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Juan Antonio Duro

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Departament d'Economia
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Universitat Rovira i Virgili
Facultat d'Economia i Empresa
Avgda. de la Universitat, 1
43204 Reus
Tel.: +34 977 759 811
Fax: +34 977 300 661
Email: sde@urv.cat

CREIP
www.urv.cat/creip
Universitat Rovira i Virgili
Departament d'Economia
Avgda. de la Universitat, 1
43204 Reus
Tel.: +34 977 558 936
Email: creip@urv.cat

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Facultat d'Economia i Empresa

The International Distribution of Energy Intensities: some synthetic results

Juan Antonio Duro

Department of Economics and CREIP, Rovira i Virgili University

juanantonio.duro@urv.cat

Abstract

The paper examines the international distribution of energy intensities as a conventional proxy indicator of energy efficiency and sustainability in the consumption of resources, by employing some descriptive tools from the analysis of inequality and polarization. The analysis specifically focuses on the following points: firstly, inequalities are evaluated synthetically based on diverse summary measures and Lorenz curves; secondly, different factorial decompositions are undertaken that assist in investigating some explanatory factors (weighting factors, multiplicative factors and decomposition by groups); and thirdly, an analysis is made of the polarization of intensities when groups of countries are defined endogenously and exogenously. The results obtained have significant implications from both academic and political perspectives.

1. Introduction

The uncoupling of energy consumption and economic growth plays a crucial in achieving a carbon-free society. Thus, for example, based on the European Union Energy Roadmap 2050, the continental objectives of reducing emissions by 80% by 2050 imply, in all working hypotheses, the need for substantial improvements in energy efficiency and hence for reduction in the consumption of resources, not only in relative terms but, most importantly, in absolute terms. In fact, the necessity for reducing consumption in absolute terms (as a strong condition) and for making this compatible with economic growth implies considerable progress in energy intensities. [1] In such circumstances, the analysis of this indicator, and its international distribution, are a subject of academic and political interest.

Energy intensity, as a broad environmental indicator can, in fact, be interpreted based on a variety of factors (Steinberger and Krausmann, 2011). Firstly, in accordance with the classical environmental impact descriptive models IPAT and STIRPAT (Ehrlich and Holdren, 1971), intensity can be associated with technology. Based on this, the environmental impact on a system (I) is the product of multiplying population factors (P), affluence (A) and technology (T). In this context, technology would attempt to balance out the requirements and excesses attributable to the demands on resources by the population and the economy. Secondly, the intensities can be interpreted in terms of the sectorial

[1] Obviously, then, improvements (i.e. reductions) in energy intensity are a necessary but not sufficient condition for achieving a strong sustainability. Strong sustainability would require a reduction in global consumption and consumption would need not merely to be inelastic to GDP growth, but to have negative elasticity (see Böhringer and Jochem, 2007).

structure and its changes. Thus, this indicator can change as a result of changes in the composition of production in favour of sectors that consume more or less energy (Schäfer, 2005). Thirdly, this indicator, being linked strictly to the demand for resources (in this case energy), is associated with a concept of sustainability and reflects, for example, the relative decoupling between the economy and the consumption of resources. In a world which, in principle, has finite energy resources, endless economic growth is only possible if energy intensity is significantly reduced. Therefore, the analysis of this indicator is interesting insofar as it relates to the sustainability of the endless development model and the demand for energy.

However, beyond the analysis of intensity levels, it may be interesting to examine how this indicator is shared between countries. In this sense, the analysis would be related to the literature on international environmental equity (Daly, 1992). In fact, in the environmental field, analysis of the international distribution of indicators has recently been attracting much interest. Technically, the analysis of international environmental distribution has relied on two major approaches, complementary in terms of the subject under study but differing in the tools employed. Firstly, a series of studies have used convergence analysis based on the suggestive works of Barro and Sala-i-Martin (1996) and Quah (1996a, 1996b), which focus on the basic use of σ- and β-convergence techniques. Secondly, there are studies that use tools developed in the analysis of inequality (Cowell, 1995), which typically examine distributions with a cross-section focus (similar, in fact, to that used in the analysis of σ-convergence), which have usually concentrated on the properties of the measurements and the possibility of their decomposition.

Environmental distribution analysis has been applied to indicators such as CO_2, the carbonization index, emissions intensity (CO_2/GDP, the environmental footprint and the consumption of materials (Hedenus and Azar, 2005; Duro and Padilla, 2006; White, 2007; Jobert et al., 2010; Duro, Alcántara and Padilla, 2010; Steinberger et al., 2010; Cantore, 2011; Duro, 2012; or Camarero et al., 2013). In particular, the analysis of the international distribution of energy intensities is of interest, both academically and in terms of policy, for the following reasons: firstly, because it helps in understanding the sharing of effort between countries in terms of relative resource consumption, and, therefore, in analysing the degree of differential responsibility within the overall context. Specifically, a situation where intensities are reduced globally, but at the cost of widening the gaps between countries, has different implications to the generally preferable situation in which the global change includes a narrowing of the inter-country gaps. Secondly, decomposition analyses can address some explanatory factors and may also have some useful policy implications. For example, as we will see, the decomposition of inequality by groups of countries (regional groupings, or by level of development) can be used as a guide for a global design of policy and strategies aimed at reducing inequality. Finally, analysis of polarization (Esteban and Ray, 1994 and Esteban et al., 2007), which is a distributive concept essentially different from inequality, seems the best approach for understanding the possibility of the materialization of international conflicts implicit in the situation – this being an aspect of great importance for current global trading scenarios. Knowledge of the degree of energy intensity polarization around poles of distant countries, and also the factors that characterize these, can be useful in guiding reductions in polarization, in alleviating the inherent distributive conflict and, thus, in increasing the chance of reaching international agreements related to this environmental target.

In terms of the literature, international distributive analysis in terms of energy intensities has relied on contributions such as those of Sun (2002), Alcántara and Duro (2004), Markandya et al. (2006), Ezcurra (2007), Duro (2012) and Herrerías (2012). Sun (2002) analysed a reduction in the inequality of energy intensity between countries in the Organization for Economic Co-operation and Development (OECD) by considering deviations from the mean. Alcántara and Duro (2004) used the Theil index, which weights observations according to GDP and gives greater importance to those countries with a greater share of global production. Markandya et al. (2006) used convergence-type analysis to confirm the relationship between energy intensities and income convergence for the countries of Eastern Europe, finding a positive ratio between the convergence of the mean European income (increase) and convergence in intensities (decrease). Ezcurra (2007) analysed inequalities in energy intensities between 1971 and 2001 using non-parametric techniques. Duro et al. (2010) analysed the role of intensities in explaining the difference in consumption per capita based on multiplicative inequality decompositions for 1980–2006. Duro (2012) analysed inequalities in energy intensities using different summary indices for the period 1971–2006 (without carrying out any decomposition analysis); Herrerías (2012) analysed the distribution of intensities between 83 countries during the period 1971–2008 based on dynamic distribution techniques. In light of the previous literature, this paper aims at extensively exploiting the analytical possibilities related to different decompositions, at carrying out a polarization analysis, and at updating the calculations to the period 1990–2011 and for a greater number of countries (137).

