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Development of green jobs in the res sector in the Visegrad Group countries

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INTRODUCTION

The increased use of resources and energy in economic processes, resulting in excessive environmental pressure, unfavourable climate changes associated with the emission of carbon dioxide and the burning of fossil fuels, is a serious economic, ecological and social problem for the whole world. One of the most important barriers to economic development is the limited range of natural resources, in particular energy resources. According to estimates, the increase in primary energy demand will amount to approximately 27% compared to 2010 (Marks-Bielska & Bielski, 2013). Therefore, care for the natural environment becomes an important determinant of further socio-economic development. The current European Union policy sets the goal of building a resource-efficient and low-carbon economy as an instrument to implement the concept of sustainable development (Graczyk & Kaźmierczak-Piwko, 2015) with particular emphasis on environmental protection issues. Among the horizontal principles of sustainable development, it is necessary to mention the initiation of pro-ecological activities in particularly key sectors of the economy, including energy production (Woodman & Baker, 2008).

Renewable energy sources are currently playing an increasingly important role in EU energy. They constitute a leading and prospective energy technology of many countries. Demand for innovative solutions in the energy sector is particularly visible in the post-communist Central European countries (CEC), in the Visegrad Group countries. The energy sector is on the one hand dominated by obsolete power plants and national energy networks, on the other hand, socio-economic development reports increased energy demand (Woodman & Baker, 2008, Boie et al., 2014). Reconciling the assurance of energy security along with sustainable development and meeting EU targets may be supported by the renewable energy sector.

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Among numerous advantages of renewable energy sources, there is a positive impact on the natural environment, especially the protection of atmospheric air and climate. The most important, however, is energy security (Bartodziej & Tomaszewski, 2009, Alberici et al., 2014, Moreno & Lopez, 2008), potential reduction of fossil fuel supplies from outside the EU, providing new sources of growth, improvement of the environment (Lund, 2007; O'Sullivan, 2014; Stern, 2010; Weber & Cabras, 2017). Changes in the energy market are also the result of changing consumer needs shaping new markets or demand for products produced using environmentally friendly methods (Kułyk & Michałowska, 2016). Investments in renewable energy sources reduce the costs of energy production from conventional sources, which is reflected in the reduction of energy prices and its carriers, especially for final recipients, i.e. households and enterprises. Lower energy costs affect the competitiveness of production. The advantage of renewable energy is the improvement of energy security in particular regions, especially in the situation of growing energy needs.

The RES sector also supports economic transformations in rural areas, modernises agriculture (biomass production) and shapes pro-environmental prosumer attitudes. Increased use of renewable energy sources stