EVALUATION OF ENERGY EFFICIENT USE AT THE LEVEL OF NATIONAL ECONOMY

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Rezumat - The paper presents the importance of evaluating energy efficient use that is explicitly stipulated in the strategic and legislative documents adopted at the national and international level, including the Directive 2012/27/EU and the Law 121/2014. Energy intensity frequently that is used in international evaluations and comparisons of energy efficient use is also used in Romania. The topic is approached both by specialists and politicians, newspapermen, representatives of the public opinion etc. This indicator has acquired axiomatic valences and its values are presented as unquestionable arguments for incontestable truths. Nevertheless, besides correct and well-balanced approaches one may come across distorted presentations and exaggerations resulting from superficially knowing the problem. The information and data presented in the paper can bring clarifications on this field.

In the first place, energy intensity characterizes the economic efficiency of energy utilization and only to little extent the technical efficiency. Its value is directly linked to macroeconomic parameters, among which the parity between the national currency and the currencies in international circulation, the structure of the national economy etc.

The paper presents different variants for the interpretation and calculation of the energy intensity indicator value, including the corresponding mathematical models. Based on the primary information obtained from reliable sources (National Institute of Statistics, EUROSTAT data base) values of this indicator are calculated in different variants that are considered and comparisons between the obtained results are made.

Choosing the variant for defining and calculating energy intensity, respectively, depends on the purpose of the analysis to be carried out and needs to be explicitly presented together with the results obtained.

The paper includes recommendations on how the calculation variants and the results obtained by carrying out these analyses according to their purpose (carrying out international comparisons, analyzing the evolution of internal situation in a certain period of time etc) should be used.

Cuvinte cheie: energy intensity, primary energy, GDP.

1. INTRODUCTION

The increase in energy efficient utilization is an essential component of all the strategies in the energy field. It contributes directly to sustainable development, increases security of supply and energy bill affordability etc.

The strategic and legislative documents adopted at the national and European level set quantitative targets for the progress that should be made. Thus:

- The national strategy in the energy efficiency field (approved by Government through GD 163/2005 in the context of the negotiations for Romania's accession to the European Union) established reduction of energy intensity by 40% by 2015 as a strategic objective.
- The strategic package envisaged the reduction by 20% of energy consumption by 2020 against the consumption that would have been registered in the absence of energy efficiency measures
- The Directive 2012/27/EU set quantitative targets for all the EU Member States relating to primary and final energy consumption and the obligation of each Member State to set and attain its own quantitative targets. These own quantitative targets may refer to primary energy consumption, final energy consumption, or values of the energy intensity indicator.

Therefore, there is no unanimously accepted indicator to characterize efficient energy use in an optimum way at the national level, but the most frequently used indicator is „energy intensity".

The high energy intensity of Romanian economy in comparison with that in the developed countries is a topic frequently discussed. This topic has been approached both by specialists and politicians, newspapermen, representatives of the public opinion etc. This indicator has acquired axiomatic valences and its values are presented as unquestionable arguments for incontestable truths. Nevertheless, besides correct and well-balanced approaches one may also encounter distorted presentations and exaggerations resulting from superficial knowledge of this issue.

We hope that the information and data that we are going to present will help to clarify this field.

2. PRIMARY ENERGY INTENSITY. DEFINITION, CHARACTERISTICS

Primary energy intensity (PEI) is the primary energy consumption (PEC) necessary for producing one unit of

Gross Domestic Product (GDP) at the national level. The relationship is the following:

$$PEI = \frac{PEC}{GDP} \quad (1)$$

PEC = primary energy consumption at the national level in a certain year, usually expressed in tons of oil equivalent (toe);

GDP = the Gross Domestic Product of the respective country in the year under consideration, given in the national currency or in another most-traded currency (Euro or USD).

This indicator represents the most synthetic indicator relating to energy utilization efficiency at the level of national economy.

Primary energy intensity mainly characterizes the economic efficiency of primary energy utilization and only to a lesser extent technical efficiency. Its value depends directly on the GDP value, which is mainly an economic parameter.

