Green Energy for Sustainable Development in Romania's Economy

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Based on representative energy indicators, this study examines the need to adopt Green Energy Economy in Romania, in relation to the economic activity and demographic changes. The data used are the main energy indicators (the CO_2 emissions, greenhouse gas emissions, the renewable energy consumption and the consumption of biofuel), the intensity of energy in economy, and the population number. The methodology consists in a quantitative analysis in EViews program. The results' interpretation will take into account that Romania has to continue to reduce the intensity of energy, by increasing the energy efficiency, focusing mainly on energy technologies with low-carbon.

Keywords: green energy, economic development, sustainable development, quantitative methods

One of the main objectives of every country is to ensure *Green Energy Economy* (GEE) [1], concept that drew *the media attention following the 2008-2009 global financial crisis* [2,3]. After the financial crisis, Romania's *labour force suffered major changes and currently is trying to improve its macro-economic situation* [4]. On the other hand, resources *acquired from foreign markets, can be either consumption by raising the standard of living (on short term) or, investments* [5].

In terms of Sustainable Development Indicators, their results follow the target-objectives outlined to be achieved at international level on the horizon of the year 2030 [6]. National institutes of statistics of the countries, Eurostat, and international organisms monitor the results of these indicators.Thereby, among the 17 Sustainable Development Goals (SDGs) to be attained by each country till the end of the year 2030, Affordable and clean energy represents the 7th goal (SDG7) of 17. The SDG Index for Romania shows the following: the global rank is 41 (of 149 countries); the score or value is 67.51/100; the regional average is 64.9/100. Regarding the SDG7, *Affordable and clean energy* at the level of 2015, Romania registered the following results: Access to electricity is 100%; Access to non-solid fuels is 82.8%; CO_2 from fuels and electricity is 1.2 $MtCO_2$/TWh; and Renewable energy in final consumption is not reported [7].

Based on data series on representative Sustainable Development Indicators (SDI) on Energy from Eurostat database and National Institute of Statistics of Romania (*Goal2, Climate change and clean energy), available for the period* 2000-2013, this study examines the need to adopt *Green Energy Economy* in Romania, by: decreasing CO2 emissions and the intensity of greenhouse gas emissions (GGE), raising the renewable energy consumption and increasing the consumption of biofuel.

The next section of the study comprises an experimental part, with presentation of the brief data and methodology description, followed by the results obtained and discussions, and the conclusions. The research tests three hypotheses and offers evidence about relationships between the representative energy variables in Romania, in order to explain the Romania's state of SDG7 related to the clean energy.

Experimental part

Database and Methodology

In order to evaluate the need for GEE in Romania, in its way to reach SDG for a clean energy, this study analyzes the following variables: Intensity of CO_2 emissions, further denoted by *I_CO2E*; Intensity of energy in economy (economic activity), further denoted by I_EE; Intensity of the Greenhouse Gas Emissions (GGE), denoted by I_GGE; Biofuel consumption, denoted by BC; Renewable energy consumption, denoted by REC; Population number, denoted by PN.

The primary energy production in Romania takes an important part in the total energy resources of this country, representing 26387 ktoe at the level of the year 2015, registering a growth of 0.6% compared to the previous year [8]. The primary energy resources were composed of: coal (5725 ktoe in 2015), oil (11513 ktoe in 2015), natural gas (10536 ktoe in 2015), imported coconut oil (503 ktoe in 2015) and hydroelectric, wind and electric-nuclear energy (5096 ktoe in 2015). Coconut oil energy resource registered a growth of 8.2% in 2015 compared to 2014 [8].

However, oil, coal and natural gas have the most important contribution to primary energy production, according to the analysis of the evolution of these three elements during the period 2000-2014. We can observe that the primary source of energy in Romania was based on oil (61.8%), followed by coal (22.2%) and natural gas (6.4%) (fig. 1).

