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# Gross Inland Energy Consumption Inequality in Europe: An Empirical Approach

## *Desigualdad en el consumo energético en Europa: un enfoque empírico*

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Abstract

The aim of this paper is to analyse gross inland energy consumption (EC) in the EU-15 - European Union countries over the period 2005-2014. The standard tools in the measurement of income inequality such as Lorenz Curve, Gini Index, and Generalized Entropy and Atkinson indices are applied. The empirical results confirm that EC inequality has decreased (the Gini coefficient falls from 44.27% in 2005 to 42.16% in 2014), that there are a small inward shift in the corresponding Lorenz Curve and there are huge differences among the four European clusters of countries (Mediterranean, Continental, Nordic and Anglo-Saxon ones).

*Key words:* Energy Consumption; Inequality Measures; Lorenz Curve; EU-15.

## Resumen

El objetivo de este artículo es analizar el consumo de energía (CE) en los países de la Unión Europea (UE-15) durante el periodo 2005-2014. Se aplican herramientas estándar en la medición de la desigualdad, como las Curvas de Lorenz, el índice de Gini, los índices de entropía generalizada y de Atkinson. Los resultados empíricos, obtenidos confirman que se ha producido un desplazamiento de las curvas de Lorenz, que la distribución de desigualdad del CE en los países de la UE-15 ha disminuido (el coeficiente de Gini cae del 44,27% en 2005 al 42,16% en 2014) y existen amplias diferencias entre grupos de países (Mediterráneos, Continentales, Nórdicos y Anglosajones).

*Palabras clave:* Consumo energético; Medidas de desigualdad; Curvas de Lorenz; EU-15.

*JEL Classification Codes:* C14, C23.

## 1. Introduction

One of the main important objectives of the European Union (EU) is focused on climate change and energy efficiency. The *EU's Europe 2020 Strategy for smart, sustainable and inclusive growth*, identifies three key targets based on climate change and energy sustainability, the so-called '20-20-20' targets (7224/1/07 REV 1: Presidency Conclusions of the European Council of 8/9 March 2007): 20% cut in greenhouse gas emissions (GHG) taking in account the 1990 levels; 20% share of EU energy consumption produced from renewable energy resources; and 20% improvement in energy efficiency on the EU primary energy consumption.

As a consequence, during the last decades, environmental and resource economists are concerned with non-income inequality measures which have become an important issue in developed countries. Modern societies are worried about different dimensions of inequality related to climate change such as GHG emissions ($CO_2$, ...), gross inland EC-energy consumption, and others. Hence, the EU countries face a transforming moment and "Europe 2020" puts forward in reinforcing priorities: smart, sustainable and inclusive growth (European Commission, 2010). As part of these growth priorities, an important inititiative concerns a resource efficient Europe and distributive problems have become visible as the most important issues in the negotiations for adopting new agreements by policy makers (Martínez *et al.*, 2011, Quinto, 2003).

The main focus of this paper is to spell out how the Lorenz curve and other inequality measures can be applied to study energy consumption evolution in the EU-15. In energy economics literature, studies apply different tools of income distributive analysis to energy economics although most of them are focused on climate change and $CO_2$ emissions. Duro and Padilla (2006) provide a method to decompose international inequalities in per capita $CO_2$ emissions into Kaya (multiplicative) factors and two interaction terms. They use the Theil Index of Inequality and analyzed inequalities factors in per capita $CO_2$ emissions across countries, between groups of countries and within them.

Groot (2010) showes that standard tools in the measurement of income inequality, such as the Lorenz curve and the Gini index, can successfully be applied to the issues of inequality measurement of carbon emissions and the equity of abatement policies across countries. These tools allow policy-makers and the general public to grasp at a single glance the impact of conventional distribution rules such as equal caps or grand fathering, or more sophisticated ones, on the distribution of GHG emissions. In addition, Duro (2013), using similar techniques, examines the role of changes in the countries' relative weights to explain the evolution of global international inequalities throughout the 1971-2007 period for some well-known environmental indicators. The author analyses the factors that could explain changes in per capita $CO_2$ emissions' inequalities using a variety of inequality measures such as the Gini index as well as the Theil family index to test the sensitivity of the results.