The structure of the national economy has a decisive influence on the value of energy intensity. Energy intensity in a country whose main economic branch is metallurgy will be higher than in a country whose main economic branch is tourism, even if the former utilizes modern and efficient technologies.

A high value of energy intensity is not a bad thing in itself (at least at first glance). Energy intensity is the only indicator used for characterizing the efficiency of energy utilization at the national level.

There are economic sectors and industrial branches that, through their nature, have high energy intensity (chemical industry, metallurgical industry, transports etc.). This can be also registered on the background of high technical and economic efficiency. The fact that in the metallurgical industry (for example) relatively much energy is consumed for producing a unit of gross added value (and of GDP, implicitly) does not automatically represent a proof of the energy inefficiency of this branch and should not represent an argument against it. It can be a modern and efficient industrial branch (and in the developed countries it does have these characteristics). On the other hand, the strategic objective of the decision-makers/managers is to increase the gross added value produced that leads to energy intensity reduction.

3. PRIMARY ENERGY DEFINITION

In the "Energy Dictionary", compiled by the World Energy Council in 1992, primary energy is defined as: "energy that has not undergone any sort of conversion". Therefore, primary energy is an energy form found in nature.

The main primary energy carriers, the forms under which primary energy is found in nature, respectively, are:

- Crude oil (the energy in the amount of oil extracted from the oil fields, respectively);
- Natural gases;
- Coal (including lignite and peat);
- Radioactive ores;
- Water heads (hydro energy);
- Other renewable energies (solar, wind, geothermal etc.).

We also consider „primary energy" the amounts of energy that are fed into (or taken out from) the analyzed contour through import/export actions.

In order to calculate energy intensity we should know the primary energy consumption at the national level (PEC) in a year's time.

In order to determine primary energy consumption we should know:

a) Internal production of primary energy (PEP); this is calculated as the sum of all energy form production. The first problem consists in expressing the energy contained in all these forms in the same measurement unit. According to the International System of Units, the unit for energy is Joule, but this unit is not frequently used. The usual measurement unit used in practice is the "ton of oil equivalent" (toe), the average amount of energy in a ton of oil, respectively.

The relationship between the two units is the following:

$$1 \text{ toe} = 41.868 \text{ GJ} \quad (2)$$

b) The import of primary energy (IMP) calculated as the sum of all imports of energy forms.

c) Export of primary energy (EXP) calculated as the sum of exports of all energy forms

d) Variation of primary energy stocks (VST) existing on the territory of the country between the beginning and the end of the year.

Thus, the value of primary energy consumption is:

$$PEC = PEP + IMP - EXP \pm VST \quad (3)$$

The evolution of primary energy consumption in Romania in the period 2000-2014 is given in Table 1.

Table 1 Evolution of primary energy consumption in Romania.

Mil.toe

Year	Production	Import	Export	Primary energy consumption
2000	28.190	10.925	2.947	36.374
2005	27.154	17.072	6.534	37.932
2010	27.428	11.239	3.992	34.817
2011	27.465	11.570	4.124	35.648
2012	27.112	11.615	3.620	34.851
2013	25.853	9.993	4.203	31.634
2014	25.488	10.700	4.600	31.410

Source: National Institute of Statistics (INS)

4. GROSS DOMESTIC PRODUCT CONSIDERATION

The Gross Domestic Product is a fundamental macroeconomic indicator. Its calculation concerns economic statistics. Further, we will refer only to certain problems that arise when calculating energy intensity.

4.1. Calculation of GDP at current prices

The annual values of the GDP in national currency are published by the National Institute for Statistics (INS) and are also called "nominal values" in the literature in the field.

The nominal values are affected by the price variation (inflation) and the par of the national currency and the currencies used in the international corporations (usually Euro or USD). They do not reflect the actual evolution of the national economy. As they are expressed in lei, they cannot be used by international corporations. Practically, the nominal values of the GDP are important only as primary information.

In the first stage the GDP is calculated in a largely used international currency by means of the official rate of exchange, observing the official par of exchange of the National Bank of Romania (BNR) (calculation of GDP in current prices).

