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METHODS OF CALCULATING ENERGY EFFICIENCY THROUGH ENERGY INTENSITY - ROMANIA

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Abstract
In the current economic and geopolitical context, energy efficiency is an important goal for every nation. Energy security, economic competitiveness and reduced environmental pollution depend on it. Energy intensity is the indicator most often used to assess energy efficiency in a national economy. It can be calculated not only at the aggregate (national) level giving an overall picture of energy efficiency, but also at the disaggregated (sectoral and sub-sectoral) level giving a detailed picture by sector and sub-sector of activity. This paper aims to highlight the different ways of calculating primary and final energy intensity with an example at the Romanian level for the period 2011-2021. The analysis of this indicator revealed that the transport sector is the least energy efficient. However, the energy intensity trend in transport is downward. At the opposite pole, the most efficient sector is the other activities sector, which includes the rest of the services. With small exceptions, however, there is a general downward trend in final energy consumption per $1000 gross value added by sector. The same downward trend was also evident for primary energy intensity.

Keywords: *energy; energy efficiency; energy intensity, primary energy consumption; final energy consumption.*

JEL Classification: *Q40, Q43*

I. INTRODUCTION

Energy efficiency is one of the EU's strategic priorities (Ciucci, 2023). Reducing energy consumption and eliminating energy waste are important EU objectives. In the current economic and geopolitical context of the energy crisis and the armed conflict between Ukraine and the Russian Federation, there is increasing emphasis on increasing energy efficiency at national level and beyond.

The EU is extremely vulnerable in this area. It does not have sufficient primary energy sources to cover its high energy consumption, which results in a rather low degree of energy independence. This is why the EU's energy policy has been conceived as a collective effort by the participants in the energy markets (producers, suppliers, consumers) to ensure energy security. It is based on economic, political and cultural interdependencies between Member States (Neguț et al., 2008, p. 5).

EU energy legislation sets a target for 2030 to reduce annual energy consumption across the EU by 32.5%. In 2023, EU leaders have set further targets for 2030, namely to reduce primary energy consumption by 38% and final energy consumption by 40.5%. The EU aims to increase security of energy supply, cut greenhouse gas emissions and reduce import costs. These are the three major objectives of EU energy policy, and each member state is making its own efforts in this regard, with Romania also following suit.

At national level, energy policy is extremely important if we also take into account the fact that the country's economic competitiveness also depends on the energy sector. Increasing the efficiency of the use of energy resources contributes significantly to improving economic competitiveness. In assessing energy efficiency, primary and final energy intensity play a key role and are in fact factors influencing economic competitiveness.

At the national level, energy security must be addressed as a strategic component of national security, and energy policy is vital to ensure it. From this point of view, the energy sector constitutes the main strategic infrastructure of the national economy on which a country's development depends (Neguț et al., 2008, p. 13). It is therefore extremely important to pay due attention to the energy sector.

This paper presents different ways of assessing Romania's energy efficiency at national level and by economic sector. The energy intensity indicator was used for the analysis, with statistical data taken from the National Institute of Statistics website and the UNCTAD website. The period analyzed was 2011-2021. Gross Domestic Product (GDP) and Gross Value Added (GVA) were expressed in current prices and in constant 2015 prices respectively. In the calculation of energy intensity by economic sectors, final energy consumption has been excluded from residential (household) consumption.

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II. ENERGY EFFICIENCY - CONCEPT AND CALCULATION METHODS

Energy efficiency is seen by experts in the field as a component of economic efficiency. It can be defined as an increase in the useful effect through the consumption of a form of energy (Muscalu, p. 37). It means using energy optimally and responsibly to achieve desired results, minimizing waste and unnecessary energy consumption.

Energy efficiency contributes to improving energy security (Simsek, 2014, p. 9), the security of energy supply as a result of reduced consumption and imports of primary energy.

The following indicators are used to express energy efficiency: energy intensity, primary and final energy consumption per inhabitant, direct and indirect specific consumption per unit of product. Of these, energy intensity is the most commonly used aggregate indicator in assessing a nation's efficient use of energy (Bongseok, Wooyoung, Bok-Keun, 2017, p. 399) and is included in the category of sustainable development indicators (www.odyssee-mure.eu/).

