 1994). In selecting a particular equivalence scale, it is therefore important to be aware of its potential effect on the level of inequality and poverty, on the size of the poor population and its composition, and on the ranking of countries. Sensitivity analyses suggest that while the level and, in particular, the composition of income poverty are affected by the use of different equivalence scales, trends over time and rankings across countries are much less affected (Burniaux *et al.*, 1998).”
So, trying to choosing one scale of equivalence in the end we would prefer the OECD because it is standard, is very close to Carbonaro’s scale, and It has a higher elasticity than the others considering also a realistic family: so because of the higher value of the elasticity, the economies of scale for consumption are lower, and we believe this is the optimal scale. And anyway as Burniaux et al. (1998) said, trends and rankings across countries are less affected.

The intensity of Energy poverty

In the end, It’s worth saying a few words about the GAP Index expressed by Miniaci, Scarpa, Valbonesi, formula 3.6, we reconsider it here:

$$PGI_u^{RI} = (\frac{1}{N})\sum_h I_h^u \times (p_c q^{pc} - p_c q_h^c)$$

They measure the positive distance between a typical basket of consumption (they pick up the absolute poverty line) and the consumption of the household. The difference is positive because the indifference function, (I), is true. Clearly if we measure the value of the basket of goods in euros the *PGI* will be in euros too.
At the end, the meaning of dividing the sum of the all distances by N becomes an average expenditure to avoid an energy poverty situation.
But if we divide the PGI by the HI index we find the intensity of the poverty situation, namely how much the poor are poor.

$$Intensity = \frac{PGI}{HI} \qquad (3.10)$$

So the intensity represents the sum of all the distances from the threshold line divided by the number of families in an Energy Poverty condition.

CHAPTER 4

An Augmented Energy Poverty Index

Observations

We start, then, from our interpretation that, follows Miniaci, Scarpa, Valbonesi (2014) about the Residual Income (RI) approach.

This approach, derived from housing economics (Thalmann, 2003), and used by Miniaci, Scarpa, Valbonesi (2014), page 460, uses the RI where the sustainability of the expenditures is useful to identify a problem of affordability.

We then look at this definition and we build on it our own interpretation. So, re-taking the formula 3.3a, taken by Miniaci, Scarpa, Valbonesi (2014), (see the previous chapter):

$$x_h - p_u q_h^u < p_c q^{pc}$$

As we have seen before, we have the basket of consumption, $p_c q^{pc}$, to guarantee a level of decent living. But looking a bit more in, we believe that in this basket we have to include some future expenditures: to maintain and preserve the home, and, in general, to avoid the losses of efficiency of the home over time, if not by means, improve the quality of living. So, we say that we need to keep up our energy asset.

This is a need that permits us to update electrical appliances and avoid the ageing of the home and definitely to see compromised a living standard that potentially can fade over time.

But those expenses can be seen like a part of the savings that, we define, having the scope to maintain the energetic consumption at the right level necessary for a minimum living standard, avoiding the Energy Poverty Trap*[1].

So, we think that in the right side of the formula 3.3a, above cited, the part of **Savings for Energy** ($Risp_E$) is missing. This is a necessary condition to cover unexpected, possible, expenditure for energy. We need to cover the expenses to keep the house modern and continue to live maintaining a minimum level of dignity over time.

So, we deviate from Miniaci Scarpa Valbonesi (2014) for at least two questions.

As discussed just before:

1. WE NEED SOME SAVINGS FOR FUTURE ENERGY EXPENDITURE

to detect the affordability problems, we should consider the following instead of the previous formula 3.3a:

$$x_h - p_u q_h^u < p_c q^{pc} + Risp_E \qquad (4.1a)$$

And from the 3.2 we have:

$$RI_h < p_c q^{pc} + Risp_E \qquad (4.1b)$$

And for the reasons that we are going to explain:

2. **WE COMPARE THE RESIDUAL INCOME OF THE HOUSEHOLD WITH A STD RESIDUAL INCOME**

The basket of minimum consumption, $p_c q^{pc}$, is intended as the definition of the Poverty Line*[2]. Miniaci, Scarpa, Valbonesi (2014b), take the Absolute Poverty Line as defined by ISTAT , (from ICF as explained at page 470), equal to:

$$Poverty_{ths} \approx p_c q^{pc}$$

In fact the Absolute Poverty threshold is defined as the minimum basket of consumption that permits surviving decently. But, we have to be clear in mind that, on the Absolute Poverty Line, the expenses for utilities are included. So the $Poverty_{ths}$ is defined as:

$$Poverty_{ths} = p_c q^{pc} + p_c q^{up} \qquad (4.2)$$

Because of that we prefer to maintain a sort of coherence. We want to compare the Residual Income ($x_h - p_u q_h^u$) with the $Poverty_{ths}$ after the basket of utilities. So the 4.1a, considered the 4.2 becomes:

$$x_h - p_u q_h^u < Poverty_{ths} - p_c q^{up} + Risp_E \qquad (4.3a)$$

condition that become essential in our analysis.

*[1]: we'll explain later what we intend for Energy Poverty Trap. For now, we retain sufficient the intuitive meaning of a critical situation of high costs from which, one cannot escape without help.
*[2]: this is intended as the absolute poverty line defined by ISTAT and considered by MIniaci, Scarpa, Valbonesi (2014b), and it is the at-risk-poverty line defined by Eurostat that we find in Hills (2012) and Faiella-Lavecchia (2014).

And to put it more easier:

$$RI_h < Poverty_{ths} - p_c q^{up} + Risp_E \qquad (4.3b)$$

Where, we repeat:

RI_h is the Residual Income of the Household

$Poverty_{ths}$ is the minimum consumption basket defined by the Poverty Line

$p_c q^{up}$ is the minimum basket for utilities (standard)

$Risp_E$ are the Savings for updating the house to keep it efficient, speaking in energetic terms

The minimum energy basket which ensures the energy expenditure that allows a standard of decent life we will call with S_{STD} ($S_{STD} = p_c q^{up}$).

So, the 4.3b can be re-written as:

$$RI_h < Poverty_{ths} - S_{STD} + Risp_E \qquad (4.3c)$$

Moreover if we consider $Risp_E$ as an absolute amount to add the minimum Income Standard to guarantee a decent life for an household, we have:

$$Y_{STD} = Poverty_{ths} + Risp_E \qquad (4.4)$$

So we could define the Residual Income Standard as

$$RI_{STD} = Y_{STD} - S_{STD} \qquad (4.5)$$

so the condition 4.3c becomes:

$$RI_h < RI_{STD} \qquad (4.6)$$

We are aware, that writing 4.4, 4.5 and also 4.6, means we are supposing that the only savings we have, are the “savings for energy”. This is not realistic, but this is just a threshold. Doing that, we want to put on evidence how the savings are important to set a threshold over which we consider an household in Energy Poverty status.

Possible case of population: a static framework

Let's start considering six possible cases of families: A, B, C, D, E, and F, with their respective income Y_A, Y_B, Y_C, Y_D, Y_E, and Y_F, and each one with their respective expense for energy S_A, S_B, S_C, S_D, S_E, S_F.

Let's put in a graph, (Graphic 4.1), this six different family cases that we have identified as the keys of lecture of our analysis. In red are highlighted the expenses S_h as part of the income Y_h.

We could face in families' cases represented with the arrows from A to F and collected under one of these three specific situations: under-income, under-consumption and over-consumption (see Graph 4.1).