Romania's GDP values in Euro and USD are given in Table 2.

Table 2. Romania's GDP values

Year	GDP	
M.U.	Billion Euro	Billion USD
2000	40.278	37.053
2005	79.496	98.861
2010	126.816	167.998
2011	133.344	185.363
2012	133.905	172.044
2013	144.282	191.587
2014	150.634	199.901

Source: ICEMENERG – OEN based on INS and BNR data

International institutions (Eurostat, World Bank etc.) publish GDP and GDP/capita values in different countries, values expressed in Euro or USD in current prices.

By expressing the GDP value in Euro or USD:

- Makes international comparisons possible
- Eliminates the influence (high) of the par of exchange between the national currency and Euro or USD.

Nevertheless, the influence (that can be great) of the price variation in Euro or USD in the internal market was maintained, so these values do not describe the evolution of the national economy rigorously either. This clearly results from the examination of the values in table 2. If the GDP at current prices is expressed in billions Euros, then in 2014 it increased 3.7 times against the year 2000. If the GDP is expressed at current prices in billions of USD then, in 2014 it increased 5.4 times against the year 2000. It is obvious that both values (3.7 times increase and 5.4 times increase, respectively) cannot be corrected and that, in fact, both are not correct being influenced by the variation of prices.

In order to eliminate this influence and consider the actual evolutions at the macroeconomic level the GDP is calculated at constant prices.

4.2. Calculation of GDP at constant prices

A base year (called "i" year) is chosen. For this year, the GDP value is equal to the value at current prices in the respective year. For example, in this paper we have selected three calculation variants corresponding to the base years 2000, 2005 and 2010.

As the comparisons are usually made with UE average or with other EU Member States, the international currency chosen was Euro. According to Table 3:

- In 2000
GDP=40.278 billion Euro 2000
- In 2005
GDP=79.496 billion Euro 2005
- In 2010
GDP=126.816 billion Euro 2010

Further we calculate the GDP evolution at constant prices corresponding to the chosen years (in our case in Euro 2000, Euro 2005 and Euro 2010) by means of an actual rate of GDP growth.

The actual GDP growth rate against the previous year (r_i) also represents an annual macroeconomic indicator published in the INS documents and can be also found in the EUROSTAT database and in other international databases. The values of this indicator for the period under consideration (2000-2014) are given in table 3.

If we know:

- The value of GDP in the year "i" expressed at current prices (in our examples in Euro 2000, Euro 2005 and Euro 2010, respectively): „GDP_i";
- The actual GDP growth rate in the year "i+1" against the year "i" expressed in percentages: „r_{i+1}", then the value of GDP in the year "i+1" expressed at prices in the year i" „(GDP^*_{i+1})" is calculated by means of the relationship:

$$GDP^*_{i+1}=GDP_i \, X \left(1+\frac{r_{i+1}}{100}\right) \quad (4)$$

In case we want to express the GDP at constant prices for several years following after the base year "i", then the relationships are the following:

$$GDP^*_{i+1}=GDP_i \, X \left(1+\frac{r_{i+1}}{100}\right) \quad (5)$$

$$GDP^*_{i+2}=GDP_i \, X \left(1+\frac{r_{i+1}}{100}\right) X \left(1+\frac{r_{i+2}}{100}\right)$$

$$GDP^*_{i+k}=GDP_i \, X \left(1+\frac{r_{i+1}}{100}\right) X \left(1+\frac{r_{i+2}}{100}\right) X \, X \left(1+\frac{r_{i+k}}{100}\right)$$

If we want to express the GDP at constant prices for several years before the base year i", then the relationships are as follows:

$$GDP^*_{i-1}=GDP_i \, / \left(1+\frac{r_i}{100}\right) \quad (6)$$

$$GDP^{*}_{i-2}=GDP_i / \left(\left(1+\frac{r_i}{100}\right)X\left(1+\frac{r_{i-1}}{100}\right)\right)$$

$$GDP^{*}_{i-k}=GDP_i / \left(\left(1+\frac{r_i}{100}\right)X\left(1+\frac{r_{i-1}}{100}\right)X.....X\left(1+\frac{r_{i-k+1}}{100}\right)\right)$$

The GDP values, expressed at constant prices describe the actual trend of the national economy.