Intensity of CO_2 emissions (I_CO2E) in Romania has decreased to 183.56 tons/mil. RON in 2013, from 373.55 tons/mil. RON in 2000 [8].

In the Sustainable Development Goals (SDGs), the aim of the energy in economy intensity (I_CO2E), which represents *the gross domestic consumption of energy in relation to the national economy or the quantity of energy required producing one unit of GDP* [8], is to provide the necessary energy, but not by increasing its use (excluding renewables), but by increasing the energy efficiency, modernization of technology, and restructure of the economy.

In Romania, although the Intensity of energy in economy decreased from 610 kgep/1000 Euro, 336 kgep/1000 Euro,

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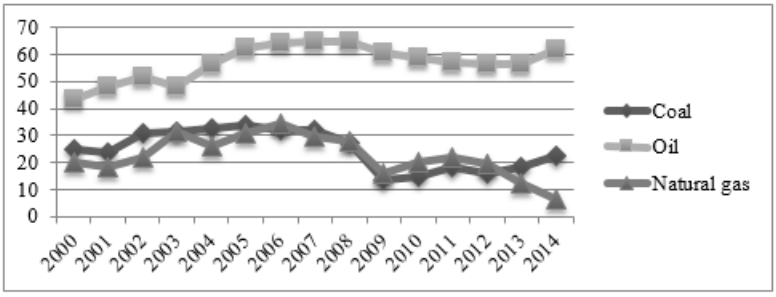

Fig. 1. Percentage of energy dependency in Romania (2000- 2014) [8]

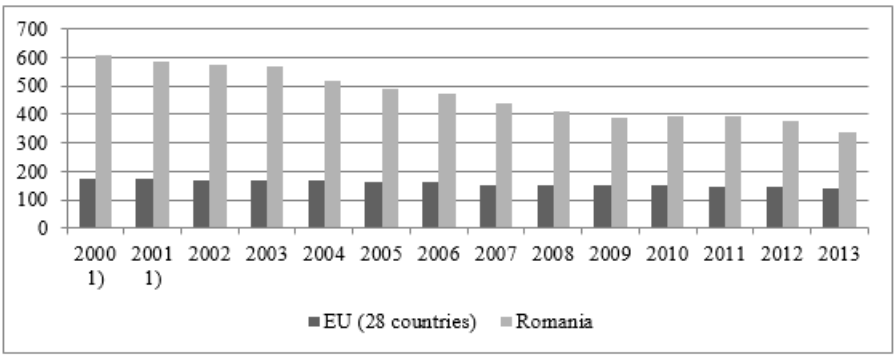

Fig. 2. I_EE in Romania, compared with the average of EU (2000-2013) [8]
Note: 1) represents data of countries from EU 27

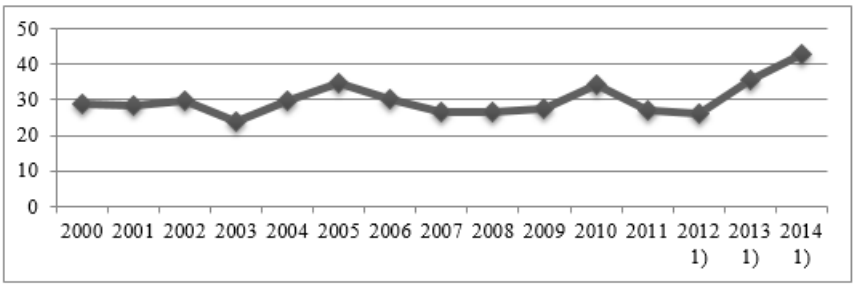

Fig. 3. Renewable energy consumption (REC) in Romania (2000-2014) [8]

during the period 2000-2013, it is almost double than the EU average, which fell slightly from 171.2 in 2000, to 141.7 kgep/1000 Euro at the end of 2013 (fig. 2).

