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ENERGY EFFICIENCY OF E.U. MEMBER STATES: A PANEL DATA ANALYSIS

Abstract. *The paper analyzes the energy efficiency of the EU member states in the context of the EU 20-20-20(20% reduction of primary energy consumption and 20% increase of the share of renewable energy by 2020).*

The grouping is based on a system of coefficients, represented by: the degree of energy dependence, total consumption of resources, consumption of renewable resources, primary energy consumption. By using the panel data regression, the variables that most influence the GDP as a result of the increase of the energy efficiency between 2004-2017 were highlighted.

The analysis of the EU member states shows that the progress registered during the transition on the energy market has been irregular within the European countries. The different progress of the European countries is also a consequence of the differences between the regulations and the political priorities of the governments of the Member States. In addition, the results show that EU countries still consume substantially more energy on GDP.

***Keywords**: energy efficiency, renewable energy, socio-economic sustainability, degree of energy dependence.*

JEL Classification: Q43, O13, P18

DOI: 10.24818/18423264/54.4.20.10

1. Introduction

Energy efficiency has become a strategic priority and it is being used as a means of promoting EU competitiveness. Therefore, the target of 2020 is the reduction of annual energy consumption by 20% and the target of 2030 by 32.5%.

Concerns about global energy resources are quite old. The report of the Club of Rome (Gabor, D. et al, 1983) has detached itself from the strategy of "zero growth" and has opted for a weighted economic growth, promoted with the sense of the historical possible, measure and time that we live in. Referring to energy, the report bases itself on the conclusion that, in the long term, sufficient energy availability can be ensured insofar as science and technology will allow the possibility of harnessing with maximum yields the potential of solar radiation, biomass, hydropower, wind power, geothermal energy and ocean energy, thus replacing fossil fuels as they dry up. On the other hand, present studies make different references to the efficiency of renewable energy. In this context, the problem of analyzing the efficiency of the renewable energy economy in relation to the total energy economy has been raised (Ladaru and Dracea, 2017). Still, renewable energy resources are a constant preoccupation of all industry actors. Their importance is due to both actual environment situation and their contribution to providing the nations's energy security and sustainability (Twidell and Weir, 2015; Elbassoussy, 2019).

More and more scientists run tests in order to achieve the best scenario of renewable energy efficiency as, for each country, the energetic independence is more of an issue of national security and economic development. Thus, Can and Korkmaz (2019) proved that renewable energy consumption and renewable electricity determine economic growth in Bulgaria by correlating the renewable energy consumption, the renewable energy output and the gross domestic product. Moreover, scientists tried to find solutions for using renewable energy in private or public institution buildings (Yu et al, 2019; Li and Zhu, 2019) and also in public transportation (Gatzert and Kosub, 2017) in order to reduce the carbon dioxide emissions and further meet the strategies of the European Union. Using an excel-based mathematical model, they conclude that, in order to meet the binding target of 10 per cent renewable energy in the transport sector by 2020.

On the other hand, Gatzert and Kosub (2017) proved that in European developed countries the investments in renewable energies are under different risks of public policy, based on scientific literature on the topic and on case studies in the field. Plus, the European countries look for solutions in order to develop strategies to protect their highly energy intensive industries. Karaduman and Gonel (2016) proved that by using an indexfor the measurement of comparative advantages for 13 European countries, on the one hand, in order to meet the EU regulations on pollution and renewable energies targets, some states force industries to adapt. On the other hand, energy-intensive industries are leaving Europe.

DOI: 10.24818/18423264/54.4.20.10

Energy efficiency is a very important issue, especially in the context of the EU 2020 targets and principle of circular economy. Obviously, there are economic sectors where the principle of circular economy is being evaluated (Marcu et al, 2016) and may be adopted very easily (Dracea et al, 2016). Several studies have already demonstrated that the waste field is one of the most flexible and adaptive sectors to do so (Banacu et al, 2019).

On the analysis of energy efficiency within the EU, apart from the established bodies that have published the efficiency indicators of the energy resources, as well as the reports of the EU member states on the achievement of the proposed objectives, but also the reports of the European Commission on the evolution of energy consumption, especially in the structure of the consumer sectors (EUROSTAT, the ODYSEE-MURE database, DG ECFIN), we find some publications on energy efficiency that are targeted though on certain segments of activity (the electronic industry, communications, institutional buildings etc.). In these cases, the analyses performed are purely statistical.

For this reason, we propose a global analysis of the energy efficiency at the macroeconomic level of the EU countries in the perspective of the sustainable development of the European space, as well as to identify what is the quantitative connection between the variables followed in the temporal and multicriteria analysis.

Most literature studies have focused on GDP as a dependent variable subjected to the influence of the various factors that determine it in a strictly mathematical sense (Can and Korkmaz, 2019; Inglesi-Lotz, 2016; Lee, 2006). In this paper, we maintained GDP as a dependent variable and considered DED (the degree of energy dependence) as a control variable to designate the variable whose effect we want to control or eliminate (Punch, 2019), while other factors (the consumption of energy resources, energy intensity) were considered explanatory variables.