Thus, table 3 presents the evolution of Romania's GDP in Euros 2000, Euros 2005 and Euros 2010.

Table 3. GDP evolution in România in Euro 2000, Euro 2005 and Euro 2010 and the GDP growth rate in the period 2000-2014

Year	Rate of GDP growth against the previous year (%)	Evolution of GDP in Euros 2000 (constant prices) (billion Euros 2000)	Evolution of GDP in Euros 2005 (constant prices) (billion Euros 2005)	Evolution of GDP in Euros 2010 (constant prices) (billion Euros 2010)
2000		40.278	60.050	82.906
2001	5.6	42.534	63.413	87.548
2002	5.2	44.745	66.711	92.101
2003	5.5	47.206	70.380	97.166
2004	8.4	51.172	76.292	105.328
2005	4.2	53.321	79.496	109.752
2006	8.1	57.640	85.935	118.642
2007	6.9	61.617	91.865	126.829
2008	8.5	66.854	99.673	137.609
2009	-7.1	62.108	92.596	127.839
2010	-0.8	61.611	91.856	126.816
2011	1.1	62.289	92.866	128.211
2012	0.6	62.662	93.423	128.980
2013	3.4	64.793	96.600	133.366
2014	2.9	66.672	99.401	137.233

Source: ICEMENERG – OEN based on INS and BNR data

By expressing the GDP at constant prices:

- Great differences according to the chosen reference year are registered; e.g. GDP in 2014 expressed in Euro 2010 is more than two times greater than the GDP in the same year expressed in Euros 2000; usually then, when the GDP value in a certain year is referred to, this value is expressed at current prices;
- The dynamics of this indicator is the actual one; e.g. in all the chosen cases, the GDP value in the year 2014 is 1.66 times greater than the GDP value in 2000; usually then, when the evolution of the GDP in two different years is analyzed, the GDP values in the respective years at constant prices are reported.

4.3. Calculation of GDP at the purchasing power parity

Prestigious institutions (IAEA, Eurostat etc.) consider that utilization of the official rate of exchange is not representative enough and recommend utilization of the "purchasing power parity" (PPP) for calculating the GDP in Euros or USD. For this a representative "basket" of base goods and services essential to daily life is selected. The total value of the goods and services included in the "basket" is calculated in different countries in the national currency. The PPP is determined through the ratio between the "basket" value calculated in the two currencies.

The differences between the official exchange rate and the purchasing power parity are greater the more different their development levels are. As a general rule, PPP is calculated through the ratio between the currency of a certain country and USD or Euro. PPP will be closer to the official parity in the case of the developed countries, but it will differ a lot in the less developed countries.

PPP has got a very subjective character. It essentially depends on the way the basket of goods and services is selected, as well as on the different analysis and calculation details.

There are different values of leu/Euro or leu/USD at the purchasing power parity according to the public institution that publishes the obtained results.

In order to obtain credible results by means of PPP enabling international comparisons it is necessary to meet two conditions:

1. PPP should be determined by a well-known institution

2. PPP should be determined by the same institution for all the countries /areas that are compared.

The calculations carried out in ICEMENERG - OEN have used the PPP calculated on the basis of the Statistical Yearbook and Eurostat data.

5. PRIMARY ENERGY INTENSITY CALCULATION

The relationship for the calculation of primary energy intensity has been previously presented.

Mention should be made from the very beginning that the values of energy intensity that we are going to present are given in toe/1.000 Euro. We have used this European currency for enabling international comparisons and because during this period of time the focus is on the comparisons with the EU countries.

We have distinctly calculated values of primary energy intensity in:

– toe/1,000 Euro – current prices;

– toe/1,000 Euro – constant prices (Euro 2000, Euro 2005 and Euro 2010);

– toe/ 1,000 Euro at the PPP.

In Romania's case and for the period of time 2000-2014, primary energy consumption was presented in table 1, and the GDP in billion Euros – current prices in table 2.