We have under-income when:

$$Y_h < Y_{STD} \qquad (4.7)$$

While we have under-consumption in the case:

$$S_h < S_{STD} \qquad (4.8)$$

Instead we have over-consumption when:

$$S_h > S_{STD} \qquad (4.9)$$

Where:

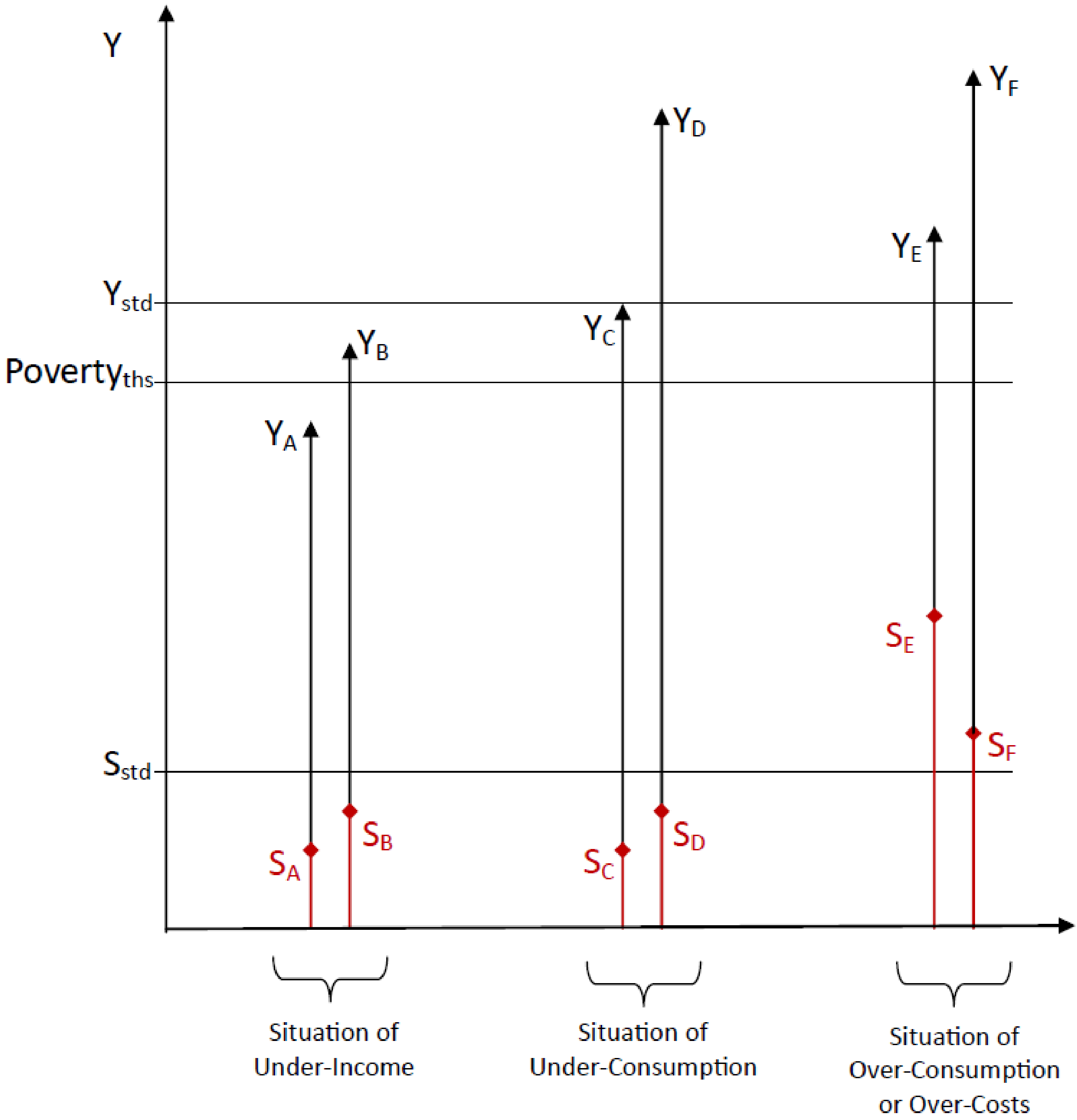
h is the *h-th* family/household under survey

From these cases, we have to distinguish between the families that are or are not in an Energy Poverty condition, giving some motivation to support our statements.

We are going to distinguish and explain the three cases considered.

Under-Income

Considering a situation of Under-Income as reported in Graph 4.1 with Y_A, we can state we are undoubtedly in a situation of Energy Poverty (EP) condition by definition: consumption is not sustainable: those who are under-income try to limit the expenses for energy. Because the energy demand is substantially inelastic, (see the end of chapter 1), these expenses weigh more on whoever has a lower income. In the long run the families with Under-Income could see these expenses increase over time finding themselves with no possibility of keeping down costs.



Graph 4.1: three distinct situations for the identification of the families' cases to identify the families in Energy Poverty. Source: our elaboration.

And this is valid also for Y_B, the families that are under this condition $Y_B > Poverty_{ths}$ because in the same way we have $Y_B<Y_{std}$. In fact, we consider the Poverty Threshold, ($Poverty_{ths}$), how the amount of the minimum consumption basket to permit a decent life (formula 4.2) and that includes the utility expenditures. But Y_{std} is higher than the Poverty Threshold because it includes the savings (formula 4.4) for future infrastructure updates, renewal of electrical appliances (with better efficiency), and the possibility of facing unexpected expenses for which their own living standard would be compromise. Being under Y_{STD} means in long run being unable to cover future expenditures for energy.

Under-Consumption

The Under-Consumption, without the condition of Under-Income, is a case where is difficult to define if we have a family in an initial difficulty, (e.g. in the case of Y_C), or a family that is interested to climb up the energy ladder (e.g. in the case of Y_D), improving their own assets, cutting thermal bridges in the building, and improving thermal dispersion or using off-grid sourcing like Thermal solar panels or Photo Voltaic solar panels. For these reasons, because we don't know the specific endowment of the household, we do not consider these cases as a possible case of EP condition.

Over-Consumption

Finally, the situation of the families in over-consumption. The cases Y_D and Y_F could look identical: both with elevated consumptions, both with high Income. But actually they are very different: to distinguish the two cases we need to consider the Residual Income of the Household *h*, that, from the 3.2, is:

$$RI_h = Y_h - S_h \quad (4.10)$$

In this last situation, of Over-Consumption, the evaluation of the Residual Income become essential. With the Residual Income we establish which household case (either E or F), is in the condition of Energy Poverty. In our graph the case E is considered in EP condition, in fact $RI_E < RI_{STD}$.

In Table 4.1 that follows, we put the several case we selected as meaningful and that withstand the situations made evident by Under-Income, Under-Consumption and Over-Consumption. Still in the Table 4.1, last column, right side, the evaluation of the Energy Poverty condition is reported, based on the criteria of Under Income and Residual Income RI_h: we are stating that the Residual Income (formula 4.6) is a condition necessary but not sufficient to explain (and to discover) a situation of Poverty Energy. So, to the Residual Income condition reported in 4.6 we need to add the condition:

$$\boldsymbol{Y_h < Y_{STD}} \quad (4.11)$$

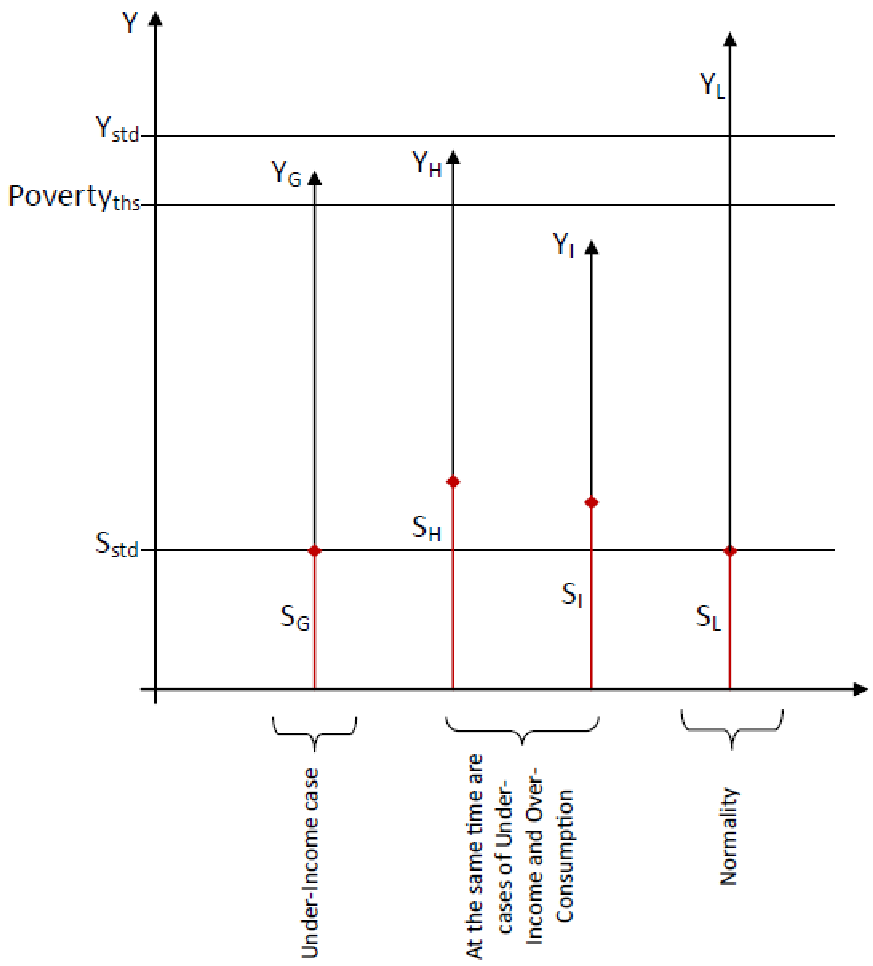
We have to be clear that making a union of the two conditions 4.11 and 4.6, respectively the Under-Income and the Residual Income condition, we need to exclude all the situations that overlap each other.