Greenhouse Gas Emissions (GGE) intensity of energy consumption (I_GCE) highlights the impact of the GCE to the air temperature increase at the surface of Land, leading to the climate changes. Thus, the values of this indicator has to as low as possible. In Romania, GGE intensity decreased from 2770 in 2000, to 2430 tonnes CO_2 equivalent/thousand tep in 2013 [8].

Between the years 2000-2006, the biofuel consumption in transport sector (BC) in Romania was 0%, increasing at 4.03% in 2012, reaching only 3% in 2014 [8]. The Romanian's strategies regarding biofuel consumption establishes that, by the year 2020 ...the percentage of biofuel utilization will amount to at least 10%, in the conditions of the new generations of biofuels [9] (p. 25).

In its way to *Green Energy Economy*, more than 40% of electric energy in Romania (42.9% at the level of 2014) came from renewable energy, trend that continues an ascendant evolution beginning with the year 2012 (fig. 3).

Renewable energy consumption (REC) in total electric energy in Romania is up to average of the European Union, of 27.5%, at the level of 2014. The highest production of renewable energy in Europe is of Norway, over 100% of the total electric energy, and lowest, up to 10% is for Cyprus, Hungary, Luxembourg and Malta [10].

Assuming that the population number (PN) influences the CO_2 emissions intensity, this research takes into account the number of population during the analyzed period. Thus, Romania registered a decrease from 22.44 mil people in 2000 to 21.52 million residents at the beginning of year 2004 and, 19.91 people in 2014 [11].

Based on the data presented above, this study further verifies the following Hypotheses:

H1. There is a strong connection between the following variables: I_CO2E, I_EE, and PN;

H2. I_EE and PN have significant effects on the I_CO2E;

H3. There are significant connections between the following variables: I_EE, I_CO2E, I_GGE, BC and REC.

The methodology applied consists in correlation for the Hypothesis 1 and Hypothesis 3 and, regression for Hypothesis 2, in EViews program.

Results and discussions

This part of the study offers the results obtained for each hypothesis.

In order to verify the 1st Hypothesis, H1, the study analyzes the correlation between the following variables: I_CO2E, I_EE and PN.

The obtained results (table 1) show that there is a strong correlation between the I_CO2E and I_EE (Pearson coefficient=0.996, $p<0.01$), and also between the I_CO2E and PN (Pearson coefficient= 0.975, $p<0.01$). Thus, the 1st Hypothesis, H1, is verified.

Further, to verify whether or not the I_EE and the PN have a significant effect on the I_CO2E, which represents the 2nd hypothesis, H2, of this study, we make use of multiple linear regression (table 2).

The following explanatory variables are defined: the dependent variable, I_CO2E; the independent variables: I_EE and PN.

The econometric analysis was made with logarithm series of the dependent and independent variables' values, facilitating the interpretation of the obtained coefficients from the regression function (L_I_CO2E, L_I_EE, L_PN).

The results of the L_I_CO2E estimation reveal the following:

Table 1

CORRELATION ANALYSIS BETWEEN I_CO2E, I_EE AND PN

Correlations				
		I_CO2E	I_EE	PN
I_CO2E	Pearson Correlation	1	,996**	,975**
	Sig. (2-tailed)		,000	,000
	N	14	14	10
I_EE	Pearson Correlation	,996**	1	,963**
	Sig. (2-tailed)	,000		,000
	N	14	14	10
PN	Pearson Correlation	,975**	,963**	1
	Sig. (2-tailed)	,000	,000	
	N	10	10	10
Correlation is significant at the 0.01 level (2-tailed).				