In particular, this paper will provide a detailed study of the different distributive analysis instruments available for the exploration of energy intensities. Thus, we can highlight the following differential contributions: firstly, a standard inequality analysis is performed in parallel with a variety of decompositions. Specifically, the paper distinguishes the importance of weighting factors as opposed to a vector of intensities in order to explain global inequality. It makes intensive use of the possibilities associated with the decomposition by country groupings (by regions, or by levels of development); the work additionally includes different multiplicative decompositions for analysing the role played by different factors. Secondly, a polarization analysis is applied to energy intensity based on both endogenous and exogenous techniques. This concept is very useful in terms of understanding both potential instability and the probability of reaching certain agreements on the world stage.

The paper is therefore structured in the following way: the second section provides a review of a variety of methodological aspects of interest relative to the measurement of inequality, its decomposition and the analysis of polarization. The third section presents the main results associated with the implementation (using an extensive territorial coverage and different groupings) of the aforementioned techniques and instruments in the analysis of international inequalities in energy intensities in the period 1990–2011. Finally, there is a section that brings together the main considerations arising from these analyses.

2. Methodological Aspects

Intensity in the consumption of resources is thus a highly important objective in guaranteeing the sustainability of the planet and in being able to balance economic growth with environmental sustainability. This study addresses the international distribution of this indicator. Although different distributive dimensions exist, the main one analysed thus far concerns inequality (or convergence if preferred). The main methodological elements of interest in respect of the initial focus come from the literature on *inequality measurement* (Cowell, 1995).

The first essential aspect concerns synthetic measurement. In this respect, the literature describes indicators that are consistent with the Lorenz dominance criterion.[2] Duro (2012), for example, has suggested some suitable candidates for this measurement in the field of analysing environmental indicators. Thus, the inequalities could be measured by means of three reasonable indicators: the coefficient of variation (CV), the Gini coefficient and the Theil index:

[2] In other words, indices that are consistent with ordering distributions based on Lorenz curves. In fact, Lorenz curves associated with different distributions occasionally can intersect, which makes the calculation of the summary indices even more important (Duro, 2012).

$$CV_{\omega} = \frac{\sigma_{\omega}}{\mu} \qquad (1)$$

$$G = \frac{1}{2\mu}\sum_i \sum_j p_i p_j \left| y_i - y_j \right| \qquad (2)$$

$$T(\beta = 0) = -\sum_i p_p \log\left(\frac{\mu}{y_i}\right) \qquad (3)$$

where p_i and p_j are GDP-shares (adapted to the analysis of energy intensities); y_i the energy intensity in country "i", μ the energy intensity world mean and σ_w the weighted standard deviation.

These indices, which are weighted (heterogeneous treatment of the observations) and measure distances between countries (energy intensities in this case) have differing properties. In particular, those that weight distances between countries do so in a different manner. The CV, for example, is neutral and therefore the position of the observations (i.e. countries) in the rankings has no importance. The curious property of the Gini coefficient is its automatic higher sensitivity to changes that occur in observations around the mean; the Theil index, meanwhile, is especially sensitive to lower intensity changes that occur (i.e. the lower part of the distribution). Given these differences, it makes sense to manage the different perspectives with a view to having a complete overview of the situation and its patterns.

Secondly, apart from measurement, another very interesting property in this context is the capacity of these indices to decompose, in particular the Theil measurement (Bourguignon, 1979). This study will make use of three possible decompositions:

1. Given that the indices are weighted (in this case, according to GDP-shares), their evolution may depend not only on how the intensity vector changes but also on how the weighting vector changes. Indeed, the reader should note that energy inequalities could change without any variation in the intensities in each country, simply through changes in their weightings. In this respect, it could be interesting to look into this question.[3]

To do so, Duro (2013), for example, used a *shift-share* decomposition exercise, which gives a very intuitive way of clarifying the role of these factors.

In particular, and assuming that a weighted-inequality index (I) depends on vector "p" for weights (in our case GDP-shares) and "e" for energy intensities it can be decomposed its temporal variation in the following way:

$$I(p_{t+1}, e_{t+1}) - I(p_t, e_t) = \{I(p_t, e_{t+1}) - I(p_t, e_t)\} + \{I(p_{t+1}, e_{t+1}) - I(p_t, e_{t+1})\} \quad (4)$$

where p_t and p_{t+1} are the GDP-shares at time t and t+1; e_t and e_{t+1} are the energy intensities at time t and t+1; and I(.) is a weighted-inequality index.

Thus, the first term in the RHS of the expression (4) captures the change in the energy intensities inequality that can be due partly to the changes in the energy

[3] Obviously the "problem" would disappear when using unweighted indices. Nevertheless, we understand that it is more reasonable to use a heterogeneous treatment of the different countries.

intensities vector; and the second term is linked to the role attributable to changes in GDP-shares vectors.

In fact, apart from its simplicity, one of the main attractions of this decomposition is that it is generally applicable to any weighted-inequality index.

2. The previous indices, especially the Theil index, can be decomposed multiplicatively thanks to the properties of the logarithm function. In this respect, a known multiplicative decomposition adopts the Kaya identity (1989) as a reference. Based on this expression (adapted in per capita terms) per capita emissions depend on three main factors: first, the carbon intensity (emissions/energy consumption) which basically is related to the energy mix the country has and, therefore, the weight of energy generation through low carbon sources (i.e. nuclear and renewables); secondly, it the energy intensity factor, related to the sectoral mix and energy efficiency; and finally the affluence component, typically measured by GDP per capita. Therefore, we should consider the following expression:

$$c_i = a_i * e_i * y_i \tag{5}$$

where c_i are carbon per capita emissions in country "i"; a_i is carbon intensity; e_i is energy intensity; and y_i is per capita GDP.

Synthetically, and as demonstrated by Duro and Padilla (2006), we can decompose global inequalities of *c*, using the Theil index, into the sum of the partial contribution to inequality attributable to each of the multiplicative factors and two correlation factors, one associated with the covariance between carbonization and the other factors, and the second associated with the interaction between intensity and affluence. Given this, we have:

$$T\ (c) = T^{a} + T^{e} + T^{y} + inter_{a,ey} + inter_{e,y} \qquad (6)$$

In a similar way, energy intensities can be decomposed as consumption per capita component (cp) and the inverse of GDP per capita (1/y). In this way, the inequalities in the intensities can be expressed as follows:

$$T(e) = T^{cp} + T^{1/y} + inter_{cp,1/y} \qquad (7)$$

This type of analysis aims at contextualizing the role of energy intensity in the context of international equity in carbon emissions (in both static and dynamic terms). This we believe to be an interesting contribution to the global debate on international emission liabilities and on mitigation / reduction strategies. It allows us, not only to clarify the role of the energy intensity factor in the changing international emission inequality scenario, but also to assess the appropriateness of focusing future strategies on reducing inequality in this factor.