Described Situation	House-hold/ Case	Condition to identify the households that fall under the specific case	Plausible Explanation	Energy Poverty Household: $RI<RI_{STD}$ or $Y<Y_{STD}$
Under-Income $Y_X < Y_{std}$	A	$Y_A < Y_{std}$ $Y_A < Poverty_{ths}$	Since income is below the poverty line, we can only consider the case in Energy Poverty.	YES
	B	$Y_B < Y_{std}$ $Poverty_{ths} < Y_B < Y_{std}$	Since the income is lower than the standard income but above the poverty line, it is not said that in the short term they are in an Energy Poverty condition, but in the long run they will be for sure. And that also for prices that increase more than inflation.	YES
Under-consumption $S_X < S_{std}$	C	$S_C < S_{std}$ $Y_C = Y_{std}$	We have put together the cases of under-consumption because we have an income either higher or equal to Y_{std}, which denotes a family's ability to use savings ($Ystd\text{-}Poverty_{ths}$) to modernize electrical equipment or get a house with less thermal dispersion, or use different sources of self-production (solar or thermal panels). In fact we are facing a residual income higher than RI_{std}.	NO
	D	$S_D < S_{std}$ $Y_D > Y_{std}$		NO
Over-consumption $S_X > S_{std}$	E	$S_E > S_{std}$ $Y_E > Y_{std}$ $RI_E < RI_{std}$	Situation E would be identical to F if we did not distinguish it for the residual income RI_E. Family E is thus the poorest family of all the cases represented. It could be due to house which is not properly insulated. Old appliances are not so efficient. Energy costs are so high that it would not allow the modernization of the home. Typical examples are families in the mountains or rural areas (see Val d'Aosta Table 2.3) with a downward energy ladder.	YES
	F	$S_F > S_{std}$ $Y_F > Y_{std}$ $RI_F > RI_{std}$	The F family over-consumes, since $RI_F > RI_{std}$ is a matter of preferences.	NO

Table 4.1: plausible cases of households in possible Energy Poverty. Source: our elaboration.

But are the described cases the unique observable? Are the only that can be represented taking care of the population considered?

We had already stated that those were the most meaningful. Let's see some cases we left out from our analysis (Graph 4.2).



Graph 4.2: cases not considered. Source: our elaboration.

From the Graphic 4.2, if we look at the households under case G, these can be classified as situations of Under-Income, so they can be capture from the previous considerations ($Y_h < Y_{STD}$).

Concerning the cases of the households H and I however, we fall into a situation where we are at the same time in a Under-Income and Over-Consumption situation: these are the cases that the UK would define LIHC, (Low Income High Cost), where for Income, they also, specify being the Residual Income.

These situations are captured from the previous conditions anyway either from the Under-Income or, from the Residual Income (for this reason it is important not to count the households twice). But, especially if we want to capture separately the conditions of Under-Income and Over-Consumption, we should pay attention to the risk of summing them inopportunely.

In the end the case of the household under the case L. The L situation would be the normality, nothing to capture relating to Energy Poverty.

On the other hand, it's worth comparing the case of household E with the case of household D, (see Graph 4.1), the former with high costs, $S_E > S_{STD}$, and a good income (over the Y_{STD} threshold); the latter with much lower costs, $S_D < S_{STD}$, but still with a good income ($Y_D > Y_{STD}$). In these cases we see different levels of expenditure for energy. This is due to the access to new technologies that has given to some (case D) the possibility to isolate thermally their own homes or to buy new homes with a higher characteristic energetic class, that enables more savings and so, at the same time, better comfort with less costs. We need to remember that the energetic scale applied to the buildings has certified the possibility that whoever can own a well isolated new home can save up to 20-30 times compared to an old one.

And this is a gap that increases energetic inequality. To give an example of the meaning of a ratio of 1:20, we can imagine that for the same square-meters available in two households, ceteris paribus, can pay €150 of gas per year or €3000 (this is in fact the ratio 1:20).

In the same manner, strong capabilities of isolation in the buildings, add to the new technologies, that exploit the thermal energy and photovoltaic energy, (so that we can call it an off-grid system), for those who can afford the costs of plants, are guaranteed considerable energy savings, that sometime reduce the energy bill to zero! But the count to zero is something we need to look inside because this is a special case of a household that doesn't have any consumption.

If the family that has the expenditure S_0 null and the income is under the case Under-Income ($Y_0 < Y_{STD}$) we could conclude that the household has no access to energy sources, maybe because they live in rural zones, however, how should we consider the case if the household has an income higher than the Income standard (Y_{STD})?

If we follow the logic adopted so far, we should suppose that the household uses other energy sources like biomass (wood) or off-grid system. But the point is this: is it a question of preference and culture, or the household maybe forced from a real problem of accessibility?

Trilussa, the Roman poet, would suggest paying attention before stating that every man can eat his own chicken. We should evaluate the dimension of the phenomena and if limited, try to understand the coverage that we have and evaluate whether we consider It an error to add to our indicator, or something that needs more investigation.

A framework to explain the Energy Poverty Trap-Cycle

From the observations of the household cases shown in Graphic 4.1 and reported in Table 4.1, we can see the households that are in Energy Poverty condition. However, these cases are a static image: a picture done in a specific moment. To fully understand Energy Poverty we should clarify the dynamic terms: namely we need to understand the dynamics that take us to the trap of Energy Poverty. In our opinion, this is a sort of cycle composed of several phases that we are going to explain.

Reconsidering Graph 4.1, we define the following phases:

1- At the beginning we are in the condition of household, like Y_D, or also household with an income like Y_D but with expenditure for energy around the standard expenditure S_{std}.

2- It is possible that a component of the family either loses his job or his wage is reduced, e.g. because of an economic downturn. The household is forced, as much as possible*[1], to reduce the energy costs: we are in the situation represented by Y_C.

3- Considering crises that continue, several effects overlap each other:
on one hand the impossibility of regaining the income lost on the household, on the other hand the need for the energy suppliers to maintain sales (profits and quantities sold). Seeing lower consumption, energy suppliers need to increase prices. But in this way the expenditures for utilities will increase, while, at the same time, the income due to the inflation effect will be lower: we are drifting to the case Y_B.

4- In the long run, with the crises prolonged, from the case Y_B, the household is not able anymore to replace their own "energy asset", the electrical appliance are less efficient compared to the newer ones, the house could show thermal isolation losses and infiltrations so that it would need an update (e.g. with a coat system). We are in a situation where the expenditures for energy increases. We are in the Low Income High Cost (LIHC) situation. If the household regains its previous income, we'll have the income after costs, (the residual income), of the household insufficient to guarantee a good living standard and we are still in an Energy Poverty condition: a situation described by the case Y_E. We have fallen into what we call an Energy Poverty Trap: the household has recouped the income but the expenditure are so high that they don't allow for a Residual Income necessary to update their "energy asset".

*[1]: The expression "as much as possible" is referred to the fact we are aware to get an energy demand basically inelastic (see Chapter 1).

This raw dynamic framework, we call an Energy Poverty Trap Cycle, drives us to make some basic considerations:

- a possible index that valuates uniquely a situation of LIHC, (Low Income High Cost), is an index of Energy Poverty of long run;
- the LIHC index doesn't give us a complete dimensional indication about the households in energy poverty status;
- In the end, even if we didn't consider the cases of households in under-consumption status as energy poor, the Under-Consumption cases become important alarm bells. Difficult to distinguish, because we need to know the technological endowments of the household, the preferences, and the culture. But others difficulties are to discern an inelastic demand where the error can be even more meaningful (household is a problem to afford or is making savings?).