The evolution of primary energy intensity in toe/1,000 Euro – current prices is given in figure 1.

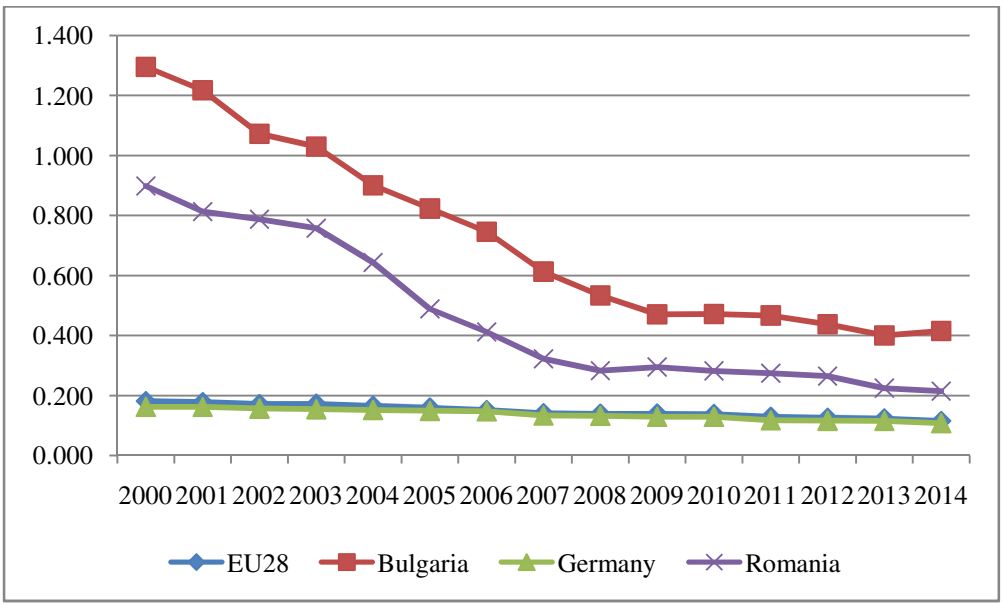

Fig.1. Primary energy intensity (toe/1,000 Euro)

In the same figure is given the evolution of this indicator for the EU 28, Bulgaria, Germany and Romania.

It is worth underlining that primary energy intensity calculated in toe/1,000 Euro – current prices in Romania decreased 4.18 times in the 2000-2014 period (from 0.898 toe/1,000 Euro to 0.215 toe/1,000 Euro). In comparison this indicator decreased 1.50 times in Germany. Thus, in 2000 primary energy intensity in Romania was 4.96 times greater than the EU28 average and in 2014 was only 1.87 times greater. The evolution has unmistakably been dramatic. It would be entirely wrong to interpret that this was due to an increase at the same pace in energy utilization efficiency in the technical sense. The main factor leading to this evolution was the variation of the PPP of the European currency in the Romanian market.

In order to eliminate the influence of this factor the evolution of energy intensity was calculated, the GDP being calculated at constant prices and in three variants (Euro 2000, Euro 2005 and Euro 2010). The results are presented in figure 2.