3. Global inequalities in energy intensities can be also decomposed into components of between- and within-group inequality, when countries are grouped by a criterion of interest. In this respect, for example, it might be of interest to use the regional criterion provided by the IEA itself, which

differentiates new regional groups. Specifically, the between- component corresponds to the inequality that would exist if the groups were internally homogenous and the only differences were between group means. The second consists of capturing the average of the internal inequalities. The Theil index is best equipped to be decomposed in this way (Shorrocks, 1984). Then, the decomposition is expressed as follows:

$$T(e) = \sum_{g=1}^{G} p_g \, T(e)_g + \sum_{g=1}^{G} p_g \, ln\left(\frac{\mu(e)}{\mu(e)_g}\right) \quad (8)$$

where p_g is the GDP-share of group g, $T(e)_g$ denotes the internal inequality in group g, and $\mu(e)_g$ represents the average energy intensity in group g.

This decomposition has two major implications, one analytical and the other in terms of policy. In analytical terms, the weight of the inter-group component indicates the analytical importance of the established groupings as well as yielding information about the internal homogeneity of the groups. In policy terms, this factor might indicate an opportunity to use these aggregations as units of reference when establishing environmental policy objectives.

Finally, in addition to the previous inequality analysis, polarization is a distributive concept that is fundamentally different from that of inequality and has attracted significant attention in recent years. This concept is associated with the structuring of distribution (in this instance, energy intensities by country) around homogeneous and opposing groups. Rather than inequality, this concept is more closely linked to the notion of conflict and potential instability (Esteban and Ray, 1999). Depending on how the groups are characterized (number of groups, their sizes, internal cohesion and discrepancies), a study of polarization can offer some guidance on possible strategies.

If we follow the pioneering approach suggested in Esteban and Ray (1993), polarization depends on the following factor: the number of groups (the fewer the groups, the greater the polarization); their size (polarization is a matter of group weight); their internal homogeneity (intra-group cohesion increases polarization); and the distance between groups. Using these axiomatic properties, Esteban, Gradín and Ray (2007) suggested a family of multi-polarization measures (EGR measures) that allow the concept to be cardinalized. They are expressed specifically as follows:

$$EGR(\alpha,\beta)=\sum_{i=1}^{n}\sum_{j=1}^{n}p_i^{1+\alpha}p_j\left|\frac{e_i}{e}-\frac{e_j}{e}\right|-\beta(G-G_s) \qquad (9)$$

where p_i and p_j are the GDP-shares of countries i and j; e_i and e_j are the energy intensities of countries i and j; e is the world average; α is a parameter that captures the sensitivity of the measure to polarization (its value goes from 1 to 1.6); β is a parameter which captures its sensitivity to the groups' cohesion (internal error); G is the Gini coefficient of the original distribution; and G_s is the Gini coefficient of the grouped distribution (between-group inequality).

At this point, two issues become worthy of comment. Firstly, there is the matter of the number of groups, which the formula does not establish. Typically, the studies tackle the analysis of 2, 3 or 4 groups, given that including more groups usually only produces a marginal gain in the explanatory capacity. The selection of the definitive “ideal” number of groups is determined by the analysis itself (the higher the EGR value, the better). Secondly, the optimum way of determining the maximum number of groups should be found, whichever the number decided on *ex-ante* might be. For this, Esteban, Gradin and Ray (2007) recommend using the optimization method proposed by Davies and Shorrocks (1989).[4]

Additionally, the literature has produced individual measures for analysing bipolarization. In this case, the measures calculate the degree to which the evaluated distribution resembles a symmetrical bimodal distribution, with the poles located at the ends of the range. One of the best known is the Wolfson measure (1994), whose additional advantage is its direct derivation from Lorenz curves. Its usual expression is the following:[5]

$$W = \frac{0.5 - L(0.5) - G}{\frac{m}{\mu}} \qquad (10)$$

where L(0.5) corresponds to the median of the Lorenz curve; G is the Gini coefficient; and m, in this case, is the average per capita intensity.

It may also be appropriate to manage groups by predetermination, as for the regional IEA groups examined earlier. In this case, we would be implicitly

[4] In fact, based on this optimum structuring method, two groups would use the measure as an inter-group separation value

[5] In fact, Esteban, Gradín and Ray (1999) demonstrated that this measure could be rewritten as an individual case within the EGR family, when $\alpha=\beta=1$ and the distributive measure are replaced by the median.

considering the existence of a feeling of identification and proximity between countries that form a geographical or administrative area. Among the measures used by exogenous groups, the suggestion put forward in Zhang and Kanbur (2001), henceforth Z–K, may be used. It basically consists of using group decomposition components (Shorrocks, 1980 and 1984) of the abovementioned inequality to reorder them, deriving a measurement consistent with the axiomatic principles of polarization. Specifically, using the Theil index (Theil, 1967), which is perfectly decomposable in these terms, the Z–K measure is expressed as the ratio of the between- and within- components:

$$Z - K = \frac{T_b}{T_w} \qquad (11)$$

3. Main Results

The data used in the section come in all cases from the International Energy Agency (IEA).[6] Energy consumption refers to the Total Primary Energy Supply (million of TPES, Tonnes of Oil Equivalent) and GDP equates to PPP (Purchasing Power Parity, billion 2005 US dollars**).** The sample includes 137 countries, representing more than 97% of global energy consumption and GDP. The reference period of the analysis is from 1990 to 2011. The start point of 1990 coincides with the first year in which data is available for all of the countries in existence today.

[6] http://www.iea.org/statistics/

Initially Table 1 shows the main results of energy intensity in a variety of exogenous country groupings, which represent the regions proposed by the IEA and the income groups identified by the World Bank.[7] Some initial points of interest can be observed in these data:

First, energy intensity dropped during the period, going from 0.24 to 0.18, representing a fall of nearly a quarter. This is a general regional pattern except in the case of the Middle East.[8]

Second, this relatively good result, which implies progress towards relative decoupling, nevertheless coincided with an increase of 48% in total primary energy consumption and growth of 13% in per capita terms.[9]

Third, the non-European OECD zones, i.e. Eastern Europe, the Middle East, China and Africa, appear as those with a higher intensity of energy use, while the European OECD countries show the least intensity.

Fourth, according to income level and in line with the above, there are the countries with higher incomes that display, on average, lower intensities (0.16) and those with low incomes that show higher levels (0.28).

Fifth, the global reduction in intensities has largely depended on the prominence of Eastern European countries (Russia) and China, with a clear process of convergence towards the mean.[10]

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[7] http://data.worldbank.org/about/country-and-lending-groups

[8] A similar pattern has occurred with other resource consumption indicators, as in the case of the consumption of materials. For example, Krausmann et al. (2009) identified a drop in the intensity of the consumption of materials during the last hundred years.

[9] If fact, this would only occur when the drop in energy intensities is higher than the GDP growth rate. Unfortunately, Richmond and Kaufmann (2006) found evidence that the turning point between income and energy use, if it occurs, would happen at very high levels of development, which exceed the current maximum levels.

Sixth, in terms of income, all the groups show falls in intensity, especially the middle-income bracket.

Seventh, a reduction can be seen in the disparities between regional blocks. For example, the max-min ratio went from 4.3 in 1990 to 2.8 in 2011.