Own calculations, using SPSS 20.00 Statistics Programs

Table 2

REGRESSION ANALYSIS FOR L_I_CO2E, L_I_EE AND L_PN

Dependent Variable: L_I_CO2E				
Method: Least Squares				
Date: 01/31/17 Time: 00:26				
Sample (adjusted): 5 14				
Included observations: 10 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-4.987777	1.952829	-2.554129	0.0379
L_I_EE	0.925943	0.217465	4.257901	0.0038
L_PN	1.612802	1.048441	1.538286	0.1679
R-squared	0.983350	Mean dependent var		5.488491
Adjusted R-squared	0.978593	S.D. dependent var		0.167525
S.E. of regression	0.024511	Akaike info criterion		-4.336075
Sum squared resid	0.004205	Schwarz criterion		-4.245300
Log likelihood	24.68038	Hannan-Quinn criter.		-4.435656
F-statistic	206.7101	Durbin-Watson stat		2.434653
Prob(F-statistic)	0.000001			

Own calculations, using EViews 8

- R square has the value of 98.335%, meaning that the variables L_I_EE and L_PN have an influence of 98.3350% on the L_I_CO2E;

- However, P value < 0.05 only in the case of L_I_EE (p= 0.0038). The variable L_I_EE is significant and influences the dependent variable L_I_CO2E. The P value>0.05 for L_PN (p= 0.1679). The variable L_PN is not significant.

The t test of the linear regression of the L_PN influence on the L_I_CO2E is not significant (p> 0.05); t<2). In Romania, the population decreased in number during the analyzed period of 2000-2014.

For the next step, the study employs **t**he simple regression for the same dependent variable, the L_I_CO2E and, only one independent variable, the L_I_EE. The econometric analysis was made with logarithm series, facilitating the interpretation of the coefficients of the regression function (L_I_CO2E, L_I_EE). (table 3)

The results of L_I_CO2E estimation show the following: R square has the value of 98.9920%, meaning that the variable L_I_EE has an influence of 98.9920% on L_I_CO2E; P value< 0.05 in the case of L_I_EE (p= 0.0000). The variable L_ I_EE is significant and influences the dependent variable L_I_CO2E; Prob (F-statistic)<0.05. L_I_EE is significant to explain L_I_CO2E (P(F-statistic)= 0.0000); The signs of the coefficients are following the economic theory: when L_I_EE undertakes a raise of one unit, L_I_EE increases with 1.222873 units.

The residual is determined as the Actual L_I_CO2E minus estimated L_I_CO2E. According to the Breusch-Godfrey serial Correlation LM test, Prob. Chi-Square=0.6652 (Prob>0.05), which can be explained by the fact that there is no serial correlation (table 4).

Next, the heteroskedasticity test is verified. The results show that there is no heteroskedasticity in the residual, according to Heteroskedasticity Test: Breusch-Pagan-Godfrey, where Prob. Chi-Squared is 0.4628 (P> 0,05) (table 5).

From the results of the Histogram (Jarque-Bera test), Prob.> 0.05 (P=0.311850) and residuals are normally distributed (fig. 4).

Thus, from the Hypotheses 2, the results obtained can conclude that, the H2 is partly fulfilled, since only L_I_EE has a significant effect on L_I_CO2E, as we can see from table 3 (t= 34.32939; sig< 0.05).

Finally, the 3rd hypotheses, H3, is verified, in order to show the possible significant relation among the following macroeconomic variables: I_EE, I_CO2E, I_GGE, BC and REC, applying the correlation function (table 6).

Table 3
REGRESSION ANALYSIS FOR L_I_CO2E AND L_I_EE

Dependent Variable: L_I_CO2E				
Method: Least Squares				
Date: 01/26/17 Time: 16:28				
Sample (adjusted): 1 14				
Included observations: 14 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.895005	0.218527	-8.671704	0.0000
L_I_EE	1.222873	0.035622	34.32939	0.0000
R-squared	0.989920	Mean dependent var		5.603514
Adjusted R-squared	0.989080	S.D. dependent var		0.235338
S.E. of regression	0.024592	Akaike info criterion		-4.441207
Sum squared resid	0.007257	Schwarz criterion		-4.349913
Log likelihood	33.08845	Hannan-Quinn criter.		-4.449658
F-statistic	1178.507	Durbin-Watson stat		2.038688
Prob(F-statistic)	0.000000			