Recent and ongoing issues related to energy supply and environmental impacts have increased national and global concerns and efforts to increase energy efficiency by reducing energy intensity. Internal factors contributing to energy intensity reduction are frequently mentioned in the literature and include the following: technological changes (Garbaccio et al., 1999; Zheng et al., 2011; 1999; Voigt et al., 2014; Adom, 2015), economic structure and energy consumption (Leach & Lucas, 1993; Alghandoor et al., 2008; Zheng et al., 2011; Li et al., 2013; Tajudeen & Wossink, 2020), energy price developments (Domingues et al., 2017). At the same time, some authors mention that increased industrialization, urbanization and infrastructure construction also contribute to the increase in energy intensity, especially in developing countries (Sun, 2003).

There are two indicators of energy intensity: primary and final. The first indicator depends on primary energy consumption, the second on final energy consumption. Primary energy is energy in its pure form, found in nature, and primary energy consumption is the total amount of energy resources used for all purposes. It is determined as the difference between the sum of total primary energy production, primary energy imports, primary energy stock changes on the one hand and primary energy exports on the other. Final energy is the energy consumed by end-users and final energy consumption is the amount of final energy used.

There is some difference between the two intensity indicators. Primary energy intensity focuses on the energy required to produce the final energy. It provides an overview of a country's energy performance over a given period and allows the assessment of progress in energy efficiency as well as the comparison of performance between different national economies. It is calculated as the ratio of gross energy consumption, also called primary energy consumption, to the value of GDP. For energy efficiency to increase, this ratio needs to get lower and lower. Final energy intensity focuses on energy consumed in specific activities. This way of establishing energy efficiency provides a detailed overview of energy consumption in each sector, allowing the identification of the most energy-intensive sectors and the development of specific strategies to improve energy efficiency in those sectors. It is defined as the ratio of final energy consumption to GDP or GVA specific to each economic sector.

Knowledge of both energy intensities (primary and final) can be useful in the context of energy policies and economic decisions. It ensures that energy efficiency can be assessed and monitored, opportunities for improvement identified and policies targeted to reduce energy consumption and greenhouse gas emissions. As such, whether set at the level of economic sectors or at the national level, energy intensity generally provides a more comprehensive understanding of energy efficiency and contributes to the development of appropriate energy strategies and policies.

In the following we will present in detail how to determine primary and final energy intensity.

Table 1. How to calculate energy intensity

Level	Energy intensity	Calculation ratio	Explanations
National	Primary	$I_e = \frac{E_p}{GDP}$ (1)	E_p = total primary energy consumption
	Aggregate final	$I_e = \frac{E_f}{GVA}$ (2)	E_f = total final energy consumption excluding that of the population established according to: $E_f = E_{af} + E_{fi} + E_{ft} + E_{fal}$
	Disaggregated final (sectoral breakdown)	$I_e = \sum_{j=1}^{4} \frac{E_{fj}}{GVA_j} * s_j$ (3) or $I_e = \sum_{j=1}^{4} \sum_{i=1}^{n} \frac{E_{fij}}{GVA_{ij}} * s_{ij}$ (4)	$\frac{E_{fj}}{GVA_j} * s_j$ = contribution of sector 'j' to aggregate final energy intensity $\frac{E_{fj}}{GVA_j}$ = final energy intensity of sector "j" s_j = share of GVA of sector "j" in total GVA $\frac{E_{fij}}{GVA_{ij}}$ = final energy intensity of subsector "i" within sector "j"

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			s_{ij} = share of GVA of subsector "i" in total GVA of sector "j"
Sectorial in:	-	-	-
Agriculture	Aggregate final	$I_{ea} = \frac{E_{fa}}{GVA_a}$ *(5)*	E_{fa}, = final energy consumption in agriculture GVA_a = GVA in agriculture
	Disaggregated final (sub-sectoral breakdown)	$I_{ea} = \sum_{i=1}^{n} \frac{E_{fai}}{GVA_{ai}} * s_{ai}$ (6)	E_{fai} = final energy consumption by subsector 'i' in agriculture GVA_{ai} = GVA by subsector "i" in agriculture s_{ai} = GVA share of subsector "i" in agricultural GVA
Industry	Aggregate final	$I_{ei} = \frac{E_{fi}}{GVA_i}$ (7)	E_{fi}, = final energy consumption in industry, VAB_i = GVA in industry
	Disaggregated final (sub-sectoral breakdown)	$I_{ei} = \sum_{i=1}^{n} \frac{E_{fii}}{GVA_{ii}} * s_{ii}$ (8)	E_{fii} =final energy consumption by subsector 'i' in industry GVA_{ii} = GVA by subsector "i" in industry s_{ii} = share of GVA of subsector "i" in GVA of industry
Transport	Aggregate final	$I_{et} = \frac{E_{ft}}{GVA_t}$ (9)	E_{ft} = final energy consumption in transport GVA_t , = GVA in transport
	Disaggregated final (sub-sectoral breakdown)	$I_{et} = \sum_{i=1}^{n} \frac{E_{fti}}{GVA_{ti}} * s_{ti}$ (10)	E_{fti} = final energy consumption by transport sub-sector 'i GVA_{ti} = GVA by transport sub-sector "i s_{ti} = share of GVA of subsector "i" in transport GVA
Other activities	Aggregate final	$I_{eal} = \frac{E_{fal}}{GVA_{al}}$ (11)	E_{fal} = final energy consumption in other sectors GVA_{al} = GVA in other economic activities
	Disaggregated final (sub-sectoral breakdown)	$I_{eal} = \sum_{i=1}^{n} \frac{E_{fali}}{GVA_{ali}} * s_{ali}$ (12)	E_{fali} = final energy consumption by subsector 'i' in other economic activities GVA_{ali} = GVAby subsector 'i' in other economic activities S_{ali} = share of GVA of subsector "i" in GVA from other economic activities