Insert Table 1 about here

However, the interest lies beyond the partial data mentioned above and is more concerned with getting an indication of what happened to inequality in energy intensities by country over the period of the analysis. To achieve this, Figure 1 initially reproduces the Lorenz curves associated with the distribution of energy intensities by country for the selected years of 1990, 2000 and 2011. It is very evident that, in Lorenz terms, the distributions for 2000 and 2011 clearly dominate that of 1990. Therefore, all of the consistent synthetic inequality indices will be lower in 2000 and 2011 than in 1990. Nevertheless, this dominance is not reflected when comparing the distribution of 2000 with that of 2011, in view of the intersections observed at the mid-section of the curves. Given this situation, firstly the summary indices (revised in Section 2) are necessary and, secondly, these may give contradictory results. In this respect, in Table 2 three benchmark summary indices of inequality have been reproduced (weighted) for selected years during the period. Specifically, they include the coefficient of variation (CV), which is a neutral index (all

[10] In the case of Eastern European countries, Markandya et al. (2006) had already identified behaviour that was imitative of Western patterns (i.e. a catching-up effect). In the case of China, Wu (2012), for example, provided a detailed analysis of the explanation of intensities and their evolution in a national and regional context. In this respect, the importance of the role of energy efficiency in the evolution of intensities is determined (and by comparison the lesser importance of the sectorial factor).

observations are treated in the same way regardless of where they are located), the Gini coefficient (which is especially sensitive to mean observations), and the Theil index (which is especially sensitive to changes in countries with lower intensities). The results unanimously indicate a drop in inequalities during the period, with the Gini and Theil indices showing the process of reduction stopping between 2005 and 2011. These differences, in fact, are attributed to the different characteristics of indices dealing with average distances between observations (Duro, 2012). In particular, the stabilization of the Gini and Theil indices relative to the CV implies that the Lorenz curves for 2005 and 2011 are very close until the middle section is reached and then are separated over the range of observations with higher intensities (i.e. inequality reduction process). In particular, the approximation to the equity line of the top section of the Lorenz curve in 2011 is basically explained by the reduction of the relative intensity experienced by China, which fell from a relative intensity of 1.69 to 1.51 between 2005 and 2011.[11] Continuing with comparisons, in particular between 2000 and 2011, it can be seen that the Gini coefficient shows little variation, far less than the drop experienced in the Theil index and the coefficient of variation. Whatever the case, and despite the differences in the degree of reduction, all three measures globally conclude that, synthetically, the international distribution of intensities has levelled out, leading to a drop in the global average and its inequality – the best possible scenario for global distribution.

Insert Figure 1 about here

[11] The author can supply further details on request. "Relative" here refers to the world level.

Insert Table 2 about here

At this point, it is worth testing the importance that the weighting factor may have had in this process. Indeed, given that the data for each country are weighted according to their GDP-share it could, hypothetically, be possible that changes in this factor might offer a significant explanation for changes in the global index. In other words, changes in the previous synthetic indices could become decomposed into a factor associated with changes in the vector of GDP-shares and another factor that effectively assimilates the role of changes in the energy intensities vector. Following Duro (2013), it is possible to clarify the situation using a decomposition based on the construction of a fictitious distribution (Equation 4). Table 3 provides the calculations for the evolution in the overall period, various sub-periods and the three previous summary indices. Specifically, the data demonstrate that during the overall period the main changes to weighted inequalities in intensities were indeed attributable to changes in the intensity vector by country. In any event, in some of the sub-periods, such as the 1990s, the role of weighting vectors, in this case GDP-shares, played a very important role in reducing summary inequalities (much of this being attributable to China and its increase in the share of GDP). Additionally, it can be seen that in the period between 2000 and 2011, changes in GDP-shares acted to encourage inequalities in intensities rather than reduce them. In this period, this result was mainly attributable to the US observation and the change that result from the application of the weighting structure 2000 (GDP-shares) in average energy intensity of 2011. In particular, this application would reduce the global average energy intensity of 2011 in relation to that actually observed, so that the energy intensity of the US would have come closer to the global average, reducing inequality compared to that actually observed in 2011. In fact, in the analysis by sub-period, the role of the weighting factor is relevant. Therefore, in general terms, it is necessary to proceed with caution when drawing conclusions on inequalities based only on changes in the vector of intensities by country.[12]

Insert Table 3 about here

On the other hand, as reviewed in the foregoing section, it is worth taking advantage of the decomposition capacities of one of the previous indices to address some interesting explanatory analyses. In this respect, we propose three exercises.

First, the intention is to evaluate the explanatory capacity of the intensities factor as a determining element in CO_2 emissions per capita, thereby updating the work undertaken by Duro and Padilla (2006), whose data ended in 2002. In this respect, if the Kaya identity is taken as a reference (1989),[13] CO_2 emissions (as a major global environmental goal subject to negotiation) can be broken down into per capita terms, with three main elements: first, the carbonization index (CO_2/energy consumption), which is typically associated with the energy mix of each country (weight of fossil fuels as part of the total); second, the

[12] The aspect of the importance of weighting factors as an element for explaining patterns in the implementation of distributive analytical tools is also highlighted by authors such as Herrerias (2012).

[13] The IEA typically uses this identity as an example to explain the CO_2 levels by country.

intensities which, as mentioned earlier, rely strictly on energy efficiency and the sectorial mix; and finally affluence, as a factor of economic scale. Following Duro and Padilla (2006), inequalities in CO_2 can, in fact, be broken down into the sum of the partial contributions of each of the factors plus a series of factorial correlations. Table 4 shows the main results. These indicate, for example, that the partial contribution of the energy intensity factor, which is the factor that concerns this paper, would have been reduced to representing 17% of international inequalities in CO_2 per capita, a weight that is not very far from that attributable to the carbonization factor, whose weight, in fact, has increased.[14] Whatever the case, the drop in inequalities is reliant, above all, on the significant reduction in the contribution of the affluence factor, which has gone from 95% to 80%. In any event, this decomposition illustrates the significant negative covariance between the energy intensity factor and the GDP per capita.[15]

Insert Table 4 about here

[14] In this respect, different studies for different samples and countries have established the importance of the energy efficiency factor and not that of the sectorial component as a powerful explanation of the reduction in energy intensities and their disparities (Wu, 2012; Mulder et al., (2014; Metcalf, 2008; or Duro et al., 2010, among others). The point, in every case, is that the greater importance of energy efficiency as an explanatory element in the reduction in intensities would increase the relative weight in the total sectorial component.

[15] Regarding this particular decomposition, the results obtained are an update of those of Duro and Padilla (2006). In that paper, a similar multiplicative decomposition of CO_2 was performed for the period 1971-1999, but with a smaller sample of countries. They observed partial reduction of the energy intensity inequality contribution up to 1999. It should be noted that there are differences between the weights obtained in that paper and those in the current paper - these differences are explained by differences between the two samples. The present paper carries out additional exercises that are focussed on energy intensities rather than carbon emissions.