Own calculations, using EViews 8

Table 4
BREUSCH-GODFREY SERIAL CORRELATION LM TEST

Breusch-Godfrey Serial Correlation LM Test:				
F-statistic	0.309218	Prob. F(2,10)		0.7408
Obs*R-squared	0.815384	Prob. Chi-Square(2)		0.6652
Test Equation:				
Dependent Variable: RESID				
Method: Least Squares				
Date: 01/26/17 Time: 16:28				
Sample: 1 14				
Included observations: 14				
Presample missing value lagged residuals set to zero.				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.009541	0.233423	-0.040874	0.9682
L_I_EE	0.001540	0.038047	0.040465	0.9685
RESID(-1)	-0.071374	0.308339	-0.231479	0.8216
RESID(-2)	-0.237226	0.311352	-0.761920	0.4637
R-squared	0.058242	Mean dependent var		2.54E-16
Adjusted R-squared	-0.224286	S.D. dependent var		0.023627
S.E. of regression	0.026143	Akaike info criterion		-4.215499
Sum squared resid	0.006835	Schwarz criterion		-4.032911
Log likelihood	33.50849	Hannan-Quinn criter.		-4.232401
F-statistic	0.206145	Durbin-Watson stat		1.968287
Prob(F-statistic)	0.889825			

Own calculations, using EViews 8

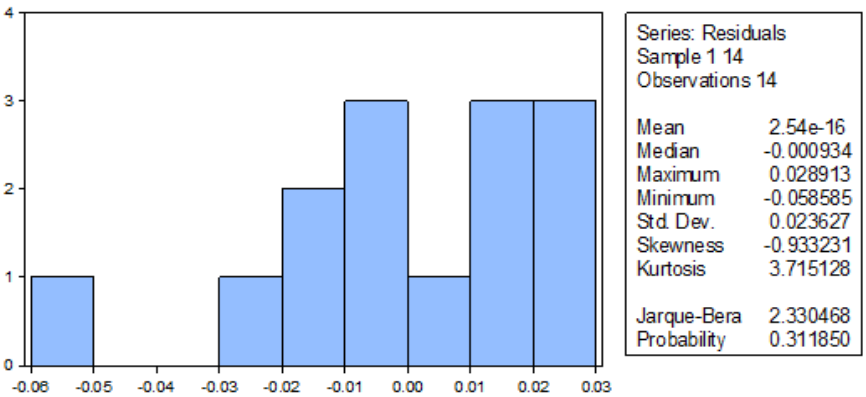

Fig. 4. Histogram (Jarque-Bera tes), Own calculations, using EViews 8

Table 5

HETEROSKEDASTICITY TEST: BREUSCH-PAGAN-GODFREY

Heteroskedasticity Test: Breusch-Pagan-Godfrey				
F-statistic	0.480663	Prob. F(1,12)		0.5013
Obs*R-squared	0.539176	Prob. Chi-Square(1)		0.4628
Scaled explained SS	0.537771	Prob. Chi-Square(1)		0.4634
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 01/26/17 Time: 16:29				
Sample: 1 14				
Included observations: 14				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006089	0.008039	0.757469	0.4634
L_I_EE	-0.000909	0.001310	-0.693298	0.5013
R-squared	0.038513	Mean dependent var		0.000518
Adjusted R-squared	-0.041611	S.D. dependent var		0.000886
S.E. of regression	0.000905	Akaike info criterion		-11.04644
Sum squared resid	9.82E-06	Schwarz criterion		-10.95515
Log likelihood	79.32508	Hannan-Quinn criter.		-11.05489
F-statistic	0.480663	Durbin-Watson stat		1.808346
Prob(F-statistic)	0.501321			