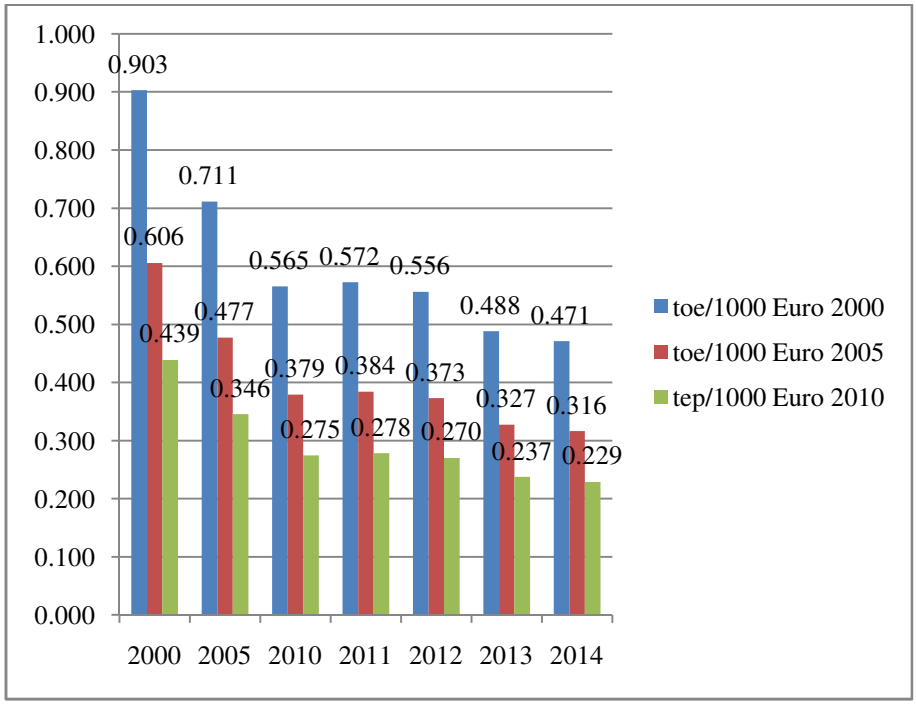

Fig.2. Intensity of primary energy in Romania

This has pointed out that:

• Regardless of the chosen measurement unit, primary energy intensity in the period 2000-2014 decreased by 48%, corresponding to an average annual rate of 3.42%;

The main factors that have contributed to this

decrease have been the following:

- The macroeconomic modifications of the national economy;
- The modifications in each sector and economic branch production structure;
- The modifications in the technical efficiency of energy utilization.

• The value of primary energy intensity can differ greatly according to the GDP measurement unit. Thus, in 2014 the values of this indicator were: 0.471 toe/1,000 Euros 2000, 0.316 toe/1,000 Euros 2005 and 0.229 toe/1,000 Euros 2010.

As we have already mentioned, these differences are determined by the variation of the PP of the Euro currency in the Romanian market. In an economy that has striven to find a balance in the analyzed period of time these variations have been important ones.

On the other hand, the variation of the PP of Euro in the developed countries has been low. Expressing energy intensity for a developed country (or for the EU average) does not differ essentially according to the chosen reference year.

Table 4 presents the values of primary energy intensity for Romania and the EU28 average in 2014, given in constant prices, in toe/1,000 Euros 2000, toe/1,000 Euros 2005 and toe/1,000 Euro 2010 namely.

Table 4. Primary energy intensity in 2014

M.U.	Romania	EU28
toe/1,000 Euro 2000	0.471	0.142
toe/1,000 Euro 2005	0.316	0.130
toe/1,000 Euro 2010	0.229	0.122

Source: ICEMENERG – OEN on the basis of EUROSTAT data

The data in table 4 prove how important the measurement unit chosen when making international comparisons is. In the same year (2014), the primary energy intensity of Romania's economy was:

• 3.32 times greater than the EU 28 average when it was calculated in toe/1,000 Euro 2000

• 2.43 times greater than the EU 28 average when it was calculated in toe/1,000 Euro 2005

• 1.88 times greater than the EU 28 average when it was calculated in toe/1,000 Euro 2010.

By calculating at constant prices and choosing an even more remote year, e.g. 1996 – the case of the IEA (International Energy Agency) statistics, the difference between Romania and the developed countries increases even more (in an artificial way, obviously).

Considering the positive evolutions of the national economy and the necessity to prove the tendency to get nearer the average EU performances, we think we should calculate energy intensity at current prices, or at constant prices at the level of one of the most recent years.

It is frequently recommended to calculate energy intensity at the PPP.

Within OEN we have calculated primary energy intensity of the Romanian economy on the basis of the information provided by Eurostat. The results are given in table 5 in toe/Euro at PPC for the period 2000-2014, together with data for the EU 28 average.