The question of this research study is what would be the degree of energy dependence of the EU member states in the context of the policyof energy efficiency. The purpose of the paper is to analyze the energy efficiency registered in the EU. In this context, the use of mediums is not recommended and, for this reason it is necessary to set up homogeneous groups of countries.For this purpose, we used a scoring system adapted to each criterion, following the Likert scale principle, and inspired by the scoring method (Gheorghiu, 2004).

The proposed model is based on four criteria (the degree of energy dependence, the final energy consumption/inhabitant, the primary energy consumption/inhabitant, the renewable energy consumption/inhabitant) and the final score is determined according to the general model:

$$\mathbf{Z = a_1 \cdot x_1 + a_2 \cdot x_2 = K = a_n \cdot x_n} \quad (1)$$

where:

x_i – the criterion involved in the analysis

a_i – the estimator;

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Based on the determined scores, we made 5 groups ofcountries (very low score, low score, acceptable score, good score and very good score), whose grouping was done both on the basis of calculations and graphically (Figure 1), without claiming that we have totally reduced the differences between countries.

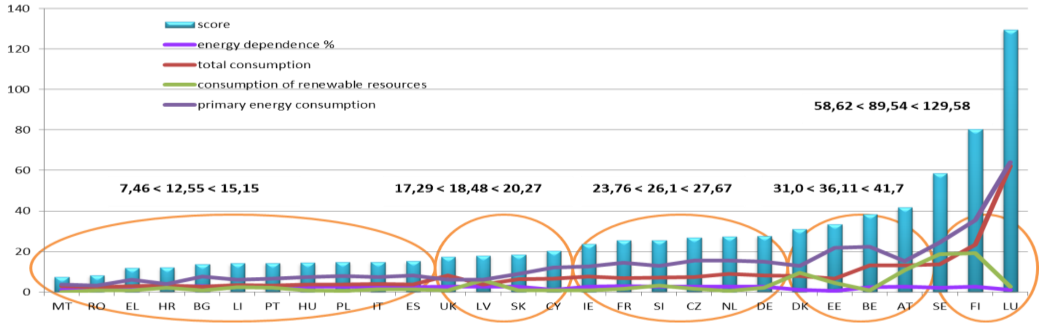

Figure 1. Creation of homogeneous groups of EU countriesfor the analysis of energy efficiency

Source: created by the authors

2. Methodology

In order to determine which of the considered variables has a higher influence on the GDP as a result of increasing the energy efficiency, we will use the econometric analysis on each country group, based on **the estimation of panel data regression**.

In the panel regression model, we consider the following equation:

$$\mathbf{y_{it} = c(1) + c(2) * x_{1it} + c(3) * x_{2it} + \cdots c(n) * x_{nit} + \varepsilon_{it}} \qquad (2)$$

According to Baltagi's specifications (Baltagi, 2008):

- i = 1,.....n shows the cross-sectional dimension;
- t = 1,.....t shows the time dimension;
- 1,....n = the number of variables taken into account;
- ε = the residual value

The model's variables are:

- GDP (euro, current prices) – as a dependent variable
- Total Final Energy Consumption (TFEC) and/or Consumption of renewable resources, Energetic Intensity (TEI) and Degree of Energetic dependence (DED) – as independent variables.

Each of the independent variables are directly or indirectly connected to GDP, which they influence in one way or another, therefore, the relation (2) becomes:

$$\boldsymbol{GDP_{it} = c(1) + c(2)^{*}\ TFEC_{it} + c(3)^{*}\ TEI_{it} + c(4)^{*}DED_{it} + \alpha_i + \varepsilon_{it}} \qquad (3)$$

Grouping the countries into the five differentiated groups in base of the

DOI: 10.24818/18423264/54.4.20.10

score determined by the four considered criteria (the degree of energetic dependence, final energy consumption/inhabitant, primary energy consumption/inhabitant, renewable energy consumption/inhabitant) allows finding answers to the following questions:

- Which of the independent variables has a greater pressure on GDP and in which group of countries?
- Does the GDP of the respective countries support the consumption of energetic resources if the energetic dependence is of high degree?
- What would be the difference between the presure upon GDP,if the consumption of the renewable energetic resources rises?
- Can we consider the results of any group of countries as arole model?

3. Results

3.1. Data

Taking into account the computation relation (3) and the research questions, we built two models of analysis:

• *in the first model*, the used data refer to: the total final consumption of energy resources (TFEC), the total energy intensity (TEI), the GDP in 2010 prices (GDP), the degree of energy dependence (DED);

• *in the second model*, the used data refer to: the consumption of renewable energy resources (CRR), the total energy intensity (TEI), the GDP in 2010 prices (GDP), the degree of energy dependence (DED).

The data source is EUROSTAT, data being taken and processed by the authors. The analyzed period covers the period between 2004-2017 and includes the 28 EU Member States, organized by the authors in 5 homogeneous groups according to the criteria specified in Introduction.

3.2. Descriptive analysis of energy efficiency

Far from being a new problem, energy efficiency is at the center of the EU's attention and is currently connected with the activity of environment protection and combating climate change effects.