An Augmented Energy Poverty Index

Now, let's consider the desiderata characteristics for a Poverty Energy Index. It should:

1. Reflect the economic crisis
2. Be sensitive to the variation of demand on the extent of its elasticity
3. Being parsimony on parameters
4. Based on statistics comparable at a European level

Regarding the capability to reflect on the economic crisis, from a research point of view, the recent crisis of 2007 becomes a good occasion, with the effects we have seen from 2008 onward. Following our proposed framework, it's clear that an index that captures the effects of an Energy Poverty condition should be sensitive to the fade of the income, but also to an increase either of costs or the diminishing of consumptions (as happened in the years 2009-2010-2011 *[2]). On the contrary, for a long run index, a period of crisis will be underlined only when the subject or family will be in that which we call the Energy Poverty Trap, with high costs and low residual income (expressed by the LIHC index): so after a meaningful period of persistent crisis. But to explain the points 1 and 2 we should possess some historical data that covers the entire period: pre-crisis, crisis and post-crisis. Moreover for point 2 we need also historical data of the energy prices. Unfortunately the only database available, at European level, (requested from point 4), is the EU-SILC. But this is not supplied to students.

*[2]: see the MIniaci, Scarpa, Valbonesi (2014b) page 253.

We can only use the survey from HFCS, that Banca d'Italia (Central Bank of Italy) and European Central Bank has supplied to us.

The drawback is that these data don't have a real historic series. To satisfy point 4, we take into consideration the HFCS (namely Household Finance and Consumption Survey). To satisfy point 3 we need to consider the indices we have seen in the previous chapter.

Starting from the LIHC index: we retain that the LIHC proposed is affect from a conceptual error. In fact, the income after energy costs is the residual income, as we called it before, and this is compared with the poverty threshold, that despite the fact that it is defined in relative terms (60% of the median of the equivalent income), has the specific meaning of threshold where the basic needs for surviving are satisfied. But this includes also energy expenditure! We retain anyway that index of extreme interest because it gives us the sense of Energy Poverty in the long run. We proceed to redefine the head-count index based on LIHC, substituting the Poverty Threshold with the Residual Income Standard (RI_{STD}), for coherence reasons.

$$H_u^{LIHC} = (\frac{1}{N})\sum_h \{I[s_h > P50_t(s_h)] * I(RI_h < RI_{STD})\} \qquad (4.12)$$

Moreover we will adopt an international scale of equivalence: OECD Standard (Oxford), because of the elasticity is the higher we have among the scales considered before.

We report, also, the Energy Poverty Gap index (*EPGI*), namely the average on all the population of the specific gap related to the conditions of the Head Count Index.

$$EPGI_u^{LIHC} = (\frac{1}{N})\sum_h \{I[s_h > P50_t(s_h)] * I(RI_h < RI_{STD})\} \times (RI_{STD} - RI_h) \qquad (4.13)$$

Indices 4.12 and 4.13 are more quasi-relative indices than a pure relative indices. If we look at 4.12 the first indicator function compare the household costs with the median, instead the second indicator function compares Residual Income with the Residual Income Standard (RI_{STD}) that relates to the basket to have a decent life (defined with formulas 4.3c, 4.5).

While the Residual Income (RI_h) is defined by the formula 3.2, the Residual Income Standard (RI_{STD}) has been defined from 4.5. In turn, Y_{STD} has been defined from 4.4, while S_{STD} is the minimum basket to get a decent life , $p_c q^{pc}$.

The quasi-relative index reported in 4.12 become more coherent with the absolute index reported in Table 4.2 that looks at the Income and Residual Income (RI_h) that we assume able to capture better Energy Poverty in a comprehensive way. For our index, we are confident, it is able to capture the energy poverty in the short term as in the long run (the families in the Energy Trap, or to use terminology used for poverty: those who are chronically in poverty status).

Going on to consider our indices, we'll valuate two Indicator Functions. The first one looks at the Under-Income, situation reflected in Figure 4.1 with the cases A and B of our static framework (formula 4.11):

$$I_h^{UI} = 1(Y_h < Y_{STD}) \qquad (4.14)$$

The second one valuates the Over-Consumption and weight only in the case that the first one I_h^{UI} is not satisfied (formula 4.6):

$$I_h^{OC} = 1(RI_h < RI_{STD}) \qquad (4.15)$$

The Indices, reported in Table 4.2 is based on our observations: formulas 4.6 and 4.11; and we'll consider the Oxford OECD scale. Moreover it considers an absolute poverty threshold ($Poverty_{ths}$) and an absolute standard costs (S_{STD}).

Because of the two Indicator functions (4.14 and 4.15) Head-Count and Gap indices, used together, become a bit complex, we introduce the negation function (or logical complement) to exclude from the computation the overlap where the Under Income conditions include Over Consumption conditions already.

Indices	Absolute
Head-count	$H^{UIOC} = (\frac{1}{N})\sum_h (I_h^{UI} + \bar{I}_h^{UI} I_h^{OC})$
Gap	$EPGI^{UIOC} = (\frac{1}{N})\sum_h (I_h^{OC}(RI_{STD} - RI_h) + \bar{I}_h^{OC} I_h^{UI}(Y_h - Y_{STD}))$

Table 4.2: Absolute Indices: Head-count and Gap. Source: our elaboration.

From previous considerations, both in terms of HeadCount and GapIndex we should find that:

$$H_u^{UIOC} > H_u^{LIHC} \qquad (4.16)$$

And so also for the Energy Poverty Gap Index (EPGI).

In the Gap index of Table 4.2, the gaps coming from an Under Income situation are summed positively to the Residual Income situation giving priority to the Residual Income gap: this guarantees that all energy poor have the resources for the minimum basket of consumption and some savings for future expenditures on energy assets.

In the next chapter we'll see how the definition of the Income Standard Y_{STD}, the Expenditure Standard S_{STD} and the Savings for energy can be reduced easily with a computation.

CHAPTER 5

Application case of Italy

Application case: the micro data from HFCS

We would take in account the route followed by Miniaci Scarpa Valbonesi (2014) considering the data EU-SILC, data panel that would fit our aim. These data, supplied to us by statistics based on the same household over time, are, actually, a data panel with a long historic series. Unfortunately the raw data (micro data) are not for students, so we need to consider another database.

The European Central Bank, on the other hand, did supply us, on request, with the micro data of the Household Finance and Consumption Survey (HFCS): in detail we take care of data kindly supplied from Banca d'Italia, that are available directly from its web site without any constraint.

"HFCS is a joint project of all the national central banks of the Eurosystem" (ECB 2016).

HFCS provides several pieces of information, including the necessary information to compute our indices like income, expenditure, and household composition.

HFCS data come in two waves: for the first one the survey has been done in 2010-2011 while the second includes a period of time variable between end-2011 and mid-2015 (for Italy the year of reference is 2014).

We cannot use the first wave because the information on expenditure is missing but we'll try to do some considerations.

For the second wave, due to the large period considered, we have different reference year among countries: we could only compare countries within the same survey year.

How the report ECB (2016) states: "Differences in reference years can be particularly relevant for the values of financial and real assets, many of which have declined substantially during the European sovereign debt crisis."

Moreover this survey is not created to analyse the poorest situation but it looks at the distribution of assets and debts. It is more focussed on the wealthiest, and it, aware that in general wealth distribution survey are skewed, declaring it. But they adopt this strategy: when the answers about income or consumption have no answer from the subject under survey, they assign a value anyway; and this assignment procedure is done differently country by country ECB (2016b).

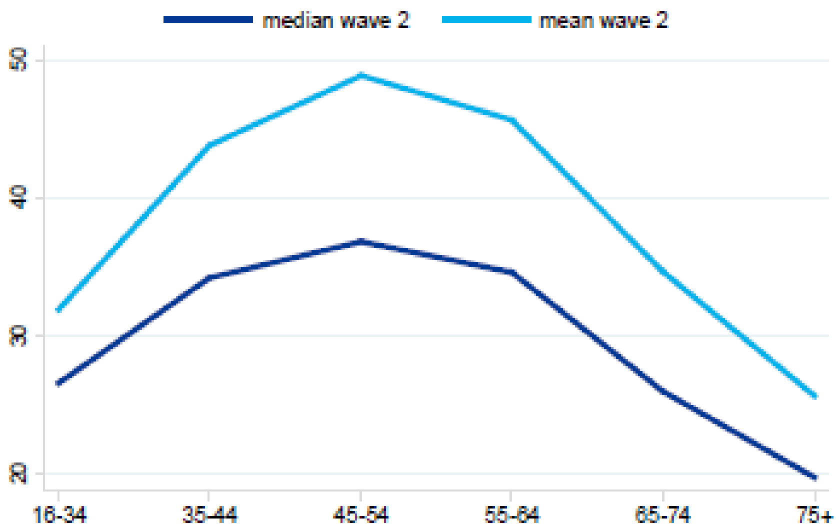
HFCS is supplied for Italy by Banca d'Italia with several files .CSV where the sample size is 8156 household with a total number of 19366 interviewed subjects (this for the second wave, year 2014; for the first wave, 2010, we have 7951 households and 19836 subjects).