Note: Relationships (4), (6), (8), (10) and (12) may be used when GVA and energy consumption information is broken down by economic sub-sectors.

Energy intensity values are subunit. However, for energy efficiency to increase, energy intensity needs to be on a downward trend. Depending on the development of energy consumption and GDP/GVA, energy efficiency will increase in the following situations:

Situation 1: when energy consumption (E) decreases and GDP/GVA increases, meaning that the consumption index is below 100% and the GDP/GVA index is above 100% (I_E < 100% and $I_{GDP(GVA)}$ >100%);

Situation 2: when energy consumption and GDP/GVA are increasing (I_E >100%, $I_{GDP(GVA)}$ >100%) and the growth rate of GDP/GVA exceeds the growth rate of energy consumption ($I_E < I_{GDP(GVA)}$);

Situation 3: when energy consumption and GDP/GVA are decreasing (I_E <100%, $I_{GDP(GVA)}$ <100%) and the rate of decrease in energy consumption is greater than the rate of decrease in GDP/GVA ($I_E < I_{GDP(GVA)}$).

III. METHODOLOGY

As the statistical data found did not allow the use of all the relationships presented in Table 1, we focused on the study of the evolution of primary and final energy intensity calculated only at national level (in aggregate and disaggregated form) and at sectoral level in aggregate form.

The period analysed was 2011-2021. The data were collected from the websites of the National Institute of Statistics and UNCTAD. To compare the results, we used GDP and GVA data expressed in current and constant 2015 prices. From the total final energy consumption we removed consumption for the residential sector (population).

The analysis methods used were: comparison, graphical representation, synthesis and economic analysis. The mathematical relationships used were (1), (2), (3), (5), (7), (9) and (11) in Table 1.

IV. RESULTS AND DISCUSSION

A) Primary energy intensity

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Trends in gross energy consumption, GDP (in current and constant 2015 prices) and primary energy intensity are shown in Table 2.

Table 2. Gross energy consumption, GDP, primary energy intensity - Romania

Years	Gross inland energy consumption		PIB (mil. $)		Primary energy intensity - national level	
	thousand toe	Annual percentage change (%)	mil. $	Annual percentage change (%)	toe/1.000$	Annual percentage change (%)
			1) GDP situation - current prices			
2011	35648	-	192613.60	-	0.1851	-
2012	34851	-2.24	179132.89	-7.00	0.1946	5.12
2013	31634	-9.23	189789.30	5.95	0.1667	-14.33
2014	31538	-0.30	199713.80	5.23	0.1579	-5.26
2015	31844	0.97	177883.90	-10.93	0.1790	13.36
2016	31638	-0.65	185287.60	4.16	0.1708	-4.62
2017	33391	5.54	210147.20	13.42	0.1589	-6.94
2018	33510	0.36	243316.10	15.78	0.1377	-13.32
2019	33016	-1.47	251017.80	3.17	0.1315	-4.50
2020	32171	-2.56	251362.50	0.14	0.1280	-2.69
2021	34102	6.00	284086.40	13.02	0.1200	-6.21
			2) GDP situation - constant prices 2015			
2011	35648	-	162044.66	-	0.2200	-
2012	34851	-2.24	165163.99	1.92	0.2110	-4.08
2013	31634	-9.23	165609.89	0.27	0.1910	-9.48
2014	31538	-0.30	172434.09	4.12	0.1829	-4.25
2015	31844	0.97	177883.90	3.16	0.1790	-2.12
2016	31638	-0.65	182967.02	2.86	0.1729	-3.41
2017	33391	5.54	197963.93	8.20	0.1687	-2.45
2018	33510	0.36	209899.22	6.03	0.1596	-5.35
2019	33016	-1.47	217986.99	3.85	0.1515	-5.13
2020	32171	-2.56	209970.49	-3.68	0.1532	1.16
2021	34102	6.00	220679.22	5.10	0.1545	0.86