The definition of the concept of "energy efficiency"[1], explained in the Directive 2012/27 / EU of the European Parliament and of the EU Council is quite ambiguous, leaving the member states the choice of their own targets based on primary or final energy consumption, primary or final energy savings, or energy intensity. This is also the reason why, in the Annual Progress Report on the implementation of the National Energy Action Plan, Member States reported to the European Commission two lines of indicators:

[1] *Directive 2012/27 / EU of the European Parliament and of the EU Council, chap. 1, art. 2: "energy efficiency means the ratio between the performance result obtained, consisting of services, goods or the resulting energy and the value of the energy used for this purpose "*

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- Trend indicators: primary energy consumption, final energy consumption (total and by industry, transport, households, services, agriculture), gross added value, total disposable income of households, GDP growth rate and other indicators);
- Result indicators: gross domestic consumption of primary energy as a basis of calculation, energy productivity, primary energy intensity, final energy intensity, primary energy consumption/inhabitant, final energy consumption/inhabitant, final energy consumption of households/inhabitant:

Primary energy consumption (PEC) is an indicator for monitoring the progress made by each member state, as well as the EU as a whole, in meeting the targets of Directive 2012/27 / EU, by which "primary energy consumption" is equivalent to gross domestic consumption, minus non-energy uses such as natural gas used as raw material for the chemical industry.

The analysis carried out at EU level between 2004-2017 based on EUROSTAT data shows that in 24 member countries there was a decrease of primary energy consumption in 2017 compared to 2014 under the conditions of GDP growth at 2010constant prices. Given the five groups of countriesachieved (Figure 1), we have the following picture of primary energy consumption compared to GDP growth (Figure 2).

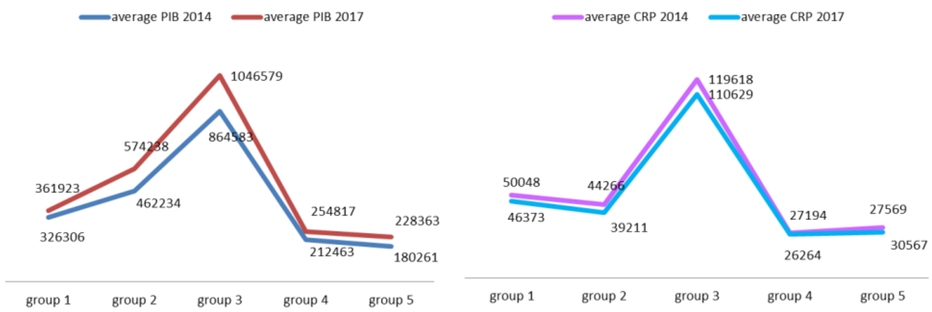

Figure 2. Evolution of primary energy consumption and GDP growth (2014 left, 2017 right), by homogeneous groups of countries
Source: data preparation based on EUROSTAT (nama_10_gdp, nrg_bal_c)

The largest decrease was recorded by countries such as Lithuania (28.05% decrease in primary energy and 46.8% growth in GDP), Finland (12.69% decrease in primary energy and 14.28% increase to GDP), Romania (13.23% decrease in primary energy and 56.40% growth in GDP), Netherlands (9.66% decrease in primary energy and 19.30% growth in GDP). An atypical case is Greece, where primary energy consumption decreased and at the same time, GDP fell by 18.05%.
As mentioned before, there is also a number of countries that have not expressed any concerns in the field of energy and, therefore, primary energy consumption has increased in 2017 compared to 2014, although at the same time, GDP has also increased, in some situations substantially. Countries in this situation are: Poland (13.89% growth in primary energy and 63.98% in GDP), Cyprus (3.35% growth in

DOI: 10.24818/18423264/54.4.20.10

primary energy and 22.40% in GDP), Estonia (10.06% increase in primary energy and 37.77% in GDP), Austria (3.8% increase in primary energy and 20.28% in GDP).

Proceeding to an analysis of the consumption of primary resources per inhabitant, besides the percentage changes of the consumption registered in the period 2004-2017, there are some changes of meaning as a result of the opposite direction (decrease or increase) of the total population. For example, in the case of Malta, although the total consumption of primary resources decreased by 13.25%, the growth rate of the population was positive of 13.28%, but per inhabitant the consumption decreased by 23.42%.

The final energy consumption (FEC) is materialized in all the energy supplied to the industry, transport, households, services and agriculture, except the energy delivered to the energy transformation sector, as well as to the energy sector. From this perspective, the quantitative final energy consumption is lower than the primary energy consumption,

Knowing the final energy consumption is important because for the calculation of the consumption of renewable resources, as well as of the total energy intensity.

As in the case of primary energy consumption, we note a decrease in final energy consumption per group of countrieswhile GDP increases (Figure 3).