We had taken all these subjects into consideration because we needed to establish the composition of the household to apply the equivalisation scale to the total income and expenditure opportunely summed.

So from HFCS files we've taken the following information: household ID, relation, size and composition of the family, net income, utility expenditures and consumption expenditures.

The European Central Bank Report on HFCS 2014

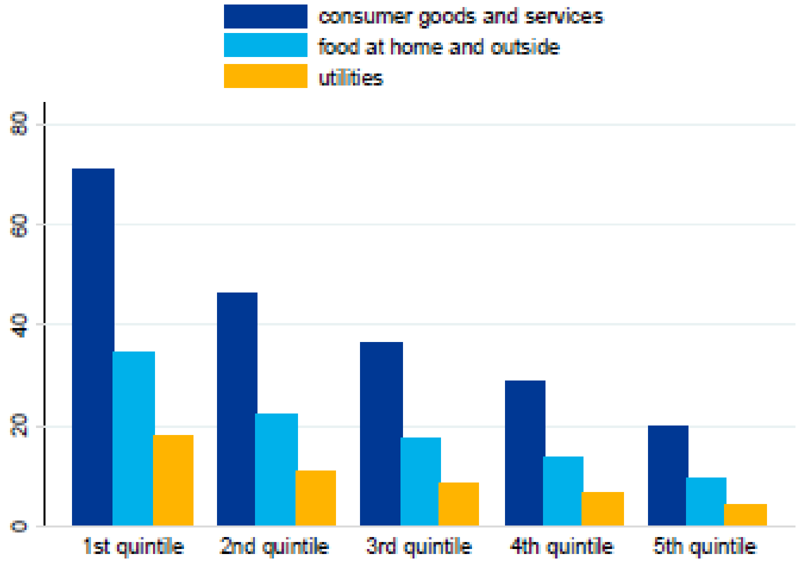
At a European level it's worth seeing a couple of graphics obtained from the ECB report (2016). Concerning income we find the following Graph 5.1 that reports the household income (thousand Euro) by age of the reference person.



Graph 5.1: Household income (thousand Euro) by age of the reference person. Source: HFCS. Euro area.

Firstly we can note the huge difference between the mean and median, indicative of the presence of inequality. If we imagine tracing, a Poverty Threshold, somewhere in the middle of the graph, we can see that the group of people that need help are the oldest and youngest: two groups that in recent times we have seen juxtaposed.

Another interesting piece of data to highlight comes from the consumption side. We report Graph 5.2 where we show the median consumption to income ratio (percentage) by income quintile.



Graph 5.2: Median consumption to income ratio (percentage) by income quintile. Source: HFCS. Euro area.

From the Graph 5.2 we can see how in the first quintile the weight of consumption is meaningful. At the same time utility expenditures weigh more in the lower quintile than in the higher quintile but the variation from the first quintile and the fifth quintile is lower than the variation we have for the consumer goods and services. This confirms that the demand for utilities is less elastic than for other consumption products, because most utilities are common goods, which are essential to survive.

The average value of expenditures on utilities is, at a European level, €3100 per year. And the median is €2500 per year. Compared with the HFCS statistics from Italy for 2014, we find lower amounts: see Table 5.1.

Utility Expenditures	Italy	Europe
Mean per year	**€2062,5**	**€3100**
Median per year	**€2000,0**	**€2500**

Table 5.1: Expenditures on utilities. Source: our elaboration.

But this isn't a surprise because, in general, with some exceptions, Italy has climatic environment that helps both in the Summer and during the Winter: temperatures are neither so high nor so low. Moreover we live in a European society where inequality is lower. Lastly, we still not have liberalized completely the energy market, so we haven't faced problems like that, as shown by Chester and Morris (2011) for the Australian Country.

Application case: our analysis

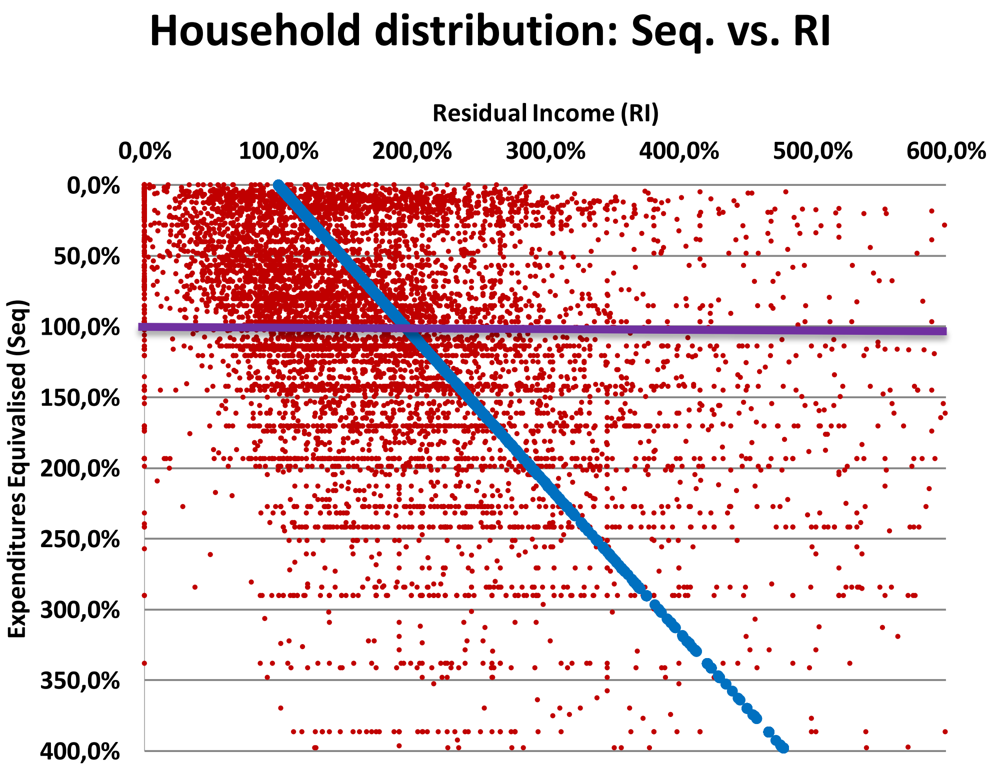
We start taking into account the quasi-relative index, or also called LIHC Index, proposed in the previous chapter, formula 4.12, for the Head-Count Index we have:

$$H_u^{LIHC} = (\frac{1}{N})\sum_h \{I[s_h > P50_t(s_h)] * I(RI_h < RI_{STD})\}$$

While for the GAP index we have 4.13

$$EPGI_u^{LIHC} = (\frac{1}{N})\sum_h \{I[s_h > P50_t(s_h)] * I(RI_h < RI_{STD})\} \times (RI_{STD} - RI_h)$$

But we want, also, to see the “original” Hills index, that we are going to call LIHC_{adj} and will be based on formula 3.1. LIHC_{adj} has the slope as request by Hills (2011): the threshold y_i* is the poverty line threshold (60% of the Median of the Income) with the equivalised costs added Seq (this gives the slope shown in Graph 5.3).



Graph 5.3: graphical distribution of household for LIHC index. Source: our elaboration.

To note that in Graph 5.3 the data are shown in percentage form, respectively: for the Residual Income to the Poverty Line (100% is actually the level of the Poverty Line), and for the Expenditures Equivalised to the median od expenditures (100% is the level of median Expenditures Equivalised).

We find the following results:

	LIHC	*LIHCadj*
HI	**6.04%**	**10.72%**
EPGI	**€147.55**	**€257.68**

Table 5.2: Percentage of LIHC people. Source: our elaboration.

Clearly, if we want to find the total amount we need to solve the Energy Poverty problem for one year we need to multiply that EPGI number by 8156 households interested in the survey and around a factor of coverage of 3160 (in fact the number of households in Italy are around 25.8Million, ISTAT 2015b). So, we have with LIHC the total amount of €3,8B, instead we have €6.6B in the case of the LIHCadj.

Our Under-Income/Over-Consumption Index

Now, let’s consider our index. From Table 4.3 we have, for the Head Count index, the following formulas:

$$H^{UIOC} = (\frac{1}{N})\sum_h (I_h^{UI} + \bar{I}_h^{UI} I_h^{OC}) \qquad (5.1)$$

Where we remember the Indicator Functions 4.12 and 4.13:

$$I_h^{UI} = 1(Y_h < Y_{STD}) \qquad I_h^{OC} = 1(RI_h < RI_{STD})$$

These are respectively used to capture the Under-Income condition and the Over-Consumption/Over-Costs condition.

