ENERGY EFFECTIVENESS AND EMPLOYMENT ISSUES IN EU-27 IN 2020s

György Iván NESZMÉLYI[1] - Sándor J. ZSARNÓCZAI[2]
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[1]Milton Friedman University, Department of International and Political Studies, Budapest, Hungary
[2]Óbuda University, Rejtő Sándor Faculty of Light Industry and Environmental Engineering, Institute of Environmental Engineering, Natural Sciences, Budapeest, Hungary

Abstract

Recently energy effectivity globally became in centre of international attention, by which economic competitiveness can be strengthened based on securing adequate or more income conditions for future economic prosperity. The study analyses correlations of energy effectiveness with employment conditions in EU-27. The study focuses on correlations and significance among real GDP per capita, investment share of GDP, employment issues, tertiary educational attainment, energy effectivity in euro per kilogram of oil equivalent, final energy consumption, final energy consumption in households and share of renewable energy in gross final energy consumption. Statistical analyses are essence of research method, as statistical package for social sciences in study. Increasing euro per kg of oil equivalent energy opposite to efficient energy effectivity did not stimulate to increase the investment share of GDP and by little increase of investment to increase to real GDP per capita in period of 2010-2023. Share of renewable energy in gross final energy consumption ensured the EU to realize its main goal to decrease carbon-dioxide gas emissions. For future economic growth of EU-27 there is important, that more efficient energy effectivity should be followed by economic policy to transfer into more green development by using more educated and skilled human resources.

Keywords: *Correlations, Employment, Investment, Real GDP, Significance, Tertiary educational attainment*

1. INTRODUCTION

Recently the energy effectivity globally became in the centre of the international attention and in European Union, by which the economic competitiveness can be strengthened based on securing the adequate or more income conditions for the future economic prosperity. The energy effectivity is based on the first cost of unified energy calculated by kilogram of oil equivalent, which is accompanying with employment issues. Globally and at national levels the energy effectivity also includes the energy consumption at the level of households. For the latest decades because of the stronger global warming the role of the renewable energy resources became more important roles of the energy use strategy to mitigate of negative influences according to human activities on the natural environment as natural background of the human society.

The employment issues are concerning the employment effectivity based on the skilled human resources coming from the educated level of employed workers. Therefore, the study overviews the main different educated levels, aged, selected employment and unemployment ratios. The energy effectivity can be successfully realised by the productive educated and skilled human resources by wide-side employment. The study aims at analysing correlations among energy effectivity and employment conditions; different educational level to increase the skilled human resources to strengthen the competitiveness of national economies in EU member states. The study analyses the correlations of energy effectivity with the employment conditions in EU-27 member states as Belgium, Denmark, France, Cyprus, Luxembourg,

Netherlands, Austria, Finland, Sweden, Bulgaria, Malta, Portugal, Romania, Czechia, Germany, Croatia, Hungary, Poland, Slovenia, Slovakia, Estonia, Ireland, Latvia, Lithuania, Greece, Spain and Italy during the period of 2010 – 2023. The main statistical data base comes from the Eurostat data based on the national statistical reports of the EU member states.

The EU declared some main analyses concerning the energy effectivity(sdg_07_30**)**. Energy effectivity is measured as the amount of economic output per unit of energy consumed (Eurostat, 19/12/2024), (sdg_07_30). The EU (2024) declared an important aim, which is to improve energy effectivity by increasing economic output while reducing energy consumption through measures like renewable energy and energy efficiency. The EU is known as net energy importer and even though the EU's need for energy was not going to increase as much as the same of China, the community is dependent on oil imports. And even if numbers have not been growing that rapidly, they are still high. At the beginning of the 1990's, major oil consumer countries in the Community (Germany, France, Italy, the United Kingdom, Spain, Belgium, the Netherlands) used about 10.5 million barrels per day (Markus 2018). The EU's *final energy consumption* has seen reductions since 2005, with 23 member states decreasing their final energy consumption. While the *primary energy consumption* has also decreased, with 25 member states reducing their consumption since 2005 (EEA, European Environment Agency, 2024). Also, the EU emphasized importance of employment in the energy sector (EEA, 26 June 2024), namely the *environmental goods and services sector employed 5.2 million people* (in FTEs) in the EU, accounting for about 2.5% of total EU employment by the end of 2021. The increase in green employment between 2010 and 2021 was largely driven by an increase of 525,000 FTEs in the number of jobs related to the management of energy resources. The Full-Time Equivalent (FTE) measures the total number of hours worked by employees in relation to a full-time work schedule The EU also declared importance of different kind of jobs in the different sectors, which are as follows: producing renewable energy; manufacturing equipment needed to generate renewable energy, such as wind turbines and photovoltaic cells; manufacturing energy-efficient equipment; research and development (R&D) activities; installation, consultancy and management services. According to these sectors also, the European Environment Agency of the EU declared (EEA, 26 June 2024): that the employment in the environmental goods and services sector has been growing faster than overall EU employment. This growth is largely due to the creation of jobs in renewable energy, energy efficiency, and waste management. Specifically, employment in renewable energy and energy efficiency has increased significantly, with over 2 million full-time equivalent jobs created between 2000 and 2022 (Eurostat April 2025). Waste management also contributes significantly to environmental employment, with an increase from 0.8 million to 2.0 million full-time equivalent jobs between 2000 and 2022 (Eurostat 26 June 2024). The renewable energy sector is expected to continue growing, potentially creating more jobs in the EU (EEA 26 June 2024). Moreover, Baranyai et al. (2022) pointed out that "greening" large customers can serve as a model for other segments and players and suggested the partial solar energy supply for further consideration for the energy needs of Liszt Ferenc International Airport (Budapest) with a PVGIS system ("Photovoltaic Geographical Information System"), which could prevent 1,300 tons of CO_2 emissions. The construction sector, which is crucial for energy efficiency renovations, employs almost 25 million people in the EU (EC 2024). Small and medium-sized enterprises (SMEs) in the construction sector benefit from the increased renovations market (EC 2024).