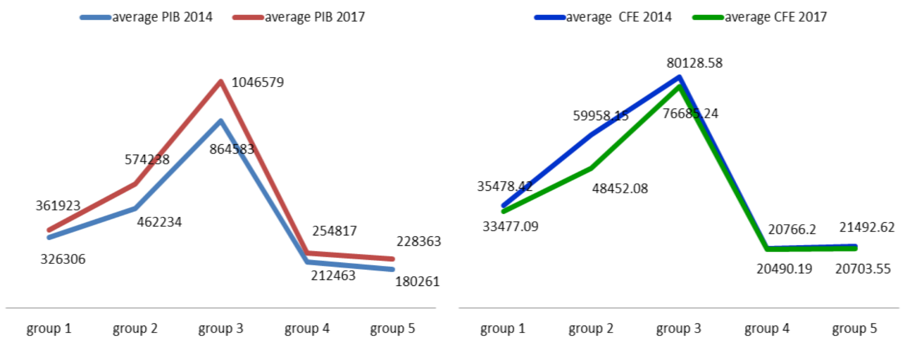

Figure 3. Evolution of final energy consumption and GDP growth (2014 left, 2017 right), by homogeneous groups of countries

Source: data preparation based on EUROSTAT (nama_10_gdp, nrg_bal_c)

The decrease of the final energy consumption is correlated with the decrease of the primary energy consumption, recording aproximately the same evolution. This decrease took place against the background of the economy of resources in industry, transport, population consumption, agriculture and forestry and other branches, while GDP has been raising.

The analysis on each EU country and on each year of theconsideredperiod (2004-2017) revels a sinous evolution, an alternation of decreases followed by increases and vice versa. This aspect is a consequence of the climatic changes that take place and which determine an oscillation of the consumption of final

DOI: 10.24818/18423264/54.4.20.10

resources, the change of the weight of energy consumption in every economic sector, of the geographical position of each country and of the climatic differences from one country to another, also.

As in the previous case, the consumption recorded at the macroeconomic level by each country does not allow the assessment of the homogeneity of the groups of countries, but, this aspect can be eliminated through the point of view of the consumption per inhabitant. Such an analysis also reveals some contradictory situations that can be synthesized in this way:

• countries that have registered a decrease of the primary energy consumption per inhabitant, but have registered an increase of the total consumption per inhabitant in the conditions of population growth (eg. Malta);

• countries that have registered a increase of primary energy consumption as well as total energy consumption per inhabitant while decreasing population (eg. Bulgaria);

• countries where the primary energy consumption per inhabitant has decreased, but the total consumption per inhabitant has increased in the conditions of population decline (eg. Lithuania);

• countries in which both primary energy consumption and total energy consumption per inhabitant increased (eg. Poland)

According to field scientific literature and the EU energy directives, we note the following indicators of energy efficiency characterization, as follows:

Energy intensity (IEP) is a traditional indicator that is being nationally established and it measures the efficiency with which energy is being used at the macroeconomic level. Statistically, this indicator is determined as a ratio between energy consumption and an activity indicator measured in monetary units.

In this context there are two alternatives of energy intensity:

•the intensity of primary energy consumption;

•the intensity of the final (total) energy consumption.

The evolution of the two alternatives of intensity, by groups of countries, is presented in Figure 4.

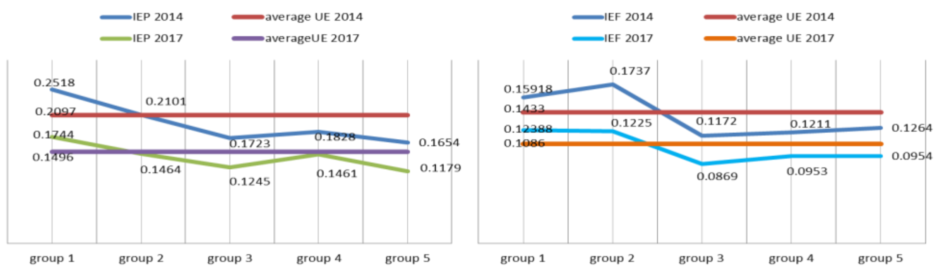

Figure 4. Evolution of the energy intensity of the primary resources (left) and of the energy intensity finals (right), on homogeneous groups of countries, between 2004-2017

Source: data preparation based on EUROSTAT (nama_10_gdp, nrg_bal_c)

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Compared to the EU average, both the primary energy intensity and the final energy intensity, in the period between 2004-2017, have registered a decrease due to the implementation of measures meant to increase the energy efficiency, especially in the energy, household, industrial and transport sectors. However, the countries in group 3, for both indicators, are below the EU average over the whole range. However, the differences that occur between the analysed countries are consequences of the existing structural economic differences.

Energy productivity (PEP) is a recent EUROSTAT indicator and it measures the amount of gross domestic energy obtained and energy consumption. Basically, we are talking about the inverse of the energy intensity. The energy productivity indicator provides the picture of the degree of decoupling of energy consumption from GDP growth and allows comparison between countries.

The calculations based on EUROSTAT data, according to the indicated methodology, demonstrate the concern of the EU member states for increasing the efficiency of energy use between 2004-2017 (Figure 5).