Source: NSI and UNCTAD data, own calculations

In terms of primary energy consumption, decreases are generally observed throughout the period. However, there have been four years of increases, the most significant being in 2017 (+5.54%) and 2021 (+6%). For GDP there have been decreases in 2012 and 2015 for GDP in current prices and in 2020 for GDP in constant prices. The last decrease, however, occurred in the context of the COVID 19 pandemic.

As expected, primary energy intensity values calculated with GDP current prices were lower than those calculated with GDP constant prices 2015. According to Table 2 and Graph 1, intensity based on GDP current prices generally showed a downward trend, except for 2012 and 2015 which marked a peak in energy inefficiency. The increases in energy intensity mentioned above occurred due to significant decreases in GDP (-7% in 2012 and -10.93% in 2015). While in 2012, there were percentage decreases in both consumption (-2.24%) and GDP, in 2015 there was an increase in consumption (+0.97%) and a decrease in GDP. At the opposite pole, the largest percentage decreases in intensity were recorded in 2013 (-14.33%) and 2018 (-13.32%). Here again, we note two totally different situations. In 2013, the reduction in intensity is explained by a reduction in gross energy consumption (-9.23%) in the context of an increase in GDP (+5.95%). In 2018, on the other hand, the reduction in intensity was due to a lower percentage increase in consumption (+0.36%) than in GDP (+15.78%).

According to the values of primary energy intensity calculated on the basis of GDP constant prices 2015, its evolution was continuously decreasing until the last two years when insignificant increases were recorded (+1.16% in 2020 and +0.86% in 2021). Looking more closely at the data in Table 2, we can see that in 2020 the percentage reduction in gross energy consumption was lower than that of GDP, while in 2021 the percentage increase in GDP was lower than that of primary energy consumption. The most significant percentage decrease was achieved in 2013 (-9.48%), which was due to the decrease in gross energy consumption (-9.23%) on the one hand and the increase in GDP (+0.27%) on the other. Overall, however, it can be said that the intensity trend was downwards, which shows the reduction in primary energy consumption to obtain $1000 GDP (see Figure 1).

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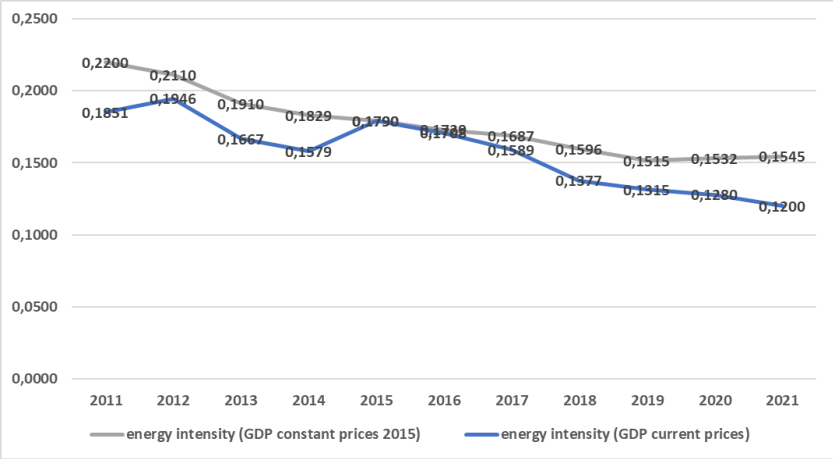

Figure 1. Evolution of national primary energy intensity
Source: own calculations

B) Final energy intensity

With small exceptions, final energy consumption and GVA have shown an increasing trend throughout the period under review. The evolution of these two indicators, both at national and sectoral level, is shown in Table 3. According to the calculations made, the largest energy consumers are industry (with shares ranging from 41.25-47.71%) and transport (with shares ranging from 35.74-42.01%). The smallest energy consumer is the agricultural sector, with shares in total consumption ranging from 2.91-3.57%.