In the European manufacturing industry, effectivity growth has been slower compared to the US, and a gap has widened since the mid-1990s and again after the Covid pandemic. This gap is evident in both overall effectivity and in the manufacturing sector specifically. Albulescu (2024) examined the asymmetric relationship between corporate tax avoidance and total factor effectivity (TFP) using firm-level data for 141 European oil and gas companies, covering the period 2007 to 2015. While some countries like Denmark and Belgium show high productivity, others, particularly in Central and Eastern Europe, have lower effectivity levels with slower improvement (da Silva et al 2024). The model accounts for key aspects of the US experience with only changes in aggregate technology. It attributes half the variation in mean and dispersion of firm size across countries to technical change. Huisman and van Nijen (2024) analysed a sample of more than 9.000 municipal bonds issued by the counties wherein

lie the 22 American coastal cities that are physically exposed to climate risk between 2015 and 2020. Distortions also affect the size distribution. To summarize, both data sources show a clear, strong, positive relationship between average firm size and income per worker, no matter whether all data is used or whether the samples are truncated. The small effect on total employment is explained because most jobs in the EU are in so-called 'white' sectors, generating few CO_2 emissions. Activities such as electricity production, transport, manufacturing, agriculture and mining sectors together produce about 90% of all CO_2 emissions in the EU, but account for less than 25% of employment (EC, EC 2019). Chen (et al 2022) similarly finds that the net effect of EPS (environmental policy stringency) tightening on total employment has been small and temporary, with a peak after two years, and a coinciding reallocation of employment from high- to low-emission firms and sectors. Timilsina and Malla (2023) mentioned that nowadays more than half a trillion USD has been invested annually in clean technologies. Based on their bibliographic analysis their findings were, mixed as most ex-post studies showed positive relationship between clean investments and energy-intensive manufacturing firms' productivity. Clements et al. (2023) found climate debt (estimated for 131 countries) was extremely large, equalling around USD 59 trillion over the period of 1959-2018. They stated climate debt was also substantially like other government liabilities which equalled G-20 about 81 percent of GDP. Also, the promoting labour market flexibility can strengthen the successful energy effectivity accompanying with employment effectivity to decrease costs of damages resulted by pollutions. The other chapters analyse correlations among energy effectivity and employment effectivity in the EU-27 for the period of 2010-2023.

2. MATERIAL AND METHODS

The statistical analyses are the essence of the research method in the case-study. The statistical package for social sciences was in detailed worked out by Field (2020) and Horváth and Mitev (2023). Aims of study are to overview changing trends of real GDP per capita (*ReaGDPCap1*); investment share of GDP (*InvGDP2*); employment rate from 20 to 64 aged year employed people in 2010 (*Empl20103*) and in 2023 (*Empl20234*); long-term unemployment rate from 15 to 74 aged in 2010 (*UnEmp20105*) and in 2023 (*UnEmp20236*); early leavers from education and training population from 18 to 24 years total in 2010 (*LevEd20107*); early leavers from education and training population from 18 to 24 years total in 2023 (*LevEd20238*); tertiary educational attainment total from 25 to 34 years based on the International Standard Classification of Education (ISCED 2011) tertiary education (levels 5-8) in 2010 (*TerEd20109*); tertiary educational attainment total from 25 to 34 years based on the International Standard Classification of Education (ISCED 2011) tertiary education (levels 5-8) in 2023 (*TerEd202310*); population unable to keep home adequately warm by poverty status in 2023 (*PopUnab11*); energy effectivity in euro per kilogram of oil equivalent (KGOE) between 2010-2023 (*EnProdKg12*); final energy consumption 2023, in million tonnes of oil equivalent, between 2010-2023 and (*EnCons13*); final energy consumption in households per capita in kilogram of oil equivalent (KGOE), between 2010-2023 *(EnConCap14*); and share of renewable energy in gross final energy consumption by sector, renewable energy sources annual, in 2023 (*RenEn15*) (Table-1, Eurostat 2024). There are ***some hypotheses***, which are focusing on main essences of researched objectives, which are as follows: The study analyses ***correlations*** between real GDP per capita [sdg_08_10], annually at market prices euro per capita between 2010 -2023 (*ReaGDPCap1*) and energy effectivity in euro per kilogram of oil equivalent (KGOE) between 2010-2023 (*EnProdKg12*). The study focuses on the correlations of employment rate from 20 to 64 aged year employed people in 2010 (*Empl20103*) and in 2023 (*Empl20234*) with long-term unemployment rate from 15 to 74 aged in 2010 (*UnEmp20105*). Analyse correlations of employment rate from 20 to 64 aged year employed people in 2023 (*Empl20234*) with long-term unemployment rate from 15 to 74 aged in 2023 (*UnEmp20236*). Study analyses correlations of early leavers from education and training population from 18 to 24 years total in 2010 (*LevEd20107*) with early leavers from education and training population from 18 to 24 years total in 2023 (*LevEd20238*) and population unable to keep home adequately warm by poverty status in 2023