Own calculations, using EViews 8

Table 6

CORRELATION ANALYSIS AMONG VARIABLES: I _EE, I_CO2E, I_GGE, BC AND REC

Correlations						
		I_EE	REC	BC	I_CO2E	I_GGE
I_EE	Pearson Correlation	1	-,229	-,874**	,996**	,928**
	Sig. (2-tailed)		,432	,000	,000	,000
	N	14	14	14	14	14
REC	Pearson Correlation	-,229	1	,083	-,262	-,266
	Sig. (2-tailed)	,432		,778	,366	,357
	N	14	14	14	14	14
BC	Pearson Correlation	-,874**	,083	1	-,875**	-,872**
	Sig. (2-tailed)	,000	,778		,000	,000
	N	14	14	14	14	14
I_CO2E	Pearson Correlation	,996**	-,262	-,875**	1	,943**
	Sig. (2-tailed)	,000	,366	,000		,000
	N	14	14	14	14	14
I_GGE	Pearson Correlation	,928**	-,266	-,872**	,943**	1
	Sig. (2-tailed)	,000	,357	,000	,000	
	N	14	14	14	14	14
**. Correlation is significant at the 0.01 level (2-tailed).						

Correlation analysis, using SPSS 20.00 Statistics Programs [7]

Thereby, the results identify the significant relationships between the variables, thereby: I_EE is closely connected not only to the I_CO2E (Pearson coefficient = 0.996, p = 0.00), but also to the I_GGE (Pearson coefficient = 0.928, p = 0.00) and BC (Pearson coefficient = -0.874, p = 0.00). The data from the Table 5 from Annex show that, together with the I_EE, the BC is not increasing. *The relative improvements in efficiency have not offset the negative effects of growing economic activity, suggesting that this factor…is a roadblock to GEE transformation* [1].

Conclusions

The study raised a very important problem: achieving sustainable development of Romania's economy in terms of energy (I_EE), by decreasing the CO2 emissions intensity (I_CO2E) and the GGE intensity (I_GGE), raising the biofuel consumption (BC) and growing the renewable energy consumption (REC). The research has underlined and verified three Hypotheses: the relation between I_CO2E and the I_EE (the economic development), respectively, the population number (PN); the possible effects of I_EE

and PN on I_CO2E; and the relationships among I_EE, I_CO2E, I_GGE, BC and REC.

The results of the study underlined that: there is a positive correlation between I_EE and PN, on one hand, and I_CO2E, on the other hand; still, analysing the effects of these two variables on the I_CO2E, only I_EE has a significant effect on the I_CO2E; and, I_EE is in a positive connection with the I_CO2E and I_GGE, and, in a negative correlation with the biofuel consumption (BC). Still, given the reduced number of observation (14 observations), the result must be regarded with prudence.

Romania has to continue to reduce the intensity of energy, by increasing the energy efficiency, modernization of technology, and restructure of the economy [12]. As Brockway et al. suggest, *the path to a low carbon future is envisaged via two key policy-supported measures: the introduction of zero/low carbon energy sources, and the deployment of energy efficiency technologies to reduce energy use* [13] (pp. 2-3). In order to attain economic development, by adopting the *Green Energy Economy,* the State should come up with concrete measures focusing mainly on low-carbon energy technologies in all industries. For instance, today, *new investments and developments place again, the telecommunications as a known power, changing people's way of communication and commerce* [14]. Moreover, the state should pay much attention to the *investor's keenness to move capital to Eastern Europe* [15]. On the other hand, companies should set *green energy goals* and then evaluate their activity by their return on equity indicator [16], which expresses *the degree to which managers have succeeded to meet the company's main objective* [17], underlying the fact that *unrealized gains erode profits* [18]. However, several other researchers underlined the importance of *performance monitoring* in public sectors, a way to periodically assess *the degree to which set objectives have been attained*, a measure that could be applied in several sectors of the economy [19].

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