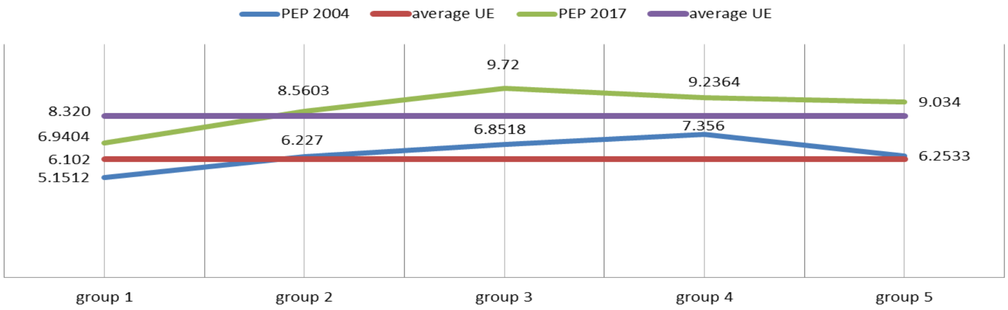

Figure 5. Evolution of energy productivity on homogeneous groups of countries,between 2004-2017

Source: data preparation based on EUROSTAT (nama_10_gdp, nrg_bal_c)

Lithuania (104.02%) registered the largest increase, followed by Malta (95.68%), Romania (80.25%), Ireland (71.79%). Countries such as Portugal (11.55% 9, Austria (15.88%), Croatia (21.66%), Spain (22.16%) are on the opposite side and the examples can be continued.

We may conclude that energy efficiency cannot be confused with economic efficiency even though both indicators are built on the same principle, respectively as the ratio between effect and effort.

The EU commitment to reduce until 2020 the energy consumption by 20%is known as "20% energy efficiency", the target for 2030 being updated to 32.5%. ***Energy saving***, as an efficiency indicator, represents the amount of energy saved based on the measurement / estimation of consumption before and after the application of measures to improve energy efficiency and is practically determined from the energy intensity.

Therefore, the energy intensity (primary and total) has decreased for all EU countries and resource savings have been achieved, both in each particular group

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and within each country.

Another EU objective is**to increase the share of energy from renewable sources** to 20% by 2020. The benefits of using renewable resources are manifold and there are found in the field of ecosystems, diversification of supply and reduction of dependence on fossil fuels, stimulation of new jobs in the sector of "green" technologies.

The processing of EUROSTAT data shows that all EU countries have made efforts to increase the share of consumption of renewable resources, but the pace is not the same. Thus the best results were recorded by the countries in group 5 (45.76%), while the lowest results are found in group 2 (10.87%). The energy resources efficiency assessment implies recording an inverse reaction of the energy intensity meaning its increase in the analyzed period. Thus, if in 2017, the energy consumed from renewable sources stood at 17.5%, the increase was arround 25.82% for the entire analyzed period between 2004-2017

When analyzing through the energy intensity point of view, we determied spectacular growths of some countries, such as the United Kingdom (501.65%), Luxembourg (375.04%), Belgium (275.39%) and other countries such as Hungary, Cyprus, Ireland, Netherlands, Germany. At the opposite, we found countries with a very small increase in the energy intensity of renewable resources, such as Croatia (1.42%), Sweden (2.90%), Slovenia (7.27%), Slovakia (11.72%) and other countries. There are, also, three exceptions regarding the increase of the energy intensity: Cyprus has registered a spectacular increase against the background of increasing the consumption of renewable resources from 0.446092 thousand TEP (2004) to 45.021096 thousand TEP (2017) and two countries with negative growth, respectively Romania and Latvia, where consumption decreased by 10.25%, respectively by 10.09%.

3.3. Econometric analysis

From the descriptive analysis of energy efficiency, we note that, in determining the energy efficiency indicators, GDP is a dependent variable, the degree of energy dependence being an indirect variable whose size depends on the size of the final energy consumption, respectively of the renewable resources. Using econometric analysis, we intend to see which of the estimated modelis most appropriate when highlighting the time factor influence on the variables, between the entities in the panel.

According to the specifications in chapter3.1., we will run the analysis using the two models of econometric analysis which are based on the regression equation in the relation (3).

1. The model based on the relationship between GDP, TFEC, TEI şi DED

We will estimate the econometric model (Baltagi, 2008) by using the data between 2004-2017 for each group of country. In this case the regreasion equation is:

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$$lnGDP_{it} = c(1) + c(2)*lnTFEC_{it} + c(3)* lnTEI_{it} + c(4)*lnDED_{it} + \alpha_i + \varepsilon_{it} \quad (4)$$

where:
c – constant
lnGDP – the natural logarithm of GDP for country *i* in year *t*
lnTFEC – the natural logarithm of final consumption for country *i* in year *t*
lnTEI – the natural logarithm of energy intensity for country *i* in year *t*
lnDED – the natural logarithm of the degree of energy dependence for country *i* in year *t*
α_i – individual effects
ε_{it} – the error term

The lower the energy intensity is, the less units of GDP will be used to ensure the consumption of energy resources, meaning here the final total consumption of energy resources.

Testing the OLSmodel for each EU group of countries, as they were grouped on a score basis, offers common features as follows:
• the global model for each group is valid from statistical optics point of view, Prob (F-statistic) being less than 5%;
• estimation errors are negatively correlated, to a greater extent in the case of group 4 where there is a maximum negative autocorrelation (Durbin-Watson being 4.081534), except for group 5 where the correlation is positive, but close to the significance threshold 2;
• the independent variables explain to a very high degree the variation of the GDP for each group of countries(between 0.95 and 0.99).

A reason for invalidating this model is that it treats the panel entities as being almost identical, in terms of economic characteristics and indicators.