(*PopUnab11*). Analyse correlations of tertiary educational attainment total from 25 to 34 years based on the International Standard Classification of Education (ISCED 2011) tertiary education (levels 5-8) in 2010 (*TerEd20109*) with tertiary educational attainment total from 25 to 34 years based on the International Standard Classification of Education (ISCED 2011) tertiary education (levels 5-8) in 2023 (*TerEd202310*). Study analyses correlations of final energy consumption 2023, in million tonnes of oil equivalent, between 2010-2023 (*EnCons13*) with final energy consumption in households per capita in kilogram of oil equivalent (KGOE), between 2010-2023 *(EnConCap14*). Also, the study analyses ***significance*** of energy effectivity in euro per kilogram of oil equivalent (KGOE) between 2010-2023 (*EnProdKg12*) with real GDP per capita (*ReaGDPCap1*), investment share of GDP (*InvGDP2*), employment rate from 20 to 64 aged year employed people in 2023 (*Empl20234*), long-term unemployment rate from 15 to 74 aged in 2023 (*UnEmp20236*), tertiary educational attainment total from 25 to 34 years in 2010 (*TerEd20109*) and population unable to keep home adequately warm by poverty status in 2023 (*PopUnab11*).

The study focuses on the ***significance*** of final energy consumption in households per capita in kilogram of oil equivalent (KGOE), between 2010-2023 *(EnConCap14*) with investment share of GDP (*InvGDP2*), employment rate from 20 to 64 aged year employed people in 2010 (*Empl20103*), early leavers from education and training population from 18 to 24 years total in 2010 (*LevEd20107*); tertiary educational attainment total from 25 to 34 years in 2010 (*TerEd20109*); tertiary educational attainment total from 25 to 34 years in 2023 (*TerEd202310*); population unable to keep home adequately warm by poverty status in 2023 (*PopUnab11*); final energy consumption 2023, in million tonnes of oil equivalent, between 2010-2023 (*EnCons13*). Naturally the economic variable as share of renewable energy in gross final energy consumption by sector, renewable energy sources in 2023 (*RenEn15*), but its share in final energy consumption is not so considerable as 27% averagely in all of EU-27 in the international compare in the researched period. Therefore, this variable can only be mentioned. The values of the economic variables in cases of correlations can be important if these are more than 0.500 or 50%. If these values of correlations are between 0.800 (80%) and 1.000 (100%), correlations of economic variables are very important, and between 0.500 (50%) and 0.800 (80%), correlations are important, but under 0.500 (50%) the correlations among variables are not important. In cases of *negative values* of correlations of economic variables, the correlations are *inversely proportional to the positive* valued correlations and *direct proportional* to other negative valued correlations of variables. In cases of the significance of economic variables this means that the values of economic variables are very closed to each-others. Namely when differences between these values of variables are 0.000 (0%) or less than 0.100 values closed to 0.000, the significance is for economic variables.

The *correlation* among economic variables means that values of correlations are bigger than 0.500 (50%) and more closed to 1.000 (100%), therefore the corelations over 0.800 (80%) are *very strong*. The *significance* among economic variables means, when the values of correlations are *0.000 (as zero*) or probably very closed to 0.000 (zero), namely within 0.100 values (10%). The values of significance of economic variables are neither negative or positive values, because these are mostly zero or very closed to zero.

3. FIGURES, TABLES AND EQUATIONS

Table 1: Energy and employment conditions in EU-27 between 2010 and 2023 in percent

Variables / EU-27	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Belgium	12	2	68	72	4	2	12	6	44	50	6	47	-15	-33	15
Bulgaria	55	-5	64	76	5	2	13	9	27	36	21	38	9	5	22
Czechia	22	1	70	82	3	1	5	6	23	34	6	49	-7	-17	19
Denmark	20	4	75	80	1	0.5	11	10	38	49	7	2	-14	-23	44
Germany	11	2	74	81	3	1	12	13	26	38	8	54	-14	-19	22
Estonia	38	7	68	82	7	1	11	10	38	43	4	93	-10.	-12	41
Ireland	95	6	65	80	7	1	12	4	50	63	7	138	-1	-40	15
Greece	-3	-2	63	67	5	6	13	4	30	44	19	24	-18	-14	25
Spain	11	-2	63	70	7	4	28	14	40	52	21	28	-9	-21	25
France	10	2	70	74	2	2	13	8	43	52	12	39	-14	-24	22
Croatia	40	1	62	71	7	2	5	2.0	26	39	6	38	-1	-10	28
Italy	7	2	60	66	4	4	19	10	21	31	9	31	-14	-21	20
Cyprus	20	-1	75	80	1	2	13	10	48	62	17	43	-1	-13	20
Latvia	60	5	64	78	10	2	13	8	35	45	7	57	-5	-13	43
Lithuania	72	6	64	78	7	2	8	6	46	57	20	57	10	4	32
Luxembourg	98	-1	71	75	1	2	7	7	44	60	2	65	-19	-32	14
Hungary	45	5	62	81	5	1	11	12	26	30	7	52	-12	-16	17
Malta	58	-3	61	80	4	1	21	10	24	46	7	57	40	23	15
Netherlands	15	1	77	83	1	1	10	6	40	54	7	63	-24	-43	17
Austria	8	3	74	77	1	1	8	9	21	43	4	30	-9	-15	41
Poland	13	-2	62	78	3	1	5	4	37	46	5	61	6	-6	17
Portugal	15	-1	67	78	6	2	28	8	25	41	21	24	-5	1	35
Romania	62	-1	56	69	3	2	19	17	21	22	12	73	5	-1	26
Slovenia	26	0.2	70	77	3	1	5	5	31	41	4	56	-12	-26	25
Slovakia	33	-1	66	77	11	4	5	6	24	40	8	47	-18	-20	17
Finland	4	-1	72	78	3	2	10	10	39	39	3	20	-13	-8	51
Sweden	11	-3	78	83	2	2	6	7	42	54	6	42	-9	-24	66
Average	***32***	***0.9***	***67***	***77***	***4***	***2***	***12***	***8***	***34***	***45***	***9.5***	***49***	***-6***	***-16***	***27***