For the Energy Poverty GAP index the following formula:

$$EPGI^{UIOC} = (\frac{1}{N})\sum_{h}(I_h^{OC}(RI_{STD} - RI_h) + \bar{I}_h^{OC} I_h^{UI}(Y_h - Y_{STD})) \qquad (5.2)$$

The result we found are reported in the following Table 5.3:

	Under-Income and Over-Consumption
HI^{UIOC}	**27.51%**
$EPGI^{UIOC}$	**€763.39**

Table 5.3: Percentage of Energy Poor people (HI^{UIOC} Index), and amount of money necessary to fill the GAP ($EPGI^{UIOC}$ index). Source: our elaboration.

As we stated in the previous chapter (4.16):

$$H_u^{UIOC} > H_u^{LIHC}$$

In fact we have:

27.51% > 6.04%

And, the same, for the EPGI's, we have:

€763.39 > €147.55

All in all, we need to evaluate how much weight the household with zero expenditure has, and how much higher either Y_{STD} or RI_{STD} is, because, as we described on page 59, this increases our uncertainty.

If we establish a $S_0 = 5\% \ S_{STD}$ we find with $Y_h > Y_{STD}$ and $S_h < S_0$ a 1,14% of the population considered. Instead if we evaluate when $RI_h < RI_{STD}$ for $S_h < S_0$ we obtain 1,25%. With both we obtain 1,25%.

How we calculate our head count index (HI^{UIOC}) and Energy Poverty Gap Index ($EPGI^{UIOC}$)

To reach these results we have some settlement to take in account, these concern the following questions:

1. Setting a savings (we have chosen €800)
2. Setting an Income Standard equal to 60% Median Income
3. Setting an Expenditure Standard equal to the Median

Point 1

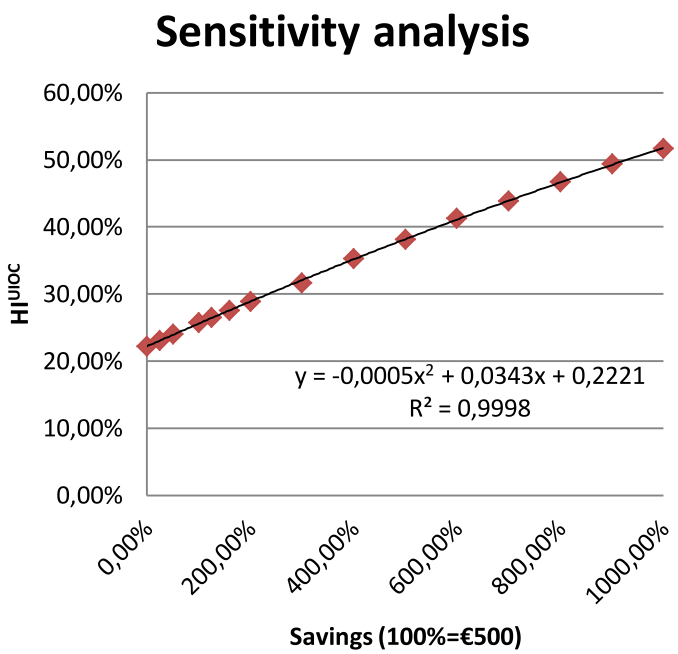
To justify the first point, (the saving of €800), we need to take in account the consideration that comes from the EU-SILC report (Eurostat website) where in the survey they ask about the capacity to face unexpected financial expenses. These expenses could be different across countries but can be intended as major repairs in the house, or replacement of durables like washing machines and so on. This variable (namely HS060) is an indicator of household deprivation.

The description of the parameter HS060 (EU-SILC 2014) says that for the calculation of the amount of the unexpected financial expenses, “the national at-risk-of-poverty threshold” has to be used with a rounded value that cannot exceed 5%.

ISTAT(2014) in their “Indagine sulle condizioni di vita” set the parameter F04.8, which relates to unexpected financial expenses of the EU-SILC to the Italian case, equal to €800. While the Poverty Threshold for the year 2014 certified by ISTAT was €625.15.

Because this variable assists us in establishing how much has to be the saving for energy, we think it necessary to proceed with a sensitivity analysis.

In the following Graph 5.4 we show the sensitivity of the HI^{UIOC} index to the saving, underlining the two options of savings (€800 and €625).



Sensitivity Analysis, base €500		
€	Savings	*HIUIOC*
0	0,00%	22,17%
125	25,00%	23,03%
250	50,00%	24,01%
500	100,00%	25,74%
625	125,00%	26,47%
800	160,00%	27,51%
1000	200,00%	28,90%
1500	300,00%	31,69%
2000	400,00%	35,26%
2500	500,00%	38,13%
3000	600,00%	41,28%
3500	700,00%	43,86%
4000	800,00%	46,70%
4500	900,00%	49,36%
5000	1000,00%	51,66%

Graph 5.4 and Data-Table: Sensitivity of the HI^{UIOC} index to the saving. Saving of 100% is equal to €500. In the Table beside the values. Source: our elaboration.

Aside the Graph 5.4 the data table of the sensitivity analysis. In this table we have defined, conventionally, €500 as a base that corresponds to 100% of savings, so, for example 200% means €1000 of savings.

In Graph 5.4 we can see the data can be explained well from the tendency curve (R^2=0,9998). For our analysis we set the Savings to €800 (160% of €500), in this way we have obtained an HI^{UIOC} of 27,51%.

Point 2

To set an Income Standard equal to 60% Median Income, we need to be aware that this is the threshold defined at the risk-of-poverty line.

We calculate it from our dataset in the HFCS and is equal to €7500. This is coherent with the median of the net Income that's €21450 pretty in line with the European data where the gross income median value is €29500 (ECB, 2016).

But we wanted to maintain our index as an absolute index so instead of the relative Poverty Line we would use the absolute Poverty Line. To do that we face two kinds of problems:

- the complexity either to reduce to a single value the absolute poverty line, (defined by ISTAT in relation to the composition of the household component and region of residence), or the complexity to compute a different value of absolute poverty and add it to each household composition
- determine a threshold value that is universally recognizable, or at least at European level, this gives us the possibility to compare it to other countries (which is what we want).

Adopting a recognizable Poverty Line means excluding the absolute Poverty Line calculated by ISTAT. But can we adopt the relative Poverty Line in place of the absolute Poverty Line? If we look at the meaning we understand that the absolute Poverty Line as defined by ISTAT is based on a basket of minimum consumption that guarantees a decent level of survival. While the at risk-of-poverty line (the Eurostat definition of relative poverty line) looks at the level of poverty or social exclusion that has a more complex meaning. At the end, however, they look just at the income (60% of the median of the income equivalised).

So, we've made a comparison between these options: absolute vs relative Poverty Threshold, and we report it in Table 5.4.

We start saying that from our Italian data from HFCS the at risk-of-poverty line is equal to €7500 per household of a single person; that means €625 per month. In the following Table 5.4, we have taken this relative threshold for a single household per month (orange cell) and multiplied it by the scale of equivalisation OECD-Oxford: we obtain the column "Series 2014" (under HFCS). We can now compare "Series 2014", "Relative Poverty Threshold" that comes from ISTAT, namely the ISPL (that looks at the consumption and use the Carbonaro's Scale) computed by them for the year 2014, with our "Series 2014" obtained from the data of HFCS. We can appreciate very similar values, and this is underlined by the ratio called "HFCS/ISPL" (namely, 60%median income eq./ISPL).

ISTAT		HFCS				ISTAT			
Relative poverty threshold (ISPL 2014, based on consumption)		60% median Income Eq. (Relative Threeshold)				Absolute worst case (Year of Reference: 2014)			
Number of components	Series 2014	Series 2014	OECD	HFCS/ ISPL	HFCS/ Av.Abs	Higher case	Lower case	Average	Abs/Rel
1	625,15	625,00	1,0	100,0%	95,9%	816,84	487,12	651,98	104,3%
2	1041,91	1062,50	1,7	102,0%	117,5%	1126,08	681,91	904,00	86,8%
3	1385,74	1375,00	2,2	99,2%	112,3%	1416,14	1031,62	1223,88	88,3%
4	1698,31	1687,50	2,7	99,4%	113,7%	1713,83	1255,37	1484,60	87,4%
5	1979,63	2000,00	3,2	101,0%	100,8%	1983,29		1983,29	100,2%
6	2250,53	2312,50	3,7	102,8%	103,2%	2241,68		2241,68	99,6%
7+	2500,58	2625,00	4,2	105,0%	105,4%	2490,47		2490,47	99,6%

Legenda:	Notes on OECD:	Notes on composition:
Details (blue)	1 is the main household	lower case are from south and small cities, are over 75
Threshold Type (pink)	+0,7 is an adult added	higher case: from north and big cities: one or two 18-59
Source of data (red)	+0,5 is a child	and after we add a one or more 11-17

Table 5.4: Comparison between the Absolute vs. Relative Poverty Threshold. Source: our elaboration.