In order to continue the estimation process of the econometric models, we tested the Fixed effects model for each group of countries, obtaining the following results:
• the model explains to a very high degree the variation of the GDP for each group of countries (R-squared is between 0.95 - 0.99);
• from the Prob result perspective (F-statistic), it is a representative global model (the null-hypothesis is rejected at a significance threshold of over 1%);
• the estimation errors are Durbin-Watsonnegatively correlated, very close to the considered reference value 4in the case of group 4 (3.901466); one exception is in the case of group 5 where the correlation is positive, but close to the significance threshold 2;
• the information loss is lower for group 5.

The third model, respectively **the random effects model** (Random effects model), generally presents the same direction of manifestation of the characteristics with the fixed effects model. The model cannot be tested in the case of group 5, due to the small number of countries in the panel, as well as due to its low degree of homogeneity.

The dilemma that arises is to choose one of the three models for each

DOI: 10.24818/18423264/54.4.20.10

group of countries, as the most suitable for modeling the link between variables. For this purpose, we carried out the Hausman test. The decision can be made based on Prob values. Associated with Chi-Sq. We consider two hypotheses:

H1: The Fixed effects model is the most appropriate model for estimating the econometric model;

H2: The Random effects model is the most appropriate model for estimating the econometric model.

Checking the probability value obtained at the random Cross-section level, we find **that for the four groups of countriesthe value is zero (less than 5%), which is why we reject the null-hypothesis and accept that the fixed effects model is the appropriate one.**

However, by determining the regression equations we find that **the influence of factors (variables) on GDP is different** (Table 1). The influence of the factors, due to the specificity of the energy efficiency, must be understood in the sense of pressure that is placed on the GDP of a country.

Table 1. The synoptic picture of the regression equations - model 1

Group	The regression equation obtained
1	LNGDP=-5.04129153328e-05+0.999977503969*LNTFEC-1.0000721796*LNTEI-4.79938767613e-05*LNDED
2	LNGDP=-0.000288120778224+1.00001919738*LNTFEC-1.00002380741*LNTEI+7.1271325671e-08*LNDED
3	LNGDP=-0.000379585070281+1.00003282533*LNTFEC-1.0000288882*LNTEI+5.3164131633e-05*LNDED
4	LNGDP=0.0015727122295+0.999836251093*LNTFEC-0.999974691879*LNTEI-3.13054374008e-05*LNDED
5	LNGDP=0.000131284655638+0.999991522619*LNTFEC-0.999974127273*LNTEI-1.88509622562e-05*LNDED

Sourse: authors' processing

Analyzing the synoptic picture of the regression equations we notice:

• the influence of the final consumption of resources in all five groups is positive and proves that an increase of one unit (1%) leads to an increase of the additional consumption of the GDP; the shareis around 10% and the highest growth was recorded by group 3. Analyzing the correlation between TFEC and GDP, we find two opposite trends: on one hand a strongly positive correlation in group 1 (0.977216) and on the other hand a very weak negative one in the case of group 2 (-0.70993) ;

• the impact of the energy intensity is positive in the sense that its decrease by 1% leads to a decrease of the units of the GDP allocated to the final consumption of energy resources, its share is oscillating around 10%. The highest influence is found in group 1 (-1.0000721796) and the smallest influence is found in group 5

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(-0.999974127273). The correlation between TEI and GDP is negative for all groups, but stronger for group 5 (-0.96447) and weaker for group 4 (-0.66387);

• the decrease of the degree of energy dependence shows the inclination of each country towards the use of renewable energy resources in the conditions in which it does not have its own traditional resources. We notice that the decrease by 1% of the degree of dependence leads to the insignificant decrease of the pressure on the GDP in the case of groups 1, 4 and 5, while in the case of groups 2 and 3 the tendency is of increase, but insignificant. In fact, the correlation between GDP and DED shows us that at the level of group 2 there is a significant positive correlation (0.672604), while at the level of group 5 there is the highest negative correlation (-0.82608).

The analysis of the model based on the correlation between GDP and final resource consumption, energy intensity and degree of dependence shows that there are differences across groups of countries, and even within them. Regardless of how big or small the influence of some factors is, the conclusion is that restrictive decisions regarding the increase of consumption are imposed, especially for the countries in group 2.

2. The model based on the relationship between GDP, CRR, TEI and DED

Following the way we analyzed the previous econometric model, we change the variable final consumption of resources (TFEC) with the consumption of renewable resources (CRR), the interpretation of the relationship between the TEI and the GDP being the same as in the previous case so that the relation (3) becomes the relation (5):

$$lnGDP_{it} = c(1) + c(2)*lnCRR_{it} + c(3)*lnTEI_{it} + c(4)*lnDED_{it} + \alpha_i + \varepsilon_{it} \quad (5)$$

where:

c - constant

lnGDP - the natural logarithm of GDP for country i in year t

lnCRR - the natural logarithm of the consumption of renewable resources for the country and in the third year

ln TEI - the natural logarithm of the energy intensity for the country in the third year

lnDED - the natural logarithm of the degree of energy dependence for the country in the third year

αi - individual effects

εit - the error term

Testing the OLS model for each EU group of countriesoffers the following features:

• the global model for each group is valid from the statistical optics point of view, Prob (F-statistic) being less than 5%;

• the estimation errors are negatively correlated, less in the case of group 1 (0.2594329) and more in the case of group 4 (3.871679), the rest of the groups having positive correlations, higher in the case of group 5 (1.634735)

DOI: 10.24818/18423264/54.4.20.10

• the independent variables largely explain the variation of the GDP of each group of countries, but in a smaller proportion than in the previous model, where they are arranged in the interval 0.858001 - 0.982137, which can be considered closer to the reality .