More recently, Mussini and Grossi (2015) study the effects of changes in countries' ranking and per capita $CO_2$ emissions on $CO_2$ emission inequality over time. To reach this aim they introduce a three-term decomposition of the change occurring in the Gini index applied to per capita $CO_2$ emissions when moving from an initial to a final per capita $CO_2$ emission distribution. They measure changes in per capita $CO_2$ emission inequality in Europe over the span period 1991–2011, using Lorenz concentration curves.

Reducing gross inland energy consumption, especially non-renewal energies, is one of the central objectives of EU countries. In this paper, we have combined methodological issues based on the standard tools in the measurement of income inequality. Although these techniques have been applied to energy economics (Groot, 2010), specially to the inequality measurement of carbon emissions to the best of our knowledge, this is the first time it is applied to gross inland energy consumption in the EU-15 countries for period 2005-2014. Mohammadi and Ram (2017) study the convergence in per capita energy consumption across the different US states over the 44-year period 1970–2013 and confirm the lack of convergence across states. From another point of view, Tobar and Wölfin (2018) analyze the distributional effects of rising energy costs for households. Rosas-Flores *et al.* (2010), state that the search for equity in energy consumption is one of the main objectives of the millennium, not only just to study about inequality, but also to demonstrate objectively its existence. The measurement of inequalities between countries and within a country is the first step before taking decisions and actions in order to put in place strategies for reducing and eventually eliminating these inequalities. Transforming the results of these studies into policy measures is a challenge to be faced.

Thus, the main objectives of this paper are to provide an assessment of gross inland energy consumption inequality in EU through different measures over the period 2005-2014 and to rank the four up-referred different clusters of EU countries based on regionalization criteria and decompose changes in the inequality groups (between and within-group components).

This paper contributes to the existing literature in three ways. Firstly, it is innovative in the way it uses final energy consumption – gross inland consumption – in order to have an indicator of the losses that occur throughout the transport, distribution and transformation stages in the delivery of final consumption energies. Secondly, inequality measures are introduced in order to study energy consumption in order to allow the ranking of the EU countries using the most recent data. Thirdly it fills a gap in the literature.

The rest of the paper is structured as follows. Section 2 describes the main methodological aspects, namely the Lorenz curves, the Parade approach and the different inequality measures. Section 3 provides the main results obtained with the above-mentioned methodology and applied to gross inland energy consumption in the EU-15 countries. The final section concludes summarizing the main findings and presenting some recommendations for policymakers.

## 2. Measuring gross inland energy consumption inequality

Let us consider $k$ countries and assume that, for every country $i$, the population $n_i$ and gross inland energy consumption are known, with $i = 1,\ldots,k$ and $n = \sum_{i=1}^{k} n_i$ . Let $EC_i$ be per capita energy consumption of country $i$ and $p_i = n_i/n$ be its population's share. The Gini index ($G$) can be expressed as follows:

$$G = \frac{1}{2\overline{EC}} \sum_{I=1}^{k} \sum_{j=1}^{k} p_i p_j \left| EC_i - EC_j \right| \tag{1}$$

where  is the average of gross inland energy consumption and the weights are the populations' shares. Gini coefficient ranges from 0 (perfect equality) to 1 (complete inequality). This index verifies the following properties: mean independence, population size independence, symmetry and Pigou-Dalton transfer sensitivity.

In addition, inequality can be made visible by means of Lorenz curves that show what percentage of total $EC$ is held by the bottom $x$% of countries. This Lorenz curve depicts on the vertical axis the cumulative $EC$ pitched against the cumulative share of the population on the horizontal axis. This methodology has been also applied to $CO_2$ emissions by Groot (2010). Thus, the Lorenz's approach is an important inequality graph usually used for international environmental analyses.

Alternatively, we use the Parade approach based on the famous story of the "parade of dwarf and a few giant" related by Pen (1971) according to which each country's gross inland consumption is represented by its "physical height". The countries are ranked in ascending order of gross inland consumption $x$ ("height") and the typical pattern shape of the resulting profile is illustrated by a solid curve.