Source: Eurostat, [sdg_08_10], [sdg_08_11], [sdg_08_30], [sdg_08_40], [sdg_04_10], [sdg_04_20], [sdg_07_11], [sdg_07_20], [sdg_07_30], [sdg_07_40], [sdg_07_60], 2024

ReaGDPCap1 =Real GDP per capita [sdg_08_10], Annual Gross domestic product at market prices euro per capita between 2010 -2023 in percent 2010= 100

InvGDP2 = Investment share of GDP by institutional sectors [sdg_08_11], annual total investment, in percent in 2023 minus 2010, difference between two years

Empl20103 = Employment rate by sex [sdg_08_30], Total employment (resident population concept – LFS), From 20 to 64 years, Percentage of total population, in 2010

Empl20234 = Employment rate by sex [sdg_08_30], Total employment (resident population concept – LFS), From 20 to 64 years, Percentage of total population, in 2023

UnEmp20105 =Long-term unemployment rate by sex [sdg_08_40], Annual total Long-term unemployment, From 15 to 74 years Percentage of population in the labour force, in 2010

UnEmp20236 =Long-term unemployment rate by sex [sdg_08_40], Annual total Long-term unemployment, From 15 to 74 years Percentage of population in the labour force, in 2023

LevEd20107 = Early leavers from education and training by sex [sdg_04_10] Annual Percentage

Population From 18 to 24 years total in 2010

LevEd20238 = Early leavers from education and training by sex [sdg_04_10] Annual Percentage Population From 18 to 24 years total in 2023

TerEd20109 = Tertiary educational attainment by sex [sdg_04_20], Annual Total From 25 to 34 years Percentage, International Standard Classification of Education (ISCED 2011) Tertiary education (levels 5-8) in 2010

TerEd202310 = Tertiary educational attainment by sex [sdg_04_20], Annual Total From 25 to 34 years Percentage, International Standard Classification of Education (ISCED 2011) Tertiary education (levels 5-8) in 2023

PopUnab11 = Population unable to keep home adequately warm by poverty status [sdg_07_60], in 2023, Annual Percentage Total

EnProdKg12 = Energy effectivity[sdg_07_30], Euro per kilogram of oil equivalent (KGOE), Annual between 2010-2023 in percent

EnCons13 = [sdg_07_11] page_spreadsheet_Final energy consumption 2023, Annual, Million tonnes of oil equivalent, between 2010-2023, in percent

EnConCap14 = Final energy consumption in households per capita [sdg_07_20], Annual, Kilogram of oil equivalent (KGOE), between 2010-2023, in percent

RenEn15 = [sdg_07_40] page_spreadsheet_Share of renewable energy in gross final energy consumption by sector, Renewable energy sources annual, in 2023, in percent

Table 2: Correlation Matrix

		ReaGDPCap1	InvGDP2	Empl20103	Empl20234	UnEmp20105	UnEmp20236	LevEd20107	LevEd20238	TerEd20109	TerEd202310	PopUnab11	EnProdKg12	EnCons13	EnConCap14	RenEn15
Correlation	**ReaGDPCap1**	1.000	.238	-.341	.119	.290	-.250	-.079	-.040	.184	.195	-.071	**.649**	.393	.106	-.253
	InvGDP2		1.000	.036	.233	.228	-.345	-.177	-.037	.215	.104	-.276	.379	-.214	-.296	.083
	Empl20103			1.000	**.583**	**-.542**	-.347	-.363	-.115	.377	.457	-.281	-.188	-.465	-.476	.374
	Empl20234				1.000	-.141	**-.719**	-.338	-.066	.232	.274	-.320	.276	.093	-.044	.225
	UnEmp20105					1.000	.362	.136	-.156	-.119	-.127	.231	.229	.126	.194	-.030
	UnEmp20236						1.000	.280	-.052	-.108	-.068	.491	-.330	-.242	.005	-.072
	LevEd20107							1.000	**.567**	-.144	-.106	**.582**	-.159	.246	.302	-.076
	LevEd20238								1.000	-.242	-.383	.186	-.134	.099	.252	.105