But in the same Table 5.4 we include, in the comparison, the ISTAT Absolute threshold. We have taken the worst case scenario: the higher values (higher case) for each cohort, by household composition, geographic area and city; and the lower values (lower case).
Between the higher case and the lower case we have done the average, because we needed to understand if on average we overestimate that threshold. The answer is yes in general but not for the single household.
Moreover, if we look at the gap between lower case and higher case, that's huge: almost double for a single household, but for a couple too. This is one of the main problems we face in Italy where we have very different economics areas with a different climatic area too: the north, the centre, and the south.
At the end, taking the threshold at risk-of-poverty (60% of median of Income equivalised) with the HFCS data in place of the other thresholds give us a good level of confidence: either if we consider the ISPL (we are aligned), or if we consider the absolute threshold supply by ISTAT (in this case we are overestimating, looking at the average with the exception of the single household where we are below by 4points).

Point 3

About to set an expenditure standard (S_h) equal to the median of expenditures for utilities. For this, we have taken the same reference as Miniaci, Scarpa, Valbonesi (2008, page 210): "the minimum quantity as the one which is considered acceptable not to be socially excluded". So the reference basket for utilities is defined in our case as a median on expenditures on utilities conditional on family size and composition (because of OECD's scale equivalisation). Differently from Miniaci, Scarpa, Valbonesi (2008) we didn't adjust for the area of residence, aware we are introducing an error, but that's necessary to maintain the index comparable among European Countries.
A non-negligible detail: we cannot have from HFCS survey the value of just the energy disaggregate from utilities expenditure. This includes electricity, gas, but also water and telephone.
In 2014 the median expenditure for the utilities was €1034.48.
This value respect to our at risk-of-poverty threshold results in a ratio of 1034.48/7500 = 13.8%. That's a bit high if we consider that in Britain 10% was the reference value.

The components of HI^{UIOC}

Explained how we have calculated our HI^{UIOC} with the three points above, let's see in our Index the two components of the HI^{UIOC}.

Starting from the Under Income situation, identified from the function: $I_h^{UI} = 1(Y_h < Y_{STD})$, with saving of €800, we record:

Yh<Ystd
25.72%

Where Y_{STD} is the Poverty Line as 60% Income with the savings added.

Instead, the situation of Over Consumption (or Over Costs), has been identified using the Residual Income method, with the function: $I_h^{OC} = 1(RI_h < RI_{STD})$, considered the saving of €800. So, we have:

RI<Ristd
25.81%

In absolute terms, that is not different from the previous figure, and considering the Head-Count Index, (sum of these last two results), it is not so different (we remember the HI^{UIOC} = 27.51%), this means that they have more or less the same household as a reference. That means whoever has a low income Yh<Ystd has also a low RI; in fact the Under-Income condition explains 93.5% of the HI^{UIOC} and the Residual-Income condition explains 93.8% of the HI^{UIOC}.

But with respect to who is at risk-of-poverty, the HI^{UIOC} tells us much more, in fact the households under the at risk-of-poverty threshold are at 20.41%.

As we have seen the *EPGI* is equal to €763.39. So, to tackle the situation of Energy Poverty in Italy in 2014 we had to invest around

€763.39 x 8156 x ~3160 = €19.7Billion

The LIHC Index, that showed a result of the €6.6B necessary to tackle the EP, has excluded a lot of population under the poverty threshold. It therefore appeared easily solve the problem, even though this is not the case.

A comparison with the first wave HFCS 2010

Adopting the same procedure we had a look into the data supply, again from HFCS, but this time for 2010-2011, known as the first wave. This sample of 62000 households (7951 households for Italy) is meaningful, despite the fact that it is not as complete as the second wave where we can find also the expenditure for utilities. Anyway we can weigh the Indicator Function, about the Under Income situation, with respect to the second wave.

With the 2010 dataset the resulting Under Income situation, identified from the function $I_h^{UI} = 1(Y_h < Y_{STD})$, is:

Yh<Ystd
24.37%

But in this case the saving has been considered of €800.

But because we find at risk-of-poverty line being €7171.76 per year, the requirements are €597.65 per month, following the EU-SILC indication we can record the result of 22.87%.

In the following Table5.5 we report the results of the comparison between the two wave surveys taking into account just the Indicator Function that looks at the Under-Income (I^{UI}) so the HI^{UI} index and others derived.

	2010	2014
HI^{UI} (Yh<Ystd)	24.37%	25.72%
Poverty Line	19.02%	20.41%
$EPGI^{UI}$	€657.63	€809.08
Intensity	€2698.05	€3145.33

Table5.5: several indices derived from I^{UI}, Poverty Index and Gap Index. Source: our elaboration.

The Poverty Line is the same as our index that consider the Under Income situation but without any kind of savings (we look at risk-of-poverty line, the 60% of median of Income equivalised). Instead the $EPGI^{UI}$ is the sum of all the gap between the Y_{STD} and Yh of the household where $Yh<Y_{STD}$, so that are positive quantities, summed, and divided by all the household under survey.

From the Table 5.5 we find that all indices increase four years later, and not only people are more poor and more in an energy poor condition but also that the gap increases. We remember that condition of HI^{UI} in 2014 has been representative of the comprehensive HI^{UIOC} index explaining the 93.5%.

This dramatic situation is certify from the Intensity (formula 3.10) that gives us the average amount of the Income that we need per poor person to fill the gap Y_{STD}-Y_h.

The Miniaci, Scarpa, Valbonesi (2014) Index

Before making a comparison among the indices we have seen, we need to add the index suggested from Miniaci, Scarpa, Valbonesi (2014). So, let's go on to calculate this index with our data HFCS 2014.

From chapter 3 we recall the function that captures the Under-Income or Over-Consumption condition, for a better understanding here we report formula (3.4): $I_h^u = I(x_h - p_u q_h^u < p_c q^{pc})$, so we obtain:

H_u
27,19%

While using formula (3.7): $I_h^c = I(x_h - p_u q_h^c < p_c q^{up})$ and valuating the Under-Consumption of utilities, we obtain a huge value of 51.01%. The main reason is because we didn't take the absolute threshold as indicated by Miniaci, Scarpa, Valbonesi (2014), essentially because we wanted to be internationally comparable, but the other, more practical reason was that from HFCS we don't have the location of the household, so we cannot identify the areas and so differentiate the threshold for consumption. For these reasons we decided on the variable HNB0810, (year of construction of the house), to exclude from the computation all the households with a recent building that give them the possibility to consume less, so the Under-Consumption is justified. This is clearly something we do tentatively with the data available to understand the endowment in terms of energy assets that households own.

We obtain the following result:

H_c
35,86%

In the end the Head-Count Index based on Residual Income suggested by Miniaci, Scarpa, Valbonesi, (from chapter 3, formula 3.11), $H^{RI} = \left[\sum_h I_h^u + I_h^c - I_h^u I_h^c \right] / N$, become:

	Under-Income or Over-Consumption, and Under-Consumption
H^{RI}	46,22%

Table 5.6: Value of H^{RI} Index of Miniaci, Scarpa, Valbonesi. Source: our elaboration.

This result is very different from our index 46.22% versus 27.51%.

We note, if we look at the two Indicator functions of Miniaci, Scarpa, Valbonesi, we can discover that a meaningful contribution to the H^{RI} come from both the Indicator functions. Opposingly our index HI^{UIOC} has two Indicator functions which insist on the same households.

We find two main differences to justify these results from our indicator:

1. as stated before, we used a unique relative threshold that overestimates the absolute threshold indicated by Miniaci, Scarpa, Valbonesi (2014). Also taking cross data from others sources, it wouldn't be possible to use that threshold because our HFCS data should be unrelated.
2. So different results from our index become clear if we are aware that we do not consider the Under-Consumption of utility in the definition of the Energy Poor. In fact if we cut out the contribution that comes from H_c we have an H_u that is 27.19% that is incredibly close to our HI^{UIOC} of 27.51%!