Secondly, these advantages can be used once again to simultaneously decompose the energy intensity factor into two components: one, the consumption per capita vector, and the other, the inverse of the affluence factor, in such a way that the intensities will be lower when consumption per inhabitant is lower and the GDP per capita is higher. This is a two-factor decomposition and thus the covariance component is very attractive in that it reflects the weighted covariance of both factors (Duro and Padilla, 2006). Table 5 illustrates the main results and points to the partial significance of the affluence factor, and given its reduction, its approximation to the consumption factor weight.[16] Indeed, the partial contribution of the consumption factor drops quite a lot less. The covariance factor is extremely high. Indeed, if consumption per capita is a function of income, in the end the bulk of the inter-factorial covariance would have to be assigned to this factor (Steinberger and Krausmann, 2011).[17] Whatever the case, the partial importance of consumption at the present day makes it necessary to explore ways of reducing its level and dispersion across every country.

Insert Table 5 about here

Thirdly, the Theil index, and hence inequalities in intensities, can be decomposed by groups. In this respect, they need to be broken down into one

[16] The partial contribution of each factor is seen as the contribution to inequality that the factor in question would have if it was the only one that varied throughout the countries (the others remaining established in the mean). See Duro and Padilla (2006).

[17] Indeed, many studies for various samples, using multiple regression analyses, emphasize the importance of income as an explanatory element of energy intensities (Metcalf, 2008; Wu, 2011, amongst many others). Thus income convergence would be significantly behind energy intensity convergence.

component that captures the differences between groups of countries and another which records internal discrepancies. This analysis, in essence, provides information on the explanatory importance of groupings of countries of interest in terms of the differences in intensities and their evolution.[18] Here, we are going to use two types of structures: one regional, in line with the groups identified by the IEA (9) and the three groups of countries grouped by income identified by the World Bank (as in Table 1). With regard to the regional groupings, the results show that these provide a good synthetic approximation of global inequalities. Indeed, almost 70% of international inequalities in energy intensities can be explained by differences between regional blocks. In fact, the bulk of the fall in international differences in intensities can be attributed to the inter-regional-group component (three-quarters of the drop). Meanwhile, the groups divided according to income do not retain a high explanatory capacity. Despite their increase, they account for just 15% of global inequalities, which means they are internally very heterogeneous. Therefore, it seems that energy intensities and their disparities respond better to regional consumption models and behavioural patterns.

Insert Table 6 about here

In addition to the previous analysis of inequalities, knowledge of the situation and the distributive dynamic calls for an analysis of other important concepts and not just the conventional inequality one. In particular, in recent years there

[18] This analysis, drawn up in this context, is similar to the cluster analyses, which are typically carried out using the convergence approach (Quah, 1996b).

has been a resurgence in the concept of polarization, which is fundamentally different from that of inequality. In this respect, the aim is not to clarify how unequal a particular distribution may be – in our case, international intensities – but rather to explore how this distribution additionally groups around poles that are both homogenous and distant. As Esteban and Ray (1999) demonstrated, this is a notion that is closer to that of inherent potential instability and conflict. To do so, and before going into the different measurements that could implement this concept, it may be useful to build the density function of the distribution of energy intensities through non-parametric techniques. This gives us a visual indication of the shape of the distribution and its change throughout the period.[19] Figure 1 hence reproduces the kernel estimates for three selected years of the period: 1990, 2000 and 2011. The distribution seems to have moved from a multimodal situation to being structured around two modes, one with a mean energy intensity lower than the global average, and a second smaller one with an intensity 50% higher than the global average. This movement is due to the combined effect of multiple changes in average energy intensities and weights across the international energy intensities vector. Three main patterns underlying the global change in energy intensities, should be noted: firstly, the relative reduction of the US, which exhibits a fall in from 1 to 0.91 between 2000 and 2011 – this contributing to a clear pole of below average intensity; secondly, the reduction experienced by China, which causes a second pole close to the average than before; thirdly, the large reduction in Russia (from 2.41 in 2000 to 1.92 in 2011), which causes a progressive

[19] The estimates are based on Gaussian kernel functions (see Quah, 1996a). These have been used previously for the analysis of the international distribution of emissions by Padilla and Serrano (2006) and Ezcurra (2007), among others. The smoothing parameter is determined endogenously from the method of Silverman (1986).

approximation of the fourth peak, to the position in China (see Figure 2). Overall, the distribution seems to move towards two major poles, one with the great majority of countries below average, and the other with higher intensity countries, among which China plays a major role.[20]

Insert Figure 2 about here

Whatever the case, it is necessary to synthesize the status of the polarization with cardinal measures. For this, we use the EGR indices for two, three and four endogenous groups, which are those typically used in the literature, and include the Wolfson measure, which strictly approximates the degree of bipolarization, and the Z–K index for the regional groups classified by the IEA. The main data are provided in Table 7 for the mean EGR parameters. The results demonstrate the following points of interest: firstly, all the polarization indices point to a drop in polarization in the aggregate period. In recent years, however, there are discrepancies. Secondly, focusing on the EGR endogenous indices, the results indicate that the most interesting structure would be the one that synthesizes distribution in just two groups, given that the value of the index is higher than the rest (see Esteban et al., 2007), and in which the relative error was only 27% in 2011. In 2011, typically, the countries in the group with lower energy intensities are, broadly speaking, the OECD countries and Latin America. Meanwhile, the group of countries with higher intensities consist of most of the countries from Eastern Europe and the former USSR, Asia, Africa and the Middle East. This being the case, dividing the countries into two groups

[20] The author can supply further details on request.

according to their mean energy intensities provides a very reasonable approximation of the underlying polarization. It can be seen, in this case, that polarization would have remained fairly stable from 2000. Consequently, the change in polarization may be due to changes in three factors (see Section 2): the within-group error (i.e. the internal cohesion component), the sizes of the groups and, finally, the between-group intensity gap. If we look at the bipolarization case (Table 7 and Figure 3) we can see a distinct evolution in these factors which may explain the stabilization of EGR (2) since 2000. Thus, we note a clear reduction in error (this tends to increase bipolarization), a reduction in the energy intensity gap between groups (mainly caused by the effect of China and Russia on the reduction in the average relative intensity in the group of higher intensities) which tends to diminish bipolarization and, finally, an equalization process of group sizes (which again increases bipolarization). In this sense, the Wolfson index, which measures bipolarization exactly (remembering that it takes as a reference for dividing the groups the median and not the mean, as EGR(2) does), would have increased even since 2000, emphasizing the relevance of the increasing polarization factors.

Thirdly, the Z–K exogenous polarization index also indicates this worsening since 2000.