	TerEd20109									1.000	**.859**	.019	.288	-.148	-.427	.085
	TerEd202310										1.000	.059	.227	-.035	-.371	-.003
	PopUnab11											1.000	-.268	.208	.363	-.095
	EnProdKg12												1.000	.192	-.214	-.321
	EnCons13													1.000	**.791**	-.102
	EnConCap14														1.000	.113
	RenEn15															1.000

Source: Eurostat, [sdg_08_10], [sdg_08_11], [sdg_08_30], [sdg_08_40], [sdg_04_10], [sdg_04_20], [sdg_07_11], [sdg_07_20], [sdg_07_30], [sdg_07_40], [sdg_07_60], 2024

Table 3: Correlation Matrix: Significant

		ReaGDPCap	**InvGDP2**	**Empl20103**	**Empl20234**	**UnEmp20105**	**UnEmp20236**	**LevEd20107**	**LevEd20238**	**TerEd20109**	**TerEd202310**	**PopUnab11**	**EnProdKg12**	**EnCons13**	**EnConCap14**	**RenEn15**
Sig. (1-tailed)	**ReaGDPCap1**		.116	**.041**	.277	**.071**	.104	.348	.421	.180	.165	.363	**.000**	**.021**	.299	**.101**
	InvGDP2			.429	.121	.126	**.039**	.188	.428	.141	.303	**.082**	**.026**	.142	**.067**	.341
	Empl20103				.001	**.002**	**.038**	**.031**	.284	**.026**	**.008**	**.078**	.173	**.007**	**.006**	**.027**
	Empl20234					.241	**.000**	**.042**	.372	.122	**.083**	**.052**	**.081**	.322	.414	.130
	UnEmp20105						**.032**	.249	.219	.278	.263	.123	.125	.266	.166	.441
	UnEmp20236							**.078**	.398	.296	.367	**.005**	**.046**	.112	.490	.360
	LevEd20107								**.001**	.237	.300	**.001**	.215	.108	**.063**	.354
	LevEd20238									.112	**.024**	.177	.252	.311	.102	.301
	TerEd20109										**.000**	.463	**.073**	.231	**.013**	.337
	TerEd202310											.385	.128	.432	**.028**	.494
	PopUnab11												**.088**	.148	**.031**	.319
	EnProdKg12													.169	.142	**.052**
	EnCons13														**.000**	.306

	EnConCap 14															.288
	RenEn15															

Source: Eurostat, [sdg_08_10], [sdg_08_11], [sdg_08_30], [sdg_08_40], [sdg_04_10], [sdg_04_20], [sdg_07_11], [sdg_07_20], [sdg_07_30], [sdg_07_40], [sdg_07_60], 2024

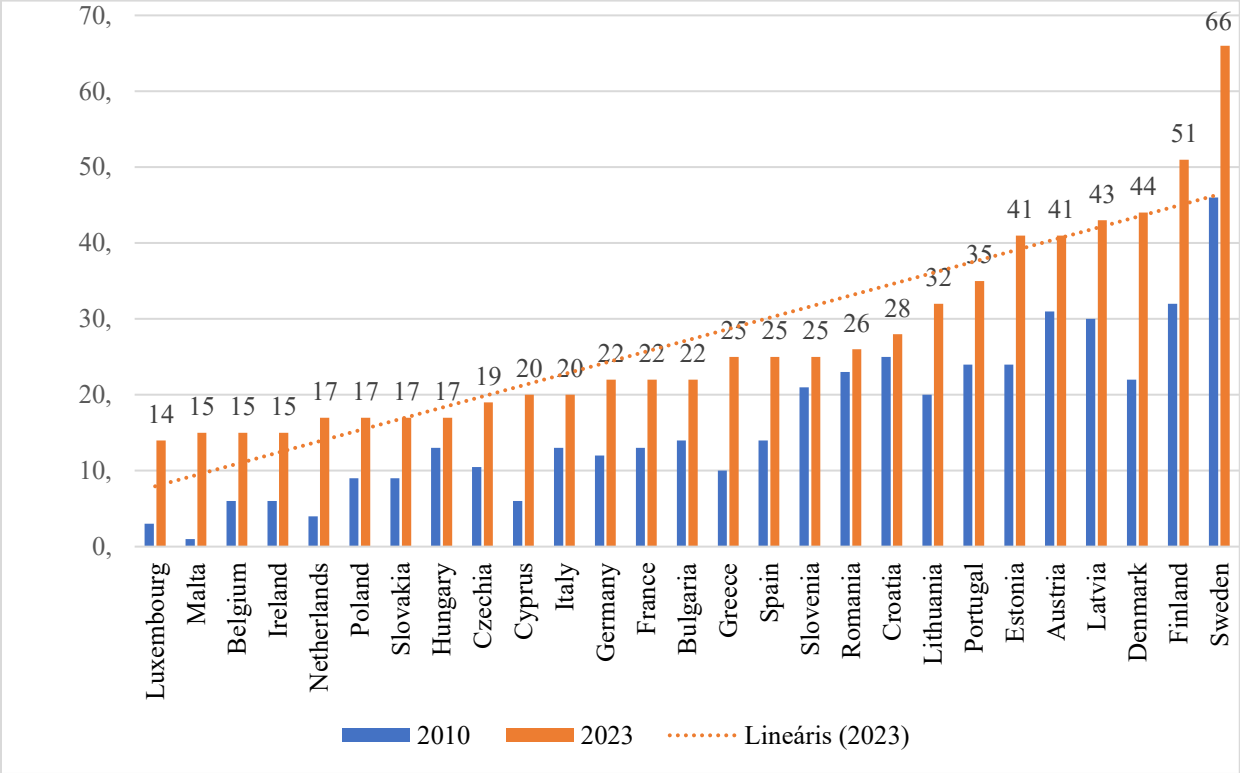

Figure 1: Share of renewable energy in gross final energy consumption by sector in EU-27 in 2010 and 2023 in percent, Source: Eurostat, [sdg_07_40], 2024