In terms of GVA at current prices, here too there is a generally upward trend. Industry has seen some fluctuations in GVA over the period studied, with shares ranging from 45.44% in 2011 to 29.27% in 2020. Industry has also seen a continuous decrease in its GVA share. Unlike industry, however, transport contributed a much smaller share of total GVA (between 9.48-13.8%), which also explains the higher final energy intensity of this economic sector (see Figures 2 and 3). If we refer to GVA at constant 2015 prices, the annual values are lower compared to those expressed in current prices. However, there are significant shares for other activities and industry, a decreasing trend for the shares of agriculture and industry in total GVA, and an increasing share of transport and other activities in total GVA. Moreover, these developments are similar to those for GVA at current prices.

Table 3. Final energy consumption and GVA (current prices) - Romania

Years	Total	Agriculture		Industry		Transport		Other activities	
Final energy consumption (1)									
	thousand toe	**thousand toe**	**%**	**thousand toe**	**%**	**thousand toe**	**%**	**thousand toe**	**%**
2011	14867	433	2.91	7093	47.71	5313	35.74	2028	13.64
2012	14867	499	3.36	6796	45.71	5351	35.99	2025	13.62
2013	14137	472	3.34	6307	44.61	5364	37.94	1994	14.10
2014	14324	426	2.97	6456	45.07	5489	38.32	1953	13.63
2015	14509	461	3.18	6438	44.37	5591	38.53	2019	13.92
2016	14879	455	3.06	6301	42.35	6049	40.65	2074	13.94
2017	15565	495	3.18	6407	41.16	6506	41.80	2157	41.80
2018	15835	566	3.57	6619	41.80	6462	40.81	2188	13.82
2019	16120	557	3.46	6659	41.31	6713	41.64	2191	13.59
2020	15504	531	3.42	6424	41.43	6514	42.01	2035	13.13
2021	16605	567	3.41	6849	41.25	6976	42.01	2213	13.33
GVA (current prices) (2)									
	Mil. $	**Mil. $**	**%**	**Mil. $**	**%**	**Mil. $**	**%**	**Mil. $**	**%**
2011	170452.8	11462.8	6.72	77453.9	45.44	16163.7	9.48	65372.3	38.35
2012	158334.4	8133.4	5.14	61665.9	38.95	18826.6	11.89	69708.6	44.03
2013	167270.5	10457.4	6.25	60873.4	36.39	22338.3	13.35	73601.5	44.00
2014	176614.8	9882.9	5.60	65049.6	36.83	21971.9	12.44	79710.4	45.13
2015	156253.4	7873.1	5.04	54809.6	35.08	20440.4	13.08	73130.3	46.80
2016	165881.4	7953.0	4.79	55812.1	33.65	21358.2	12.88	80758.0	48.68
2017	190097.1	9328.1	4.91	61174.4	32.18	24946.8	13.12	94647.8	49.79
2018	220068.2	11106.3	5.05	70363.8	31.97	27659.1	12.57	110939.0	50.41
2019	227086.8	11095.2	4.89	69260.3	30.50	29207.3	12.86	117524.0	51.75

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2020	227992.9	10504.1	4.61	66731.6	29.27	30944.9	13.57	119812.4	52.55
2021	256624.9	12356.9	4.82	78929.9	30.76	35404.5	13.80	129933.6	50.63
GVA (constant prices 2015) (2)									
	Mil. $	**Mil. $**	**%**	**Mil. $**	**%**	**Mil. $**	**%**	**Mil. $**	**%**
2011	141760.80	7991.75	5.64%	57984.11	40.90%	12430.54	8.77%	63354.40	44.69%
2012	148903.45	6066.18	4.07%	50989.02	34.24%	16104.61	10.82%	75743.65	50.87%
2013	146925.11	8082.62	5.50%	49250.70	33.52%	17618.19	11.99%	71973.59	48.99%
2014	152239.03	8752.78	5.75%	52749.70	34.65%	18665.36	12.26%	72071.20	47.34%
2015	156253.42	7873.07	5.04%	54809.63	35.08%	20440.42	13.08%	73130.30	46.80%
2016	160653.58	8067.02	5.02%	55787.32	34.73%	23066.77	14.36%	73732.47	45.90%
2017	173747.98	9089.22	5.23%	59616.17	34.31%	26126.69	15.04%	78915.90	45.42%
2018	183502.29	10339.18	5.63%	62612.12	34.12%	27257.73	14.85%	83293.25	45.39%
2019	189980.76	10009.30	5.27%	62078.98	32.68%	29516.96	15.54%	88375.53	46.52%
2020	182141.29	8480.61	4.66%	59225.60	32.52%	28001.18	15.37%	86433.90	47.45%
2021	191406.79	9072.20	4.74%	61788.84	32.28%	30602.05	15.99%	89943.70	46.99%