Insert Table 7 about here

Insert Figure 3 about here

4. Conclusions and Policy Implications

This paper has analysed the international distribution of energy intensities, as a sustainability and energy efficiency indicator, based on the instruments associated with the literature for measuring inequality and polarization. In particular, with respect to the inequality analysis, it has used different decompositions of interest, by weights as opposed to energy intensities vector, by multiplicative factors, and finally by regional country groupings. In terms of the basic results, we obtain that the fairly generalized reduction in energy intensities coincided with an improvement in their international equality (good news), although these advances stopped to a large extent from 2000 and there are intersections in the Lorenz curves, for example in 2000 and 2011. The main protagonists of this reduction were the countries of Eastern Europe and the former USSR (especially Russia) and China. In fact the drop in the disparities of CO_2 emissions per capita in the same period was partially attributable to the equalizing role played by own energy intensity factor. Although most of the improvement in international inequalities in energy intensities was due indeed to changes in the intensities vector the weightings-vector has been relevant in some sub-periods. Another interesting result found is that exogenous groups of countries have a high explanatory capacity for global inequalities in intensities when these follow the regional structure used by the IEA. Indeed, the reduction in the gap between world regions is the essential reason behind the positive process of international equalization of energy intensities during the period. Also the decomposition of intensity inequality into consumption and affluence factors illustrates the weight of the latter factor in the level of inequalities and how they change. And, finally, the analysis of the polarization of intensities, which is a fundamental different dimension from that of inequality, demonstrates their reduction and good informative synthesis through bimodal distribution. However, the advance towards bimodality and particularly the stability of this polarization since 2000 give rise to certain doubts about the distributive process in these terms.

The above results yield, first of all, a pair of academic and analytical implications that need to be taken into account. Care must be taken when extracting unequivocally precise results based on the observation of specific environmental inequality indices. The intersection of the Lorenz curves, and discrepancies in the size of the changes according to the summary measures used, demonstrate the need to manage a full complement of measures and examine the status of the curves. Moreover, the use of weighted-inequality measures to analyse the international distribution of intensities demonstrates the importance of weighting factors in different sub-periods and the need to take these into account when interpreting the results in specific years.

On the other hand, some useful policy implications may be derived from the main results found. For instance, and in spite of the reduction in world mean intensities and their inequality across countries, energy consumption in per capita terms has increased rapidly since 1990. True environmental success will come about when there is a reduction in intensities on a scale that exceeds the actual rate of economic growth and, therefore, implies a decrease in per capita energy consumption. This is the big challenge in environmental and energy policy: the absolute decoupling of energy and economic growth as a key element in a sustainable development strategy. It would be necessary to intensify energy-saving technologies, improve the use of energy resources and encourage activities that do not use energy intensively worldwide. This result has not been achieved thus far. On the other hand, and despite the overall reduction in energy intensity inequalities, which is positive, it is also true that there seems to be a process of stabilization in recent years. It is therefore of interest that the downward trend in inequality recommenced. This would depend crucially on outlier countries like China and Russia (in 2011 their energy intensity relative to the global average was still 1.5 and 1.9 respectively) making progress on converging to the global average energy intensity. In this regard, further reductions will have to come from the international convergence on the main factors that explain the energy intensities. Among them, our decomposition analysis has stressed the importance of the income convergence process as a global factor and hence we would need to address the factors which explain it, technology, human resources and sectorial structure. But this income convergence must be accompanied by a policy on intensity of resource use which has a sustainability objective. Moreover, we found that inequality in intensities is a very regional phenomenon. In this work, we have taken as reference the nine regions proposed by the World Bank, which basically arise from geographical criteria. Therefore, as a political tool it would make sense to use the regions as an essential foundation for designing a global sustainability policy for energy and the consumption of resources, if necessary. And, finally, the polarization analysis (which is generally related to the notion of conflict) reveals a clear consolidation (on endogenous criteria, rather than exogenous ones such as regions) of two poles of countries according to their energy intensities, one above the world average and one below. In particular, there is evidence that when the distribution of emissions is simplified into two poles (i.e. analysis of bipolarization) there would have been a stabilization (or even an increase according to some measures such as Wolfson), in polarization since 2000. This pattern could hamper country-based negotiations. This scenario is not unrealistic since countries that consume more resources argue (to relax their responsibility and avoid having to make sacrifices), that their resource-use intensity is lower. It is interesting, therefore, to encourage a process of intensity equalization (consistent with a reduction in the global levels) between groups of countries, which can reduce the bipolarization. This might be achieved, either through the known mechanisms of technological diffusion and energy savings, or directly through a process of economic convergence (or indeed by a combination of both). Thus, because the inherent lower potential instability, a reduction in the international polarization of energy intensities may favour international environmental agreements (Esteban and Ray, 1999).

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Tables

Table 1: Energy Intensities by Regional Groups, selected years 1990-2011

	1990	1995	2000	2005	2011
OECD Americas	0,2345	0,2250	0,1996	0,1836	0,1645
OECD Asia Oceania	0,1490	0,1563	0,1581	0,1474	0,1370
OECD Europe	0,1597	0,1514	0,1369	0,1304	0,1151
Non-OECD Europe	0,4811	0,5408	0,4677	0,3686	0,3214
Africa	0,2941	0,3101	0,2936	0,2806	0,2495
Asia	0,2461	0,2309	0,2258	0,2063	0,1821
China	0,6342	0,4387	0,3291	0,3186	0,2666
Non-OECD Americas	0,1525	0,1445	0,1486	0,1464	0,1338
Middle East	0,1892	0,2491	0,2329	0,2553	0,2599
Low-income	0,3466	0,3556	0,3518	0,3262	0,2773
Middle-income	0,3013	0,2744	0,2416	0,2365	0,2128
High-income	0,2111	0,2010	0,1847	0,1721	0,1572
World	**0,2372**	**0,2240**	**0,2037**	**0,1956**	**0,1814**
Ratio max/min reg groups	**4,26**	**3,74**	**3,42**	**2,83**	**2,79**

Source: Own elaboration based on International Energy Agency data (2013)

Table 2: Cross-country inequality in energy intensities through summary indices, selected years 1990-2011

	CV	Gini	Theil
1990	0,0874	0,2847	0,1303
1995	0,0708	0,2605	0,1110
2000	0,0507	0,2309	0,0873
2005	0,0411	0,2243	0,0813
2011	0,0339	0,2223	0,0794

Source: Own elaboration based on International Energy Agency data (2013)

Table 3: Decomposing international inequality changes in energy intensities between GDP-share changes and energy intensity changes over selected periods and for different inequality indices

	C.V.			Gini			Theil		
	Total Change	**E.I.**	**GDP share**	**Total Change**	**E.I.**	**GDP share**	**Total Change**	**E.I.**	**GDP share**
1990-2000	-0,0367	-0,0156 (43%)	-0,0211 (57%)	-0,0538	-0,0254 (47%)	-0,0285 (53%)	-0,0430	-0,0199 (46%)	-0,0231 (54%)
2000-2011	-0,0169	-0,0173 (103%)	0,0004 (-3%)	-0,0085	-0,0180 (212%)	0,0095 (-112%)	-0,0079	-0,0138 (174%)	0,0059 (-74%)
1990-2011	-0,0536	-0,0447 (84%)	-0,0088 (16%)	-0,0623	-0,0530 (85%)	-0,0094 (15%)	-0,0509	-0,0432 (85%)	-0,0077 (15%)

Source: Own elaboration based on International Energy Agency data (2013)