4. RESULTS AND DISCUSSIONS

The study analyses the main correlations and significance of economic variables in cases of EU-27 member states within the researched period of 2010 and 2023. The Table-2 for correlation matrix (Eurostat 2024) widely and cleanly shows the exact correlation values among different economic variables. Based on the results of the research it can be declared that value of ***correlations*** of real GDP per capita [sdg_08_10] with annually at market prices euro per capita between 2010 -2023 (*ReaGDPCap1*) by 0.649 (64.9%), as *strong with* energy effectivity in euro per kilogram of oil equivalent (KGOE) between 2010-2023 (*EnProdKg12*).

The correlations of employment rate from 20 to 64 aged year employed people in 2010 (*Empl20103*) are *strong* by 0.583 (58.3%) *with* employment rate from 20 to 64 aged in 2023 (*Empl20234*) and by contradictive strong minus 0.542 (-54.2%) *with* long-term unemployment rate from 15 to 74 aged in 2010 (*UnEmp20105*). Manly this last one means that when the employment has averagely considerably increased by 67% in 2010, the long-term unemployment increased only little by 4% in EU-27 in the same year. The correlations of employment rate from 20 to 64 aged year employed people in 2023

(*Empl20234*) are minus 0.719 (-71.9%) contradictive negative valued with long-term unemployment rate from 15 to 74 aged in 2023 (*UnEmp20236*). The employment averagely increased by 77%, but the long-term unemployment increased only very little by 2% in EU-27 in 2023 (Table-2; Eurostat 2024). Finds of research declared that correlations of early leavers from education and training population from 18 to 24 years total in 2010 (*LevEd20107*) are *strong* by 0.567 (56.7%) *with* early leavers from education and training population from 18 to 24 years total in 2023 (*LevEd20238*) and *strong* by 0.582 *with* population unable to keep home adequately warm by poverty status in 2023 (*PopUnab11*). Additionally, to above mentioned results correlations of tertiary educational attainment total from 25 to 34 years based on the International Standard Classification of Education (ISCED 2011) tertiary education (levels 5-8) in 2010 (*TerEd20109*) are *very strong* by 0.859 *with* tertiary educational attainment total from 25 to 34 years based on the International Standard Classification of Education (ISCED 2011) tertiary education (levels 5-8) in 2023 (*TerEd202310*). This trend shows very consequence increase in fields of tertiary educational attainment during the researched period. This trend provides proof that more participants or students continued their study at highly level education system, which can lead to increase level of labour forces in EU. This trend also can strengthen the innovative technological development at firm level. Correlations of final energy consumption in million tonnes of oil equivalent, between 2010-2023 (*EnCons13*) are *mostly very strong* by 0.791 *with* final energy consumption in households per capita in kilogram of oil equivalent (KGOE), between 2010-2023 *(EnConCap14*). This trend shows that the *decrease of final energy consumption* by 6% at the level of EU-27 can stimulate final energy consumption per capita per 16% to decrease during the period of 2010-2023. Naturally decrease of this final energy consumption per capita can also strengthen the decrease of final energy consumption at national and EU-27 levels.

It can be declared that the ***significance*** of energy effectivity in euro per kilogram of oil equivalent (KGOE) between 2010-2023 (*EnProdKg12*) is 0.000 *with* real GDP per capita (*ReaGDPCap1*), 0.026 investment share of GDP (*InvGDP2*), 0.081 *with* employment rate from 20 to 64 aged year employed people in 2023 (*Empl20234*), 0.046 *with* long-term unemployment rate from 15 to 74 aged in 2023 (*UnEmp20236*), 0.073 *with* tertiary educational attainment total from 25 to 34 years in 2010 (*TerEd20109*) and 0.088 *with* population unable to keep home adequately warm by poverty status in 2023 (*PopUnab11*) (Table-3, Eurostat 2024). Also, the ***significance*** of final energy consumption in households per capita in kilogram of oil equivalent (KGOE), between 2010-2023 *(EnConCap14*) 0.067 *with* investment share of GDP (*InvGDP2*), 0.006 *with* employment rate from 20 to 64 aged year employed people in 2010 (*Empl20103*), 0.063 *with* early leavers from education and training population from 18 to 24 years total in 2010 (*LevEd20107*); 0.013 *with* tertiary educational attainment total from 25 to 34 years in 2010 (*TerEd20109*); 0.028 *with* tertiary educational attainment total from 25 to 34 years in 2023 (*TerEd202310*); 0.031 *with* population unable to keep home adequately warm by poverty status in 2023 (*PopUnab11*); 0.013 *with* final energy consumption 2023, in million tonnes of oil equivalent, between 2010-2023 (*EnCons13*) (Table-3, Eurostat 2024). Naturally significance values of economic variables are somehow similar with correlation values, but some other values of significance are more exact data than general values of correlations. For example, data of energy effectivity in euro per kilogram of oil equivalent in fields of investment share of GDP, employment rate from 20 to 64 aged year, long-term unemployment rate from 15 to 74 aged in 2023, tertiary educational attainment total from 25 to 34 years in 2010, population unable to keep home adequately warm by poverty status in 2023. In case of final energy consumption in households per capita compares were exact with investment share of GDP, employment rate from 20 to 64 aged year employed people in 2010, early leavers from education and training population from 18 to 24 years total in 2010 tertiary educational attainment total from 25 to 34 years in 2010 and in 2023 and population unable to keep home adequately warm by poverty status in 2023.