However, there are additional inequality's measures which are based on other points of view (World Bank, 2005; Cowell, 2011). Among the most widely used, there is the family of the generalized entropy measures ($GE$) which is defined as:

$$GE(\alpha) = \frac{1}{\alpha^2 - \alpha} \left[ \frac{1}{k} \sum_{i=1}^{k} \left( \frac{EC}{\overline{\overline{EC}}} \right)^{\alpha} - 1 \right] \tag{2}$$

Thus, when $\alpha = 0$, GE(0)= $\frac{1}{n}\left[\sum_{i=1}^{k} \log\frac{\overline{EC}}{EC_i}\right]$; when GE(1) $=\frac{1}{n}\left[\sum_{i=1}^{k} \frac{EC_i}{\overline{EC}}\log\frac{EC_i}{\overline{EC}}\right]$; and when $\alpha = 2$, GE(2)= $\frac{1}{2\overline{EC}^2}\left[\frac{1}{k}\sum_{i=1}^{k}(EC_i)^2\right]$.

Therefore, measures from the *GE* class are sensitive to changes on the lower end of the distribution for α close to zero, are equally sensitive to changes across the distribution for α equal to one and are also sensitive to changes on the upper end of the distribution for higher values. As a result, the generalized entropy index has several inequality metrics as special cases. For example, *GE*(0) is the log deviation mean, *GE*(1) is the Theil index, and *GE*(2) is half of the squared coefficient of variation.

Finally, Atkinson proposed another class of inequality measures, which have a weighting parameter ε considering different degrees of aversion to inequality. It is given by:

$$A_\varepsilon = 1 - \left[\frac{1}{k}\sum_{i=1}^{k}\left(\frac{EC_i}{\overline{EC}}\right)^{1-\varepsilon}\right]^{1/(1-\varepsilon)}, \varepsilon \neq 1 \qquad (3)$$

$$A_\varepsilon = 1 - \frac{\prod_{i=1}^{k} EC_i^{(1/k)}}{\overline{EC}}, \varepsilon = 1. \qquad (4)$$

Therefore, this index incorporates a sensitivity parameter (ε) which can range from 0 (meaning that the researcher is indifferent about the nature of the energy consumption distribution), to infinity (where we are concerned only with the consumption position of the very lowest group). The Atkinson index then varies between 0 and 1 and is a measure of the amount of social utility to be gained by complete redistribution of a given distribution. Atkinson argued that this index was a tool to incorporate Rawls' idea of social justice into the measurement of inequality. In practice, ε values 0.5, 1, 1.5 or 2 are used; the higher the value, the more sensitive the Atkinson index becomes to inequalities at the bottom of the distribution. This index varies between 0 and 1 and it is a measure of the amount of social utility to be gained by complete rearrangement of a given distribution.

Although the indices used in this paper have different characteristics, they help us to deep in the analysis of gross inland energy consumption. Gini index is more sensitivity to changes in observations located around the distributive mode whereas Theil family indices are characterized by greater sensitivity to changes in observations located at the lower end (or upper end) of the distribution ranking. In fact, all these indices support the hypothesis that it is important to examine the robustness of the results under varying inequality measures. After all, a situation of large energy consumption differences within the bottom, middle or top of the distribution are different "*types*" of inequality.

The generalized entropy (*GE*) class of indicators, including the Theil indices, can be decomposed across different partitions in an additive way into "within" and "between" components (Maio, 2007). We focus the next results on *GE*(0) and *GE*(1) decomposition. *GE*(0) can be decomposed as:

$$GE(0) = \sum_j \left(\frac{1}{N}\right) ln\left(\frac{Y}{Y_j N}\right) = \sum_j \left(\frac{N_j}{N}\right) GE_j + \sum_j \left(\frac{N_j}{N}\right) ln\left(\frac{\frac{N_j}{N}}{\frac{Y_j}{Y}}\right) \quad (5)$$

where $Y$ is the total *EC* of all $N$ countries in the sample, $Y_j$ is the total *EC* of a subgroup with $N_j$ members and $GE_j$ is the value of *GE*(0) for subgroup $j$.