Source: data (1) NSI and (2) UNCTAD, own calculations

Figures 2 and 3 illustrate the evolution of final energy intensity at national and sectoral level. According to them, a general downward trend is observed. If we consider the intensity calculated on the basis of GVA current prices, then we can mention that the lowest levels were recorded in the other economic activities sector, below 0.04 toe/1,000$. Values closer to those mentioned above are also observed for agriculture (below 0.062 toe/1.000$). Comparing the two sectors, final energy consumption in agriculture is much lower, but GVA in other activities far exceeds GVA in agriculture. Therefore, there is a difference in energy efficiency between the two sectors. In fact, if we take a closer look at the data in Table 3, we see that the sector of other activities creates the highest GVA. This also explains the lower final energy intensity values of this sector compared to the rest. As such, in Romania, the best performing economic sector from an energy point of view is the other activities sector, which includes services.

With regard to the evolution of final energy intensity (GVA current prices), the calculations carried out allow us to highlight certain important aspects. Although there have been decreases in final energy intensity in all sectors, there have been some differences. In agriculture and industry there were two years of increasing intensity (2012 and 2015), while in other economic activities and transport only one year of increase (2015) and three consecutive years of energy inefficiency (2014, 2015, 2016).

By comparison, final energy intensity calculated on the basis of constant price GVA was higher than that on the basis of current price GVA (Figures 2 and 3). The explanation is that GVA expressed in current prices is higher than that in constant 2015 prices. For this reason, the evolution of final energy intensity at national level and by economic sector is also slightly different in the two cases. Figure 3, however, shows much better the downward trend of energy intensity in transport. In agriculture and industry, however, the calculations showed a slight increase in this indicator at the end of the period analyzed.

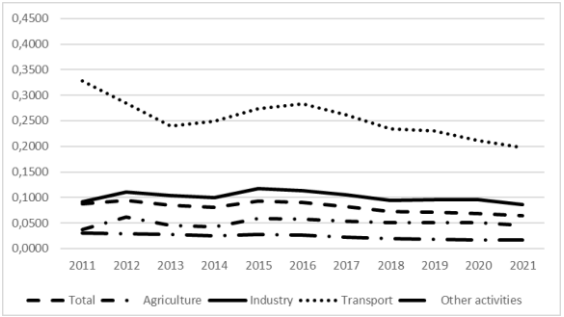

Figure 2 - National and sectoral final energy intensity (GVA in current prices)
Source: own calculations

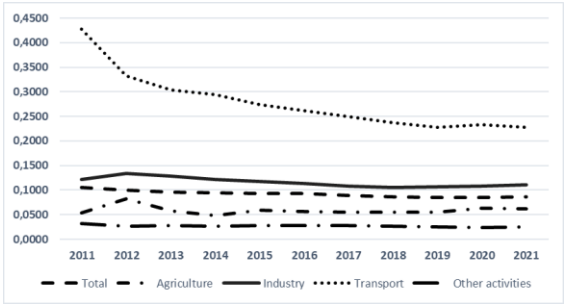

Figure 3 - National and sectoral final energy intensity (GVA in constant 2015 prices)
Source: own calculations

The influences of annual percentage changes in total final energy consumption and GVA on national energy intensity are illustrated in Figures 4 and 5. According to Figure 4, there were two years in which energy intensity (GVA current prices version) increased. In 2012, the increase in intensity was generated by a decrease in GVA of -7.11% and the final consumption remaining at the same level as in 2011. In contrast to 2012, energy inefficiency in 2015 was driven by a decrease in GVA (-11.53%) on the one hand and an increase in final energy consumption of +1.29% on the other. Although in absolute terms the increase in energy intensity in 2015 does not seem to be significant (+0.0067 toe/1,000$), in percentage terms we can no longer say the same (+14.49%). If we refer to the

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increase in energy efficiency, we can say that it was achieved in 2018 (-12.12%) in the context of an increase in consumption of 1.73% and GVA of 15.77%.