Table 5. Primary energy intensity (toe/1,000 Euro PPC)

Year	Romania	EU 28
2000	0.326	0.181
2005	0.222	0.159
2010	0.136	0.138
2011	0.133	0.129
2012	0.121	0.125
2013	0.110	0.123
2014	0.104	0.115

Source: ICEMENERG – OEN on the basis of EUROSTAT data

It should be underlined that primary energy intensity in Romania has been lower than the EU average since 2012 if we calculate the GDP at PPP. Such a conclusion totally contradicts the allegations on the energy–intensive character of the Romanian economy.

6. CARRYING OUT THE OBJECTIVES OF THE NATIONAL STRATEGY IN THE ENERGY EFFICIENCY FIELD (G.D. 163/2004)

In the context of Romania's negotiations for joining the European Union in 2004 the G.D. 163/2004 National Strategy in the Energy Efficiency Field was drawn up and approved. The strategy stipulates that:

"The main goal of the policy in the energy efficiency field is to reduce energy intensity.

In order to ensure the development under efficient and sustainable conditions a reduction in primary energy intensity by 40% in the period 2004-2015 is envisaged"

The time horizon of the strategy has been attained and, in our opinion, an evaluation of the way "the main goal of the policy in the energy field" has been attained would be opportune. As the statistical data for the year 2015 have not been published yet the data for the year 2014 will be used.

Since the beginning it should be noticed that the text of the document does not specify the way primary energy intensity should be calculated, the measurement unit of this indicator, respectively.

If energy intensity is calculated at current prices, then the value of this indicator has decreased from 0.489 toe/1,000 Euro in 2005 to 0.215 toe/1,000 Euro in 2014, by 56% respectively. In this variant the above mentioned strategic objective strategic was surpassed.

If energy intensity is calculated at constant prices (regardless of the reference year), then the value of this indicator decreased by 34%. In this variant, the above mentioned strategic objective has not been achieved.

If energy intensity is calculated at the PPP, the value of this indicator has decreased by 53%. In this variant the above mentioned strategic objective has been surpassed as well.

The purpose of this paper is not to analyze the way the provisions of the strategy have been carried out. What we would like underline once again is the importance of the calculation method and of the measurement unit chosen for the "primary energy intensity" indicator and of the explicit presentation of the options. In their absence any qualitative conclusions are possible and any conclusion is questionable.

7. CONCLUSIONS

Primary energy intensity represents the primary energy consumption necessary for producing a GDP unit. This parameter characterizes the economic efficiency of energy utilization and only to a lesser extent the technical efficiency.

Energy intensity can be calculated in toe/1,000 Euro – current prices, toe/1,000 Euro – constant prices or toe/1,000 Euro at the PPP. All these measurement units are usual ones and choosing one of them is the decision of an institution (or of a specialist) that analyzes the respective problem. The measurement unit chosen has a great importance for the qualitative conclusions.

If the calculation is made in toe/1,000 Euro – current prices, then it results that primary energy intensity decreased by 4.18 times in the 2000-2014 period (from 0.898 toe/1,000 Euro in 2000 to 0.215 toe/1,000 Euro), being 1.87 times lower than the EU28 average in 2014.

If the calculation is made at constant prices, toe/1,000 Euro 2005, then the value of this indicator decreased only 1.92 times in the same time interval and the value of the ratio against the developed countries is 2.43.

If the calculation is made in toe/1,000 Euro 2000, the value of the same indicator in 2014 was 3.32 times greater than the EU28 average.

If we express intensity in toe/1,000 Euro at the PPP then in 2014 the EU28 average is 1.11 times greater than the value corresponding to Romania.

Therefore, the qualitative assessments of primary energy intensity of the Romanian economy can oscillate between positive and negative.

Choosing the energy intensity measurement unit depends on the purpose of the analysis that is carried out.

If we want to make a comparison between Romania and the EU average (or any international comparison) for a certain year, the most correct thing to do, in our opinion, is to use primary energy intensity calculated at current prices (or at PPP possibly).

If we want to analyze the progress made by Romania in a certain period of time (by comparing our situation in different years), then it would be more correct to utilize primary energy intensity calculated in constant prices (the year of reference has practically no importance in this instance).

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