Correspondingly, *GE*(1) can be expressed as:

$$GE(1) = \sum_j \left(\frac{Y_j}{Y}\right) GE_j + \sum_j \left(\frac{Y_j}{Y}\right) ln\left(\frac{Y_j/Y}{N_j/N}\right) \quad (6)$$

where $GE_j$ is the value of *GE*(1) for subgroup $j$.

Thus, we can separate the inequality measure into two components, the first of which represents the within-group inequality while the second term represents the between-group inequality.

## 3. Empirical results

On February 2015, the European Commission launched a new strategy for a resilient EU with a forward-looking climate change policy. This strategy is linked to energy consumption and its impact on GHG emissions, energy efficiency and renewable energy. Gross inland energy consumption of energy within the EU published by Eurostat (EC, 2016), shows decreasing consumption levels more as a result of the global economic crisis than as a structural shift in the pattern of energy consumption. This data set includes annual gross inland energy consumptions and final energy consumptions (both expressed in million tonnes of oil equivalent, TOE). Gross inland energy consumption, also known as total primary energy supply, represents the quantity of energy necessary to satisfy the domestic consumption of the geographical entity under consideration. This primary energy contains the final energy consumption and the energy that is consumed in the stages before the delivery to the final consumer. Hence, final energy consumption is the amount of overall energy actually consumed by the different economic sectors.

As previously said, *EC* is the total energy demand of a country or region, including energy consumption by the energy sector itself, distribution and transformation losses and final energy consumption by end users. Table 1 gives an overview of the scores of the variables. All the data are from the span period 2005-2014 and were obtained from the Eurostat database.

A simple but effective way to examine inequality is to calculate decile ratios. The calculation is done by taking, for example, *EC* by the top 80% of countries and dividing that by the *EC* by the bottom 20% of countries (P80/P20). However, it ignores information about EC in the middle of the distribution, and does not even use information about the distribution within the top and bottom deciles.

Alternatively, all the information contained in Table 1 can be made visible by means of Lorenz curves (shown in Figure 1). The diagonals of the Lorenz curves correspond to equitative *EC* distributions across countries. Table 2 shows that the value of the Gini coefficient for *EC* in EU-15 countries varies from 0,4427 in 2005 to 0,4519 in 2006, and a decrease since 2010 on.

As can be noticed there is a small shift of the Lorenz curve and the distribution inequality of *EC* across countries decreased (the Gini coefficient decreases from 44,27% to 42,16%). Though, since the distributions over time are so close to each other, we will concentrate on the distributions in 2005 and 2014 (the last year for which we have data). However, these differences are clearer when we base our results on the Parade approach. This graph plots per capita *EC* against cumulative percentage of countries. In this sense, it is important to point out that although inequality decreased over the period 2005-2014, *EC* was much higher at the bottom of the distribution in 2005 than in 2014.

FIGURE 1: LORENZ CURVE: 2005 VERSUS 2014. VARIABLE GROSS INLAND ENERGY CONSUMPTION - EU-15 COUNTRIES.

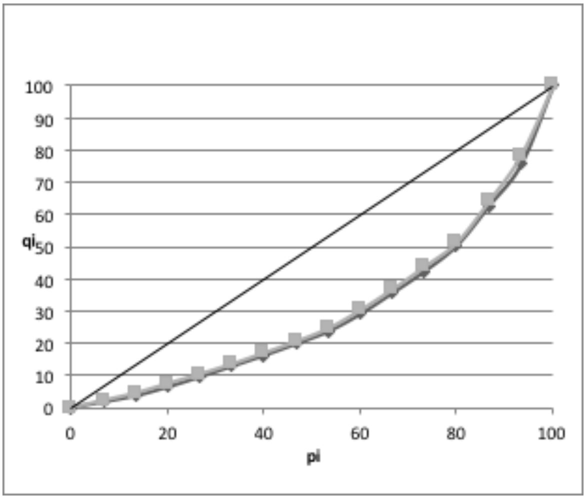
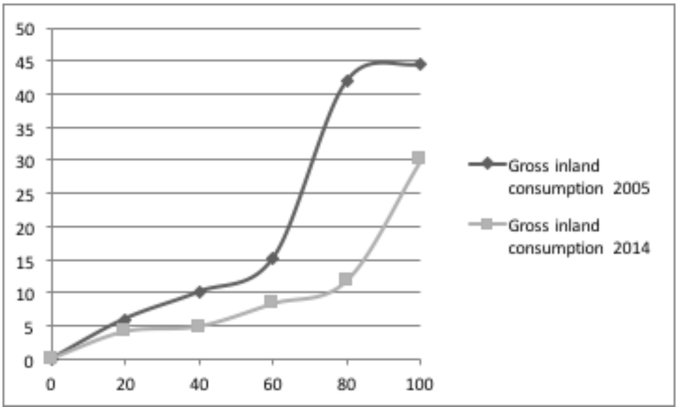