The Fixed effects model for each group of countries generated the following results:

- the model less explains the variation of the GDP of each group of countries compared to the previous model, the values being in the range 0.858001 - 0.982137;
- from the Prob result perspective (F-statistic), the model is a global representative one (the null-hypothesis is rejected at a significance threshold of over 1%);
- the estimation errors are positively correlated for groups 2, 3 and 5, group 5 hasthe highest value (1.653404) and group 3 has the lowest value (1.166497). Groups 1 and 4 have negative correlations which, in the case of group 4, are close to the significance threshold 4 (3.70087);
- the information loss is small for all five groups.

The third model, the Random effects model, generally presents the same characteristics manifestation as the fixed effects model, specifying that in the case of group 5 the model cannot be tested due to the small number of countries in the panel, as well as due to the group low degree of homogeneity.

The Hausman test shows that the probability value obtained at the random Cross-section level for the four groups of countriesis zero (less than 5%), which is why the null-hypothesis is rejected and the fixed effects model is accepted as the appropriate one.

However, determining the regression equations we find that **the influence of the factors (variables) on the GDP** is also different in this model (Table 2), and the interpretation being similar to the previous model.

Table 2. The synoptic picture of the regression equations - model 2

Group	The regression equation obtained
1	LNGDP=4.55617707032+0.0311371702358*LNCRR-1.62126010585*LNTEI+0.0912211644635*LNDED
2	LNGDP=12.9920990132-0.000177859010955*LNCRR-0.558228172875*LNTEI-0.01564110935 39*LNDED
3	LNGDP = 10.520620734 - 0.0790139937524*LNCRR - 0.744340504471*LNTEI - 0.462899664308*LNDED
4	LNGDP=10.48374418+0.442761568278*LNCRR+0.65863675012*LNTEI-0.093265281739*LNDED
5	LNGDP=8.8684727832+0.283213199315*LNCRR-0.479219589423*LNTEI-0.0624135945123*LNDED

Source: authors'preparation

DOI: 10.24818/18423264/54.4.20.10

Analyzing the regression equations from the generated coefficients point of view:

- the influence of the consumption of renewable resources is positive in the case of groups 1, 4 and 5 and this islegitimate if we consider that things cannot happen by themselves but investment efforts are needed to constitute the energy support. However, we observe, in the case of group 1 where the average consumption of energy resources during the analyzed period is 15.09% of the total resources consumed per capita, that the impact of the increase of consumption on the GDP is only 3.11%; on the contrary in the case of group 4, where the average consumption of energy resources is 19.82% of the total consumption per inhabitant, an increase of 1% of the consumption of renewable resources requires 44.28% increase of the GDP. On the other hand, there are two groups (2 and 3) where the influence of the increase of the renewable energy consumption is negative, insignificant in the case of group 2 (of 0.02%) and of 7.9% in the case of group 3; these groups are made up of highly economic developed countries (such as, France, Netherlands, Germany, Ireland). The analysis of the correlation between CRR and GDP is a positive one, more intense in the case of group 4 (0.961624) and more moderate in the case of group 3 (0.746666);
- the impact of the energy intensity is positive in the sense that its decrease by 1% leads to a decrease of the consumption of the GDP allocated to the final consumption of energy resources, except for the group 4 where the impact is negative. The highest impact of decreasing energy intensity is found in group 1 (correlation coefficient being -1, 62126010585) and the lowest in case of group 5 where the correlation coefficient is -0.479219589423.
- the correlation between the TEI and the GDP is negative for all groups, the same in size as determined in model 1;
- the decrease of the degree of energy dependence denotes the inclination of each country towards the use of renewable energetic resources, as long as it does not have its own traditional resources. We note that the decrease of 1% of the degree of dependence leads to the insignificant decrease of the pressure on the GDP in the case of group 2 (1.56%) and significant in the case of group 3 (46.29%). The correlation between GDP and DED shows that in group 2 we have a high positive correlation (0.672604), while in group 5 we have the highest negative correlation (-0.82608).

The analysis of the model based on the correlation between GDP, the consumption of renewable resources, the energy intensity and the degree of dependence shows that there are differences between groups of countries, and even within these groups. Regardless of how big or small the influence of some factors is, the conclusion is that restrictive decisions regarding the increase of consumption are imposed within each group of countries acting on those factors which present a significant pressure on GDP.

If, within each model, we presented the way of manifesting the influence

DOI: 10.24818/18423264/54.4.20.10

of the variables considered, the question arises to see which model is the best for each group of countries and which variable should be modeled. For this purpose we will select the two informational criteria Akaike info criterion and Schwarz criterion, the smallest values used to choose the solution. Also, when choosing the best variant, the information about R-squared and Adjusted R-squared is important as well.