5. CONCLUSIONS AND SUGGESTIONS

Based on the significance two economic variables can be emphasized, namely energy effectivity between 2010-2023 and final energy consumption in households per capita in 2010-2023. The energy effectivity has very strong correlation with real GDP growth per capita, because both variables have sharply increased. The energy effectivity has unfavourable conditions for the researched period, because the euro per kilogram of oil equivalent energy averagely increased by 49% in EU-27, because of strong increasing trend of crude oil price at global market, while the real GDP per capita [sdg_08_10] at market prices euro increased by 32% in the same period. The sharply increasing crude oil price made press for decreasing final energy consumption [sdg_07_11] in EU-27, which decreased by 6%, but final energy consumption in households per capita [sdg_07_20] in kilogram of oil equivalent (KGOE) decreased by 16% between 2010-2023 (Table-1). Therefore, decrease of the final energy consumption and the energy effectivity resulted by global oil price increase and not the real productive energy consumption.
In case of energy effectivity during the researched period in EU-27 *not the energy effectivity increase, but this decrease was based on the increase in euro per kilogram of oil equivalent energy*. The investment share of GDP by institutional sectors [sdg_08_11] decreased by 0.9% in EU-27 in 2023 comparably the level of investment share in 2010. This did not result so considerable final energy consumption decrease. In case of Hungary investment share of GDP by institutional sectors increased by 5%, more intensively increased than in cases of EU-27, while the final energy consumption at national level decreased by 12% and the final energy consumption per capita by the same rate 16% as well as in EU-27. In Hungary the energy effectivity was unfavourable as in case of EU-27, because as the euro per kilogram of oil equivalent increased by 52%, more than level of EU-27. The energy effectivity could have been better if the euro per kg of oil equivalent had decreased (Table-1, Eurostat 2024). According to employment the GDP per capita has averagely increased by 32% in EU-27 for the period of 2010-2023, while the energy effectivity was less favourable because of the euro per kilogram of oil equivalent increased by 49% in the same period. This means that the GDP per capita increased less than increase of price of energy resources. Mostly the world price of crude oil increased pressed the increasing growing rate of GDP based on increasing production cost leading to decreasing competitiveness of the EU-27 at the global market (Table-1, Eurostat 2024). Pollitt (2024) examined the 2021–2023 energy crisis in Europe exacerbated by the energy consequences of the full-scale Russia-Ukraine war and the European Union's attempts to co-ordinate EU-27 responses to the crisis. Naturally the real GDP growth per capita and energy cost as kilogram of oil equivalent can sharply be different in cases of EU member states. The *oil equivalent energy price* mostly increased by 138% but the real *GDP per capita* increased by 95% in *Ireland*, which last one was the second largely after Luxembourg by 98%. In Ireland the costly energy prices built into the final market price of products, which resulted considerable increase of real GDP per capita, while the *investment share of GDP* considerably increased by 6% in 2023 comparably to investment in 2010 after increasing by 7% in Estonia and by 6% in Lithuania and averagely by 0.9% in EU-27. The energy price increased by 93% in *Estonia* as second after Ireland, but real GDP per capita increased by 38% over the average level of EU-27. The third biggest increase of oil equivalent energy price has increased by 73% in *Romania* but the real GDP per capita could increase by 62% for the same period, in spite that investment share of GDP decreased by 1%. But in case of *Poland* the biggest fifth increase of oil equivalent energy price was 61% and the real GDP growth rate per capita increased very little by 13%, which was little more than by 4% in Finland by 8% in Austria and by 11% in Sweden, Spain and Germany. Also, similarly the result of Netherlands was 63% in field of energy price increase and by 15% little more than in Poland in field of real GDP growth increase per capita (Table-1, Eurostat 2024).
In case of *Germany* the oil equivalent energy price increased by 54% more than average level of EU-27, as 49%, but also real GDP per capita growing rate increased only by 11% less than in Poland, while investment share of GDP increased by 2% in 2023 comparably level of 2010. Therefor the little increase of investment could not stimulate to increase real GDP per capita. In case of *France* in sipe that the oil equivalent energy price increased by 39% less than in Germany and EU average level, but the 2%