Table 4: Decomposition of CO_2 emissions per capita into Kaya factors, 1990-2001

	Carbon	**Intensity**	**Affluence**	**Cov 1**	**Cov 2**
1990	0,1365 (15%)	0,1889 (21%)	0,8433 (95%)	0,1689 (19%)	-0,4522 (-51%)
1995	0,1403 (18%)	0,1457 (19%)	0,7565 (97%)	0,1144 (15%)	-0,3770 (-48%)
2000	0,1358 (18%)	0,1275 (17%)	0,7253 (96%)	0,1058 (14%)	-0,3400 (-45%)
2005	0,1376 (19%)	0,1212 (17%)	0,6434 (91%)	0,1027 (14%)	-0,2942 (-41%)
2011	0,1352 (21%)	0,1100 (17%)	0,5229 (80%)	0,1068 (16%)	-0,2228 (-34%)

Note cov 1 is related to the component, which includes the covariance among carbon intensity and the rest of factors; cov 2 is related to the component which includes the covariance among energy intensity and affluence.
Source: Own elaboration based on International Energy Agency data (2013)

Table 5: Decomposition of energy intensity into consumption and affluence, 1990-2001

	Consumption	Affluence	Cov
1990	0,3111	0,7305	-0,9113
1995	0,3245	0,7047	-0,9182
2000	0,3333	0,6921	-0,9381
2005	0,3126	0,6177	-0,8490
2011	0,2723	0,4875	-0,6805

Source: Own elaboration based on International Energy Agency data (2013)

Table 6: Decomposition of energy intensities inequality by subgroups components, 1990-2011

	Total	Regional		Income	
		Between	Within	Between	Within
1990	0,1303	0,0920 (71%)	0,0383 (29%)	0,0141 (11%)	0,1162 (89%)
1995	0,1110	0,0767 (69%)	0,0343 (31%)	0,0116 (10%)	0,0994 (90%)
2000	0,0873	0,0588 (67%)	0,0285 (33%)	0,0096 (11%)	0,0777 (89%)
2005	0,0813	0,0551 (68%)	0,0262 (32%)	0,0132 (16%)	0,0682 (84%)
2011	0,0794	0,0540 (68%)	0,0254 (32%)	0,0123 (15%)	0,0671 (85%)

Source: Own elaboration based on International Energy Agency data (2013)

Table 7: Polarization of energy intensities according to the EGR family of indices, Wolfson's measure and Z-K measure

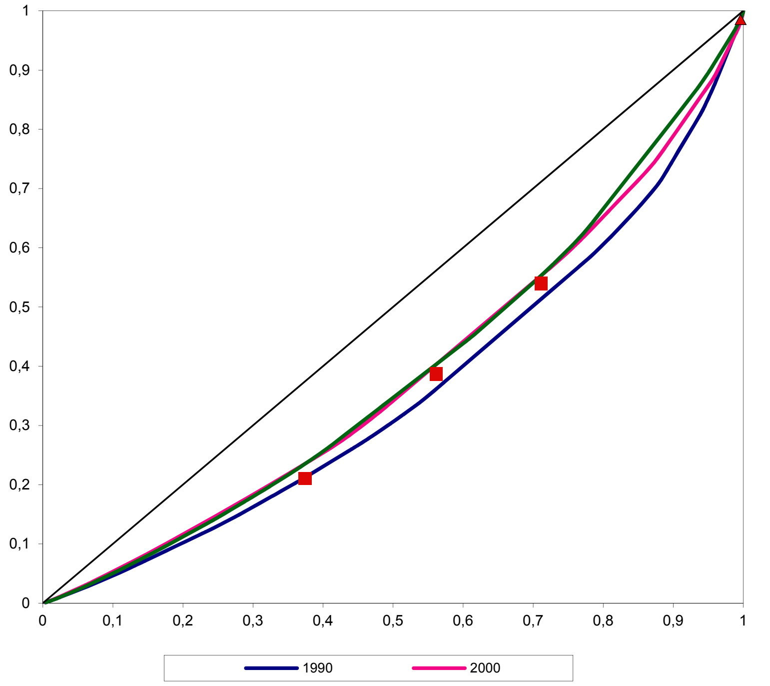
	EGR (2)	ε/Gini	EGR (3)	ε/Gini	EGR (4)	ε/Gini	W	Z-K reg
1990	0.0811	29.7%	0.0631	9.9%	0.0429	6.0%	0.1223	2,4049
1995	0.0739	29.8%	0.0604	8.9%	0.0465	11.4%	0.1146	2,2333
2000	0.0665	31.3%	0.0522	10%	0.0389	10.1%	0.0854	2,0589
2005	0.0673	28.0%	0.0481	9.7%	0.0441	12.0%	0.0966	2,1062
2011	0.0664	26.9%	0.0469	10%	0.0358	6.6%	0.1017	2,1285

Note: ε is the absolute error associated with the groupings and ε/Gini is the relative error, which can be considered as a proxy of the explanatory capacity of the groupings

Source: Drawn up by the authors using the World Bank data set

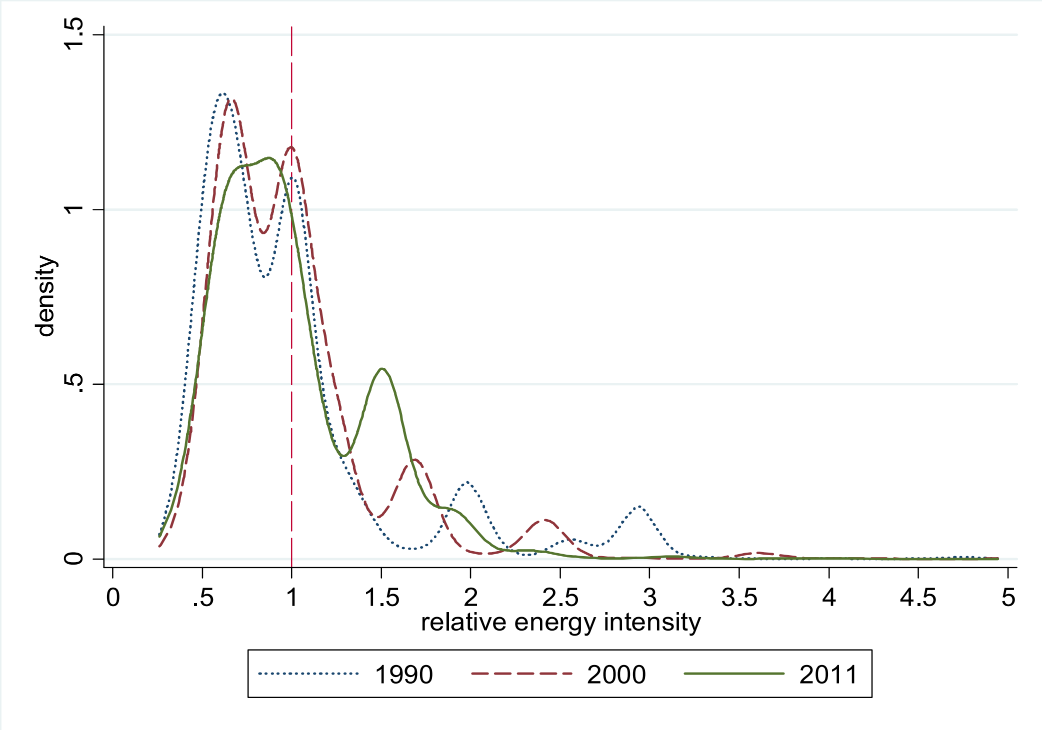
Figures

Figure 1: Evolution of density functions of the international distribution of energy intensities, selected years 1990–2011