Respecting the imposed restriction, we find that for all 5 groups, **the model based on the correlation between the total final consumption of energy resources, the energy intensity and the degree of energy dependence is strongest** and itallows the optimization of any of the variables. Although the strategic direction of the EU is to increase the consumption of renewable resources, and the EU countries are working in this direction. Measures to increase the energy efficiency should generally be based on the total consumption of energy resources whose modeling must allow the reduction of traditional resources in favor of renewable resources. On the other hand, in the linear regression analyzed, the final total consumption of resources is a control variable, while the energy intensity and the degree of energy dependence are explanatory variables. The same could be said for the second model, the level of consumption of renewable resources being a control variable, and the energy intensity and the degree of energy dependence are explanatory variables. We should also consider that when refering to the consumption of renewable resources we refer in fact to only a small part of the total consumption of energy resources, and the energy intensity as an efficiency indicator based on the total consumption of resources.

4. Conclusions

The analysis of the EU member states reveals that, despite strong goals set in the energy strategy until 2020 and the target that is set for 2030, the progress made in the energy market transition has been unequal between the European countries. The different progress of the European countries is also a consequence of the differences between the regulations and the political priorities of the governments of the Member States, to which the degree of economic development recorded and measured by the GDP/inhabitant indicator is added naturally.

According to the results of the study, although the consumption of renewable resources has experienced an upward trend for the countries in group 2 (by 369.97% more in 2017 compared to 2004) and, in comparison, very little significant at the level of group 5 (36.58% in 2017 compared to 2004), the decrease in energy intensity shows a rather slow and almost uniform rate by all groups, the most important decrease being recorded by the countries in group 1 (-30.74% in 2017 compared to 2004) and the smallest decrease being registered by the countries in group 4 (-0.08% in 2017 compared to 2004).

This shows that EU countries still consume substantially more energy for GDP. The results should not only be viewed from the point of view of

DOI: 10.24818/18423264/54.4.20.10

mathematical values, but they must be correlated with certain factors that have made their mark on the evolutions in the energy field. In this regard we consider the degree of decoupling of energy consumption from the GDP growth measured by the energy productivity indicator, meaning that groups 5 (44.47% in 2017 compared to 2004) can be mentioned, group 3 with 41.86% and the lowest degree being found in group 4 (25.56%).

The decomposition of energy intensity data shows different patterns in the evolution of energy efficiency over the period between 2004-2017.The models show a strong correlation between the final consumption of energy resources and the GDP, especially in group 3(Ireland, France, Slovenia, Czech Republic, Netherlands, Germany) where the reform of the energy sector was wider, which helps us to explain the differences in energy intensity.

Taking into account the results and the research questions of the study, we may affirm that:

• the models cannot be copied, they are based on the same tools, techniques and procedures, but the interests and the mode of action is different from one country to another;

• the countries in the first group (Malta, Romania, Greece, Croatia, Bulgaria, Lithuania, Portugal, Hungary, Poland, Italy, Spain) register the lowest consumption of renewable resources / inhabitant (0.2423 PET) due to the lack of investment given the low level of GDP / inhabitant (the average of the period is 14.160 euros);

• at the opposite pole are the countries from group 5 (Sweden, Finland, Luxembourg) which, although registering a high degree of energy dependence, register the highest GDP / inhabitant (the average of the period being 52,060 euros) which has the capacity to support a high consumption of energy resources (5.498 thousand PET / inhabitant on average per year). Sweden also has the characteristic of having 10 nuclear reactors that contribute to reducing total energy intensity and thereby reducing the pressure on GDP;

• Group 3 countries (Ireland, France, Slovenia, the Czech Republic, the Netherlands, Germany), although not excelling in terms of GDP / capita (the average for the period is 29,416 euros), have a favorable situation in terms of energy intensity with the lowest level in within the analyzed period (0.1001 PET / 1000 euro). This is due to the investment effort in renewable energy resources (for example, France has 59 nuclear reactors, Germany has 17 nuclear reactors to which are added wind and solar energy covering 46% of energy production in 2019) and which has contributed to the lowest degree of energy dependence. The model of the countries from group 3 is the best in terms of registered parameters and shows the way forward in the energy field.

Therefore, each country, regardless the group it belongs, must make investment efforts to increase the consumption of renewable resources and which, indirectly, will help to strengthen the long-term relationships between the analyzed regression variables. In economic terms we can talk about increasing the security

DOI: 10.24818/18423264/54.4.20.10

of energy supply of the country. The detailed reform of the energy sector, including the adjustment of tariffs and the introduction of the commercial discipline is still being established as a necessary condition for the efficient use of energy.

Understanding the interactions between energy consumption and sustainable growth of the economy is one of the ways used to plan the demand for energy in each country. The analysis and the results obtained from this study show that we can obtain more income (GDP) while we are more energy efficient. This can be achieved with the help of energy conservation policies and the development of continuous policies to improve energy technologies, including digitization in the energy field and replacing traditional resources with renewable resources.

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DOI: 10.24818/18423264/54.4.20.10