increase of investment share of GDP from 2010, the real GDP per capita increase was only by 10%. This also shows less favourable economic conditions of France than EU average level. In case of *Italy*, as the other considerable big EU member state the energy price increased by 31% with increasing 2% in investment share, but GDP per capita increase was only by 7% in the researched period. This result was better than by decreasing 3% in Greece and 4% in Finland, but the economic conditions of Italy were unfavourable. The energy price increased by 20% in *Finland* and by 42% in *Sweden* as less than EU average level, but the investment share of GDP in Finland was decreasing 1% and decreasing 3% in Sweden as much as in Greece in the same period. But their real GDP per capita increase was 4% in Finland and 11% in Sweden. This less GDP per capita increase mostly resulted by decreasing line of investment share of GDP (Table-1, Eurostat 2024). In case of *Denmark*, This EU member state has the less increase price of energy by 2% for the same period and its investment share of GDP was by 4%, more than three biggest EU member states, as Germany, France and Italy. But this investment share was not enough to increase rate of real GDP growth per capita, which was 20% under the EU average level of 0.9%. In case of *Hungary* there was highly level of per kilogram of oil equivalent energy by 52% accompanying with higher level investment share of GDP by 5% and both ensured by 45% increase in field of real GDP per capita increase, considerably over the EU average level. In order that EU-27 can ensure more green economy and economic development the EU extended the share of renewable energy in gross final energy consumption. Therefore, this share became averagely 27% by the end of 2023. From this point of view the top green economic Sweden in EU by 66% with Finland by 51% and Denmark by 44% (Eurostat [sdg_07_40] 2024. The three largest EU economies have little less share than the EU average level, because Germany and France by 22% and Italy by 20. The green energy mostly comes from solar, water and wind energy sources. The EU can help member states additionally to the national supports and self-financing resources of firms and companies. The *Figure-1* shows that the share of renewable energy has sharply increased from 16% in 2010 to 27% in 2023, of which increase was more than half during this period in EU-27 (Table-1, Eurostat 2024). In the study there are not strong correlations of employment issues with energy effectivity in EU-27 within the researched period from point of view of the statistical approach. But the employment rate from 20 to 64 years, in percentage of total population, in 2010 and in 2023 (Eurostat, [sdg_08_40] 2024) shows considerable increase from 67% to 77% and the long-term unemployment rate from 15 to 74 years in percentage of population in the labour force in 2010 and in 2023 show important decrease from 4% to 2% (Eurostat, [sdg_08_40] 2024). These development trend can also ensure considerable increase in field of real GDP per capita in the researched period. The modern innovative technology should follow the *strategy of new green technology*, which needs for the highly developed, educated and skilled human resources. This green innovative technology demands for more educational period for human resources, which can be proofed by less *earlier leavers from education and training* (Eurostat [sdg_04_10] 2024) in annual percentage of population from 18 to 24 years total in 2010 and in 2023, which decreased from 12% in 2010 to 8% in 2023 at the average level of EU-27. This shows considerable one-third decrease. Also, *tertiary educational attainment* (Eurostat [sdg_04_20] 2024), annually total from 25 to 34 years percentage based the International Standard Classification of Education (ISCED 2011) was 34% in 2010, which increased to 45% at the average level of EU-27. This increase was considerable about one-third. Also, the economic growth resulted low level of population unable to keep home adequately warm by poverty status [sdg_07_60] from 12% in 2010 to 9.5% in 2023 as average level of EU.

6. CONCLUSIONS

The study overviews the correlations and significance among different economic-ecological variables for EU-27 during the researched period 2010-2023. The main issue is to realise such economic innovative green development to implement energy effectivity by using educated and skilled human resources. Naturally, the increasing euro per kg of oil equivalent energy *opposite* to the efficient energy effectivity did not stimulate to increase the investment share of GDP and by little increase of investment to increase to the real GDP per capita in the researched period. Also, the increasing trend in investment

share of GDP can contribute to the increase of real GDP per capita. Some Central-East European EU member states as Bulgaria, Croatia, Latvia, Lithuania, Hungary, Romania and Slovakia and over this region Ireland considerably contributed to increase average level of real GDP per capita in EU-27. The increasing highly level of employment, decreasing level of long-term unemployment, less early leavers from education and training from 18 to 24 aged years and increasing tertiary education attainment from 25 to 34 aged years stimulated increase of real GDP per capita. The share of renewable energy in gross final energy consumption has considerably increased for the researched period, which ensured the EU to realize its main goal to decrease carbon-dioxide gas emissions by 20% in the 2020 years. The population unable to keep home adequately warm by poverty status considerably increased between 2010 and 2023 as average level of EU, which shows increase of living standard in EU-27. For the future economic growth of the EU-27 there is important, that more efficient energy effectivity should be followed by the economic policy to transfer into more green development by using more educated and skilled human resources in wide-side sectors. Also, the investment share of GDP in the EU member states should increase by decreasing unemployment rate, extending the tertiary educational attainment and increasing the share of renewable energy in gross final energy consumption accompanying with less final energy consumption at the national economic level and in fields of households per capita.

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Corresponding author:
Name SURNAME: **J. Sándor ZSARNÓCZAI**
Department/Laboratory, Faculty, University/Company:
Institute of Environmental Engineering, Natural Sciences,
Rejtő Sándor Faculty of Light Industry and Environmental Engineering,
Óbuda University
Address of Institution/Company: *Doberdó u. 6.*
Postal code, City, STATE: H-1034 Budapest, Hungary
E-mail: zsarnoczaisandorjozsef@gmail.com