Source: Own elaboration based on International Energy Agency data (2013)

Figure 2: Evolution of density functions of the international distribution of energy intensities, 1990–2011



Source: Own elaboration based on International Energy Agency data (2013)

ANNEX

EGR2 2011

Low-energy intensities group:

Hong Kong, Colombia, Peru, Ireland, Switzerland, Panama, Botswana, Dominican Republic, Albania, Malta, United Kingdom, Costa Rica, Gabon, Other Asia, Uruguay, Denmark, Spain, Portugal, Sri Lanka, Italy, Congo, Greece, Tunisia, Austria, Germany, Israel, Cyprus, Turkey, El Salvador, Ecuador, Lebanon, Philippines, Japan, Luxembourg, Croatia, Singapore, Morocco, Norway, Netherlands, Argentina, Mexico, Chile, France, Angola, Bangladesh, Brazil, Lithuania, Chinese Taipei, Slovenia, Yemen, Latvia, Hungary, Australia, Poland, Sweden, Algeria, Paraguay, Slovak Republic, Romania, Nicaragua, Azerbaijan, Guatemala, Senegal, FYR of Macedonia, Cameroon, Belgium, Jamaica, Georgia, New Zealand, United States, Tajikistan, Bolivia, Egypt, Honduras, Armenia, Czech Republic, Cuba, Sudan

High-energy intensities group:

Other Non-OECD Americas, Malaysia, DPR of Korea, Myanmar, India, Korea, Gibraltar, Pakistan, United Arab Emirates, Finland, Canada, Brunei Darussalam, Syrian Arab Republic, Indonesia, Venezuela, Jordan, Bulgaria, Thailand, Serbia, Qatar, Estonia, Vietnam, Belarus, Kuwait, Bosnia and Herzegovina, Ghana, Islamic Rep. of Iran, Kyrgyzstan, People's Rep. of China, South Africa, Benin, Other Africa, Haiti, Mongolia, Nepal, Saudi Arabia, Republic of Moldova, Kenya, Nigeria, United Rep. of Tanzania, Bahrain, Libya, Russian Federation, Oman, Côte d'Ivoire, Iraq, Kazakhstan, Ethiopia, Ukraine, Zambia, Togo, Mozambique, Iceland, Uzbekistan, Turkmenistan, Trinidad and Tobago, Netherlands Antilles, Dem. Rep. of Congo, Zimbabwe

EGR3 2011

Low-energy intensities group:

Hong Kong, Colombia, Peru, Ireland, Switzerland, Panama, Botswana, Dominican Republic, Albania, Malta, United Kingdom, Costa Rica, Gabon, Other Asia, Uruguay, Denmark, Spain, Portugal, Sri Lanka, Italy, Congo, Greece, Tunisia, Austria, Germany, Israel, Cyprus, Turkey, El Salvador, Ecuador, Lebanon, Philippines, Japan, Luxembourg, Croatia, Singapore, Morocco, Norway, Netherlands, Argentina, Mexico, Chile, France, Angola, Bangladesh, Brazil, Lithuania, Chinese Taipei, Slovenia, Yemen, Latvia, Hungary, Australia

Medium-energy intensities group:

Poland, Sweden, Algeria, Paraguay, Slovak Republic, Romania, Nicaragua, Azerbaijan, Guatemala, Senegal, FYR of Macedonia, Cameroon, Belgium, Jamaica, Georgia, New Zealand, United States, Tajikistan, Bolivia, Egypt, Honduras, Armenia, Czech Republic, Cuba, Sudan, Other Non-OECD Americas, Malaysia, DPR of Korea, Myanmar, India, Korea, Gibraltar, Pakistan, United Arab Emirates, Finland, Canada, Brunei Darussalam, Syrian Arab Republic, Indonesia, Venezuela, Jordan, Bulgaria.

High-energy intensities group:

Thailand, Serbia, Qatar, Estonia, Vietnam, Belarus, Kuwait, Bosnia and Herzegovina, Ghana, Islamic Rep. of Iran, Kyrgyzstan, People's Rep. of China, South Africa, Benin, Other Africa, Haiti, Mongolia, Nepal, Saudi Arabia, Republic of Moldova, Kenya, Nigeria, United Rep. of Tanzania, Bahrain, Libya, Russian Federation, Oman, Côte d'Ivoire, Iraq, Kazakhstan, Ethiopia, Ukraine, Zambia, Togo, Mozambique, Iceland, Uzbekistan, Turkmenistan, Trinidad and Tobago, Netherlands Antilles, Dem. Rep. of Congo, Zimbabwe.

EGR4 2011

Low-energy intensities group:

Hong Kong, Colombia, Peru, Ireland, Switzerland, Panama, Botswana, Dominican Republic, Albania, Malta, United Kingdom, Costa Rica, Gabon, Other Asia, Uruguay, Denmark, Spain, Portugal, Sri Lanka, Italy, Congo, Greece, Tunisia, Austria, Germany, Israel, Cyprus, Turkey, El Salvador, Ecuador, Lebanon, Philippines, Japan, Luxembourg, Croatia, Singapore, Morocco, Norway, Netherlands, Argentina, Mexico, Chile, France, Angola, Bangladesh.

Lower-Mid energy intensities group:

Brazil, Lithuania, Chinese Taipei, Slovenia, Yemen, Latvia, Hungary, Australia, Poland, Sweden, Algeria, Paraguay, Slovak Republic, Romania, Nicaragua, Azerbaijan, Guatemala, Senegal, FYR of Macedonia, Cameroon, Belgium, Jamaica, Georgia, New Zealand, United States, Tajikistan, Bolivia, Egypt, Honduras, Armenia, Czech Republic, Cuba, Sudan

Upper-Mid energy intensities group:

Other Non-OECD Americas, Malaysia, DPR of Korea, Myanmar, India, Korea, Gibraltar, Pakistan, United Arab Emirates, Finland, Canada, Brunei Darussalam, Syrian Arab Republic, Indonesia, Venezuela, Jordan, Bulgaria.

High-energy intensities group:

Thailand, Serbia, Qatar, Estonia, Vietnam, Belarus, Kuwait, Bosnia and Herzegovina, Ghana, Islamic Rep. of Iran, Kyrgyzstan, People's Rep. of China, South Africa, Benin, Other Africa, Haiti, Mongolia, Nepal, Saudi Arabia, Republic of Moldova, Kenya, Nigeria, United Rep. of Tanzania, Bahrain, Libya, Russian Federation, Oman, Côte d'Ivoire, Iraq, Kazakhstan, Ethiopia, Ukraine, Zambia, Togo, Mozambique, Iceland, Uzbekistan, Turkmenistan, Trinidad and Tobago, Netherlands Antilles, Dem. Rep. of Congo, Zimbabwe.