Figure 2: Pen's Parade (Quantile Function) for Gross inland energy per capita consumption, EU15 countries, 2005 and 2014




Note: On the horizontal axis, each country is ranked from poorest to richest and the vertical axis shows the level of EC per capita.

Table 1: Gross inland consumption per capita (thousands) and population (millions) by quintile. EU-15

| Gross inland consumption per capita | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| Lowest (P20) | 5.23 | 5.08 | 4.84 | 4.72 | 4.43 | 4.53 | 4.25 | 4.34 | 4.31 | 4.08 |
| Low-mid (P40) | 6.04 | 5.94 | 5.89 | 5.74 | 5.50 | 5.36 | 5.13 | 5.02 | 5.03 | 4.87 |
| Middle (P60) | 10.11 | 9.93 | 9.78 | 9.88 | 9.43 | 9.79 | 9.24 | 9.05 | 8.82 | 8.30 |
| Mid-upper (P80) | 15.24 | 15.17 | 15.14 | 14.69 | 13.52 | 13.50 | 13.09 | 12.94 | 12.21 | 11.83 |
| P80/P20 | 2.91 | 2.98 | 3.13 | 3.11 | 3.05 | 2.98 | 3.08 | 2.99 | 2.83 | 2.90 |
| | | | | | | | | | | |
| Population | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| Lowest (P20) | 5.39 | 5.40 | 5.43 | 5.46 | 5.49 | 5.51 | 5.53 | 5.56 | 5.58 | 5.62 |
| Low-mid (P40) | 9.90 | 9.95 | 9.99 | 10.02 | 10.06 | 10.10 | 10.11 | 10.12 | 10.12 | 10.12 |
| Middle (P60) | 13.18 | 13.22 | 13.25 | 13.29 | 13.32 | 13.34 | 13.35 | 13.38 | 13.44 | 13.52 |
| Mid-upper (P80) | 58.80 | 59.15 | 59.60 | 60.06 | 60.44 | 60.77 | 60.99 | 61.30 | 61.59 | 61.37 |
| P80/P20 | 10.92 | 10.95 | 10.98 | 11.01 | 11.02 | 11.03 | 11.02 | 11.03 | 11.04 | 10.92 |

Source: Authors' elaboration.

Table 2: Inequality measures

| Inequality measures | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|
| Gini Index | 0.4427 | 0.4519 | 0.4505 | 0.4445 | 0.4437 | 0.4445 | 0.4384 | 0.4324 | 0.4321 | 0.4216 |
| *GE*(0) | 0.2812 | 0.2924 | 0.2902 | 0.2831 | 0.2822 | 0.2823 | 0.2735 | 0.2656 | 0.2651 | 0.2510 |
| *GE*(1) | 0.2948 | 0.3127 | 0.3080 | 0.2969 | 0.2965 | 0.2986 | 0.2871 | 0.2776 | 0.2779 | 0.2628 |
| *GE* (2) | 0.3766 | 0.4110 | 0.3999 | 0.3771 | 0.3776 | 0.3824 | 0.3604 | 0.3435 | 0.3447 | 0.3211 |
| $A_{0.5}$ | 0.1356 | 0.1420 | 0.1405 | 0.1366 | 0.1363 | 0.1368 | 0.1324 | 0.1286 | 0.1285 | 0.1220 |
| $A_1$ | 0.2451 | 0.2535 | 0.2519 | 0.2466 | 0.2459 | 0.2460 | 0.2393 | 0.2333 | 0.2329 | 0.2219 |
| $A_{1.5}$ | 0.3297 | 0.3372 | 0.3359 | 0.3306 | 0.3296 | 0.3286 | 0.3210 | 0.3139 | 0.3128 | 0.2992 |
| $A_2$ | 0.3940 | 0.3992 | 0.3981 | 0.3933 | 0.3923 | 0.3897 | 0.3817 | 0.3742 | 0.3725 | 0.3571 |

Source: Authors' elaboration.