In the case of energy intensity - GVA constant price version (Figure 5), we see energy inefficiency in 2020 and 2021. Unlike the previous version, in this case the energy inefficiency is not significant. The increase in intensity is only 0.32% in 2020 and 1.92% in 2021. In 2020, inefficiency was caused by a greater reduction in GVA (-4.13%) than in consumption (-3.82%), whereas in 2020, energy inefficiency was caused by a greater increase in consumption (+7.1%) than in GVA (5.09%). From an economic point of view, the best percentage change in intensity was achieved in 2012 (-4.8%), due to the percentage increase in GVA (+5.04%) and the maintenance of the same final energy consumption as in 2011.

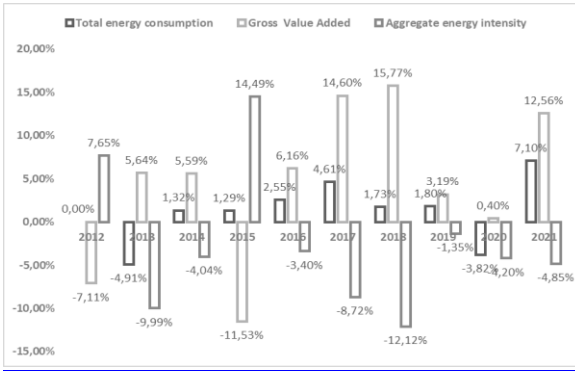

Figure 4. Annual percentage changes (GVA version current prices)
Source: own calculations

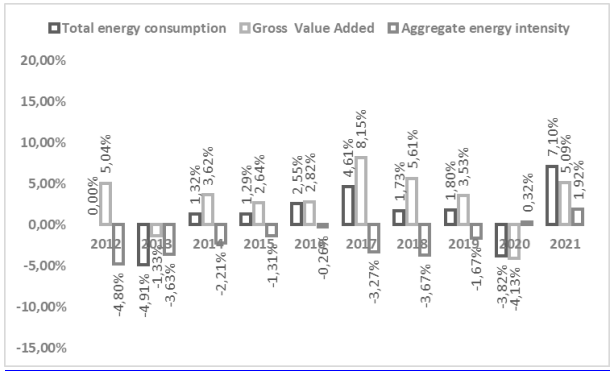

Figure 5. Annual percentage changes (GVA version constant prices 2015)
Source: own calculations

The contributions of the four economic sectors to aggregate final energy intensity are shown in Figures 6 and 7. As expected, the contribution of the sectors to intensity formation (GVA constant prices) is higher than for intensity (GVA current prices). Industry and transport had the highest contributions to national final energy intensity formation. Transport contributed between 0.0272-0.0365 toe/1,000$ in the case of intensity (GVA current prices) and between 0.0352-0.0377 toe/1,000$ in the case of intensity (GVA constant prices). In industry, the variation in contributions was slightly higher than in transport: between 0.0267-0.0416 toe/1,000$ in the case of intensity (GVA constant prices). In agriculture and other activities, the contributions were in much smaller ranges than for transport and industry.

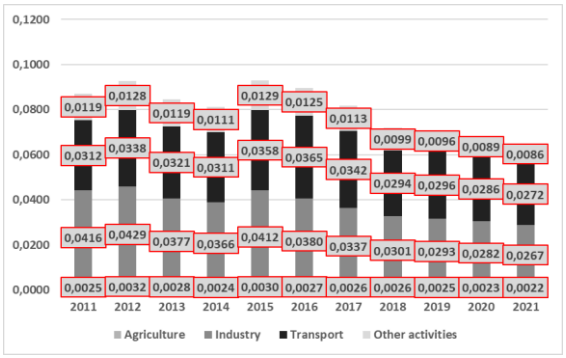

Figure 6. Components of final energy intensity - GVA current prices (thousand toe/1,000$)
Source: own calculations

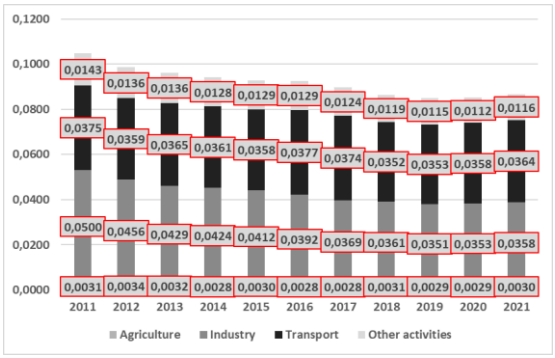

Figure 7. Final energy intensity components - GVA constant prices 2015 (thousand toe/1,000$)
Source: own calculations

The evolution in relative magnitudes of final energy intensity by sector of activity is shown in Figures 8 and 9. They show that for intensity (GVA current prices) the annual percentage changes are much higher than for intensity (GVA constant prices).