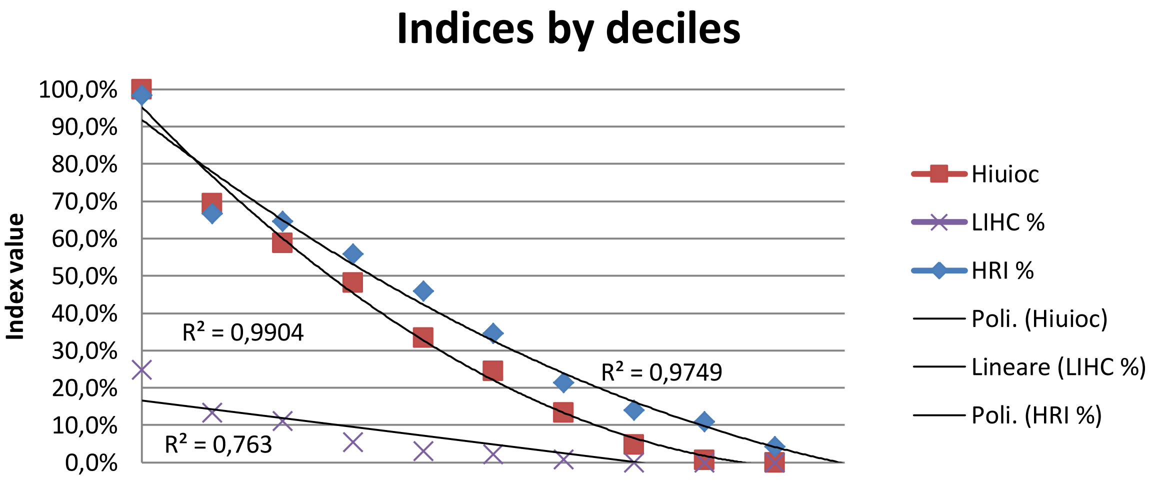
The two Headcount Indices (H_u and HI^{UIOC}) are very close. Comparing $I_h^u = I(x_h - p_u q_h^u < p_c q^{pc})$ with $I_h^{OC} = 1(RI_h < RI_{STD})$ we discover that the Residual Income is the same and the threshold $p_c q^{pc}$ compared with the RI_{STD} are slightly different: we add the necessary savings to the Poverty Line, but at the same time we had subtracted the utilities expenditure; where for $p_c q^{pc}$ Miniaci, Scarpa, Valbonesi take just the Poverty Line.

So if these two Indices (H_u and HI^{UIOC}) are very close it is likely they represent two ways of reasoning that arrives at the same results.

A Comparison Amongst Indices

In the end, It's worth making a comparison between *LIHC*, HI^{UIOC}, and the H^{RI} indices.

In the following Graph 5.3 we show the household captured by the different Indices by deciles of Income.



Graph 5.5: Indices by deciles of Income. Source: our elaboration.

We can see from Graph 5.5 how the three Indices to capture the Energy Poverty situation are distributed.

First of all, we want to remember that the indices *LIHC*, derived by Hills, and H^{RI} of Miniaci, Scarpa, Valbonesi, are from our computation approximates for the reasons explained before.

So, a general consideration is about the fact, as was in our expectations, lower income deciles are more subject to be in a problem of affordability. But it was in our expectations to find a curve (because every index should reflect inequality). In Graph 5.3 we report the tendency of the several Indices: we have already discussed the LIHC indicator as a long run indicator. Instead for the H^{RI} we find it is a bit high for the higher income decile and this is due to the contribution of the H_c , the Under-Consumption of Utilities (but we have introduced a distortion taking the relative threshold in place of the absolute one): as we have already stated we should consider the asset endowments of the households.

CONCLUSION

Conclusion

We believe it was essential to present an Index based on an idea as background. Our simple frameworks presented in this thesis can be taken as a reference to enable others to make easy comparisons and, if necessary, others observations. With the Index based on Residual Income that evaluates the Under-Income and the Over-Consumption (or Over-Costs) we are able to identify at least three affordability problems: the necessary minimum Income, and the capability to keep down the costs.

When we say "keep down the costs", we mean as relates to the capability to make savings. These savings are useful in the future to keep the domestic "energy asset" efficient. So, we retain that Energy Poverty is strongly connected with dynamics of social innovation and updating the assets means keeping down the costs (good examples are: newer white goods or a newer more isolated house). But taking the words of Reddy <<Because efficient devices tend to have higher first costs, the poor invariably end up with less efficient devices that consume more energy for a given level of service. >> (Reddy et Al., 1994). And, we add, this is also a valid argument for buildings. All these questions make us speak about social exclusion, and a solution could be the incentive. But we have to make a distinction: if we speak about incentives for white goods, an incentive scheme can be designed easily enough, but speaking about buildings, clearly, here, a problem of incentive arise if a household does not own the house. In this case the owner could renew the house, but, consequently, increase the costs of rent because the house is renovated; and the renter has to find another less costly house, which will likely be less efficient.

To solve these questions, it becomes more and more important that Government takes control of incomes and prices: incomes which are too low have to be sustainable, huge variations of energy prices in the market have to be controlled. Controlling the dynamics highlighted, in this way, permits us to adopt inclusive politics for those who have less, with benefits to all of the community.

Another point we need to touch on in this conclusion is about the *LIHC* index. It looks created for who even wants to keep the problem of Energy Poverty silent. We are sure that is not the intention of the Professor when from page 57, Hills (2012) argues that the measure of Energy Poverty is not based on absolute principle but on a compromise to avoid capturing too many households. Anyway considering just the households that encounter high costs is, for us, a long-run-dynamic; despite the creative adjustments and thresholds, out of every standard, that Professor Hills adopts.

But I would add some more words about the Residual Income Index suggested by Miniaci, Scarpa, Valbonesi, that drove me onto a new, very close, path. They have considered also the Under-Consumption of Utilities. This is a very hard choice, because, as already discussed, you don't know the technological asset of the household: have they a low consumption because they possess a good technological asset which is very efficient, or because they cannot afford an higher expenditure for utilities? Anyway, for this index the interest is high because, with the information of the technological status of the household, it can be considered an index inclusive of a very short run. This can be wake-up call for a possible near future. The function of this wake-up call is clear if we think we recorded an H^{RI} of 46.22%, referring to the year 2014: if we follow the ISTAT (2016b) Italy has a number of people at risk-of-poverty which has grown, and moreover has increased the risk of poverty or social exclusion and severe material deprivation. It's clear we would need to analyse the historic data but are all evidence that makes us state that the Miniaci, Scarpa, Valbonesi Index can be considered a predictive index, if we follow the logic proposed with our framework.

We left as our last argument the first Indicator Function of our Index: the comparison of the household Income Y_h with the Income standard Y_{STD}, where in the Income standard the Savings for future energy expenditure are included.

If one is saving something, how much of these savings will be spent to maintain the house and the white goods in an efficient condition? This is certainly a question relating to sustaining the income of the poorest adequately, directly and/or indirectly. But, we would understand what the strategy is of the single household that determines the frequency of the energy asset update!

Of course, for this, there is a cultural question that needs to be diffused, against waste, in the direction of saving as synonymous with less consumption but in a more efficient way. But this approach is strongly connected to the commons that are managed by a Community, as we have seen before in Chapter 1 with Mattei (2011). In this situation of common sharing each household feels the responsibility for it and each one feels they are part of this ecosystem. This approach, moreover, give us the possibility to face sustainability from an environmental point of view, bringing a true ecological revolution in a economic sense.

ABBREVIATIONS

.CSV	extension that denote a text format file
ECB	European Central Bank
ENI	Multinational company born in Italy for oil, gas and electricity
EPGI	Energy Poverty Gap Index
EU-SILC	EUropean statistics on income and Social Inclusion and Living Conditions
HFCS	The Household Finance and Consumption Survey
HI	Head-Count Index
HS060	Variable part of the EU-SILC report
I or IF	Indicator Function
ID	Identification
ISTAT	Italian National Statistics Institute
ISPL	International Standard Poverty Line
LIHC	Low Income High Costs
LPG	Liquefied Petroleum Gas
OC	Over-Consumption
OECD	Organisation for Economic Co-operation and Development
RI	Residual Income
Risp	Saving
S	Expenditure
UI	Under-Income
UN-HESI	The Higher Education Sustainability Initiative (HESI), is a partnership between United Nations Department of Economic and Social Affairs and several other entities. Through its strong association with the United Nations, HESI provides higher education institutions with a unique interface between higher education, science, and policy making.
Y	Income

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