All the inequality measures considered (Gini index, Generalized Entropy measures and Atkinson indices) agree that inequality is lowest in 2014 and is highest in 2006 (see Table 2). So, the choice of one measure over another is not a key point in the discussion of *EC* distribution. As the EU-15 countries are extremely heterogeneous in some aspects, four clusters of countries are generally considered: Mediterranean border (Spain, Italy, Portugal and Greece), Continental (Germany, France, Belgium, Luxembourg and Austria), Nordic (Denmark, Finland, Sweden and the Netherlands) and Anglo-Saxon ones (United Kingdom and Ireland).

The results of these decompositions are included in Table 3. As can be noticed, the "within inequality" is very small in all the groups of countries and the "between-group" component of inequality explains the highest share of total inequality. As pointed out by Cowell (2005), Theil's approach to the measurement of inequality is set in the context of subsequent developments over recent decades. It leads naturally to a very general class of decomposable inequality measures which are closely related to other ones.

Thus, once we have decomposed changes in the inequality groups (between and within-group components) and countries have been grouped according to a regionalization criteria, we want to point out the following results. Firstly, inter-group inequality, and its decline, can explain the reductions that occurred in international inequalities. Secondly, with regard to the "between" component the main reduction is noticiable when we compare 2005 and 2014. Thirdly, we have to take into account the relative population of each group. The results suggest that althoug *EC* per capita typically explains international inequalities, there exist differences among the groups of countries.

The economic crisis suffered by EU countries during the last years has been remarkable given its intensity and complexity. Also, we have to take into account population changes over time which depend on three main factors: births, deaths and migratory flows. In addition, the current low levels of fertility and mortality are linked with a progressive ageing of the population. This phenomenon is particularly detected in Mediterranean countries. Between 2014 and 2005, the share of Mediterranean's population increase from 32,05% to 32,14%, Continental's one fall from 42.13% to 41.38%; Nordic's one increase from 9.32% to 9.44% and Anglo Saxon's one increase from 16.49% to 17.05%. So, the variations are not very significant.

However, Mediterranean countries have been very sensitive to the economic crisis. Duiella and Turrini (2014) reviewed development in poverty across EU countries after the crisis and analysed their main macro drivers. In fact, these authors pointed out that those countries most severely hit by the crisis (Spain, Greece, Ireland, Portugal and Italy) recorded steep increases in severe material deprivation, at risk of poverty rates and high unemployment rates. From another point of view, some authors (Chiou-Wei *et al.*, 2008; Tsani, 2010; Belke *et al.*, 2011; Yildirim, 2012) have found a strong causal relationship between consumption of energy and GDP growth. Thus, the better understanding of all these factors, could help us to explain gross inland energy consumption in Europe.

Table 3: Decomposition of Inequality in EC per Capita by clusters of countries, 2005-2014 using the Generalized Entropy Indices