For energy intensity (GVA current prices), the most significant percentage changes were in agriculture, industry and other activities in 2013 and 2018. More specifically, in 2013, the best developments were noted in agriculture (-26.43%) and transport (-15.52%), while in 2018 in other economic activities (-13.46%) and industry (-10.18%). At the opposite pole, the worst performances were recorded in 2012 and 2015. From this point of view, significant increases were observed in 2012 in agriculture (+62.42%) and industry (+20.34%), while in 2015 increases were reported in all four sectors: +35.84% in agriculture, +18.35% in industry, +12.68% in other activities and +9.49% in transport (see Figure 8).

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However, if we refer to intensity (GVA constant prices), then the highest increase was recorded in 2012 in agriculture, with +9.71%. This was followed in 2016 by transport at +5.23%. In industry and other activities the increases were reported in 2021, at 1.45% and 3.48% respectively. The best results in terms of energy intensity reduction were achieved as follows: in industry in 2012 (-8.78%), in agriculture (-12.9%) and other activities (-5.47%) in 2014 and in transport (-5.96%) in 2018 (see Figure 9).

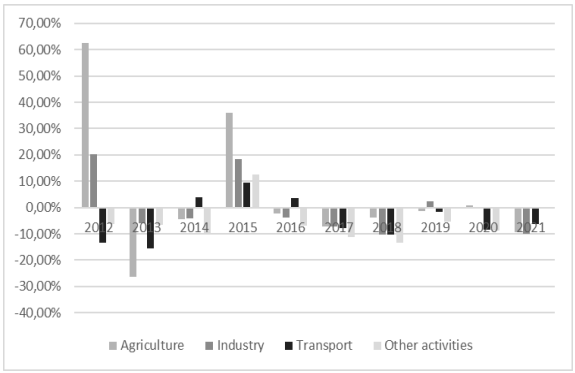

Figure 8. Annual percentage changes in energy intensity by sector (GVA current prices)
Source: own calculations

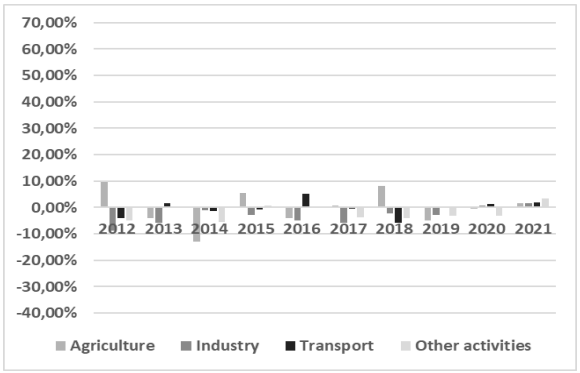

Figure 9. Annual percentage changes in energy intensity by sector (GVA constant prices)
Source: own calculations

V. CONCLUSIONS

Energy intensity is the qualitative and quantitative expression of energy efficiency and is the most representative synthetic indicator for assessing energy efficiency at both national and sectoral level. It shows the relationship between energy consumption and economic growth. It is continuously monitored to establish future projections for reducing energy consumption at national and sectoral level.

Romania's energy efficiency has continuously improved over the period studied. This is evidenced by the downward trend in energy intensity. The comparative analysis of aggregate (national) and disaggregated final energy intensity calculated by GVA in current prices and GVA in constant prices illustrates the higher level for the latter. Also at sectoral level, the highest energy efficiency is found for the other economic activities sector. Within this sector, the level of consumption is the lowest while the level of GVA is the highest.

The years of inefficiency are different for the two versions of final energy intensity (GVA current prices and GVA constant prices 2015). If in the case of the first version, the inefficiency years are 2012 and 2015 in the case of the second version, we are talking about the last two years studied (2020 and 2021).

At the same time, energy inefficiency was generated by the following situations: 1) maintaining the same energy consumption and decreasing GVA; 2) increasing energy consumption and decreasing GVA; 3) a greater decrease in GVA compared to consumption; 4) a greater increase in consumption compared to GVA. At the other end of the scale, energy efficiency was achieved in the following situations: a) consumption decreased and GVA increased; 2) GVA increased more than consumption; 3) consumption decreased more than GVA.

The decomposition of final energy intensity by sector of activity showed that there are two sectors with the highest contribution to national energy intensity: industry and transport.

Overall, the most inefficient sector is transport and the most efficient sector is other activities.

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