| | Clusters of countries | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | All EU15 | 0.2812 | 0.2924 | 0.2902 | 0.2831 | 0.2822 | 0.2823 | 0.2735 | 0.2656 | 0.2651 | 0.2510 |
| | Continental | 0.1805 | 0.1975 | 0.1891 | 0.1810 | 0.1870 | 0.1813 | 0.1674 | 0.1577 | 0.1623 | 0.1503 |
| | Mediterranean | 0.0272 | 0.0200 | 0.0171 | 0.0167 | 0.0167 | 0.0122 | 0.0102 | 0.0122 | 0.0120 | 0.0085 |
| ***GE*(0)** | Nordic | 0.0355 | 0.0337 | 0.0333 | 0.0338 | 0.0321 | 0.0432 | 0.0410 | 0.0376 | 0.0521 | 0.0454 |
| | Anglo-saxon | 0.0027 | 0.0004 | 0.0008 | 0.0001 | 0.0006 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0001 |
| | Decomposition | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| | Within inequality | 0.0773 | 0.0802 | 0.0766 | 0.0738 | 0.0754 | 0.0752 | 0.0694 | 0.0659 | 0.0712 | 0.0645 |
| | Between inequality | 0.2040 | 0.2122 | 0.2136 | 0.2093 | 0.2068 | 0.2071 | 0.2041 | 0.1998 | 0.1939 | 0.1865 |
| | Clusters of countries | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| | All EU15 | 0.2948 | 0.3127 | 0.3080 | 0.2969 | 0.2965 | 0.2986 | 0.2871 | 0.2776 | 0.2779 | 0.2628 |
| | Continental | 0.0071 | 0.0763 | 0.0710 | 0.0651 | 0.0677 | 0.0724 | 0.0629 | 0.0563 | 0.0604 | 0.0525 |
| | Mediterranean | 0.0270 | 0.0199 | 0.0170 | 0.0165 | 0.0166 | 0.0121 | 0.0101 | 0.0121 | 0.0119 | 0.0085 |
| ***GE*(1)** | Nordic | 0.0321 | 0.0307 | 0.0304 | 0.0309 | 0.0292 | 0.0383 | 0.0366 | 0.0335 | 0.0452 | 0.0399 |
| | Anglosaxon | 0.0027 | 0.0004 | 0.0008 | 0.0001 | 0.0006 | 0.0000 | 0.0000 | 0.0002 | 0.0003 | 0.0001 |
| | Decomposition | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 |
| | Within inequality | 0.0141 | 0.0550 | 0.0515 | 0.0477 | 0.0489 | 0.0532 | 0.0468 | 0.0423 | 0.0472 | 0.0407 |
| | Between inequality | 0.2807 | 0.2577 | 0.2566 | 0.2492 | 0.2477 | 0.2454 | 0.2402 | 0.2353 | 0.2308 | 0.2221 |

Source: Authors' elaboration.

Note: *GE* denotes the corresponding Generalized Entropy Index when $\alpha = 0$ or $\alpha = 1$.

## 4. Conclusions

The analysis done yields some interesting results such as small shifts in the Lorenz curves; decreasing inequality measures over the period; important differences among the four clusters of countries (Mediterranean, Continental, Nordic and Anglo-Saxon) even at the bottom of the distribution; a very small within group inequality. The Theil indexes provide helpful information for the debate on inequalities related to energy consumption in the EU countries. As can be noticed from the small shift of the Lorenz curve, the inequality in the distribution of *EC* across countries has decreased from 44.27% to 42.16% along the period. However, these differences are clearer when we base our results on the Parade approach: although inequality decreased over the period 2005-2014, *EC* was much higher at the bottom of the distribution in 2005 than in 2014 and the value of the Gini coefficient for *EC* distribution varies from 0,4427 in 2005 to 0,4519 in 2006, decreasing since 2010. This important result has consequences on climate change. The EU-15 *EC* falls over the last years although there exist huge differences among countries.

Finally, it is important to notice that the analysis undertaken, concerning the study of international inequalities in *EC* per capita, is relevant for the study of world inequality in itself (between countries). However, and as described by Duro (2013), worldwide inequality can be broken down into a component that reflects differences in average *EC* between countries Inequalities in gross inland energy consumption, that EU countries (specially mediterranean ones) have suffered during the last years and it could reflect the impact of the global economic crisis on energy utilization intensity. Evidencing the necessity of maintaining high sustainability levels (socially and economically) and of reducing inequalities should be an important point for policymakers.

This paper contributes to the existing literature since it is innovative in the way it uses final energy consumption – gross inland consumption – in order to have an indicator of the losses that occur throughout the transport, distribution and transformation stages in the delivery of final consumption energies, inequality measures are introduced to study energy consumption in order to allow the ranking of the EU countries using the most recent data and feels a gap in the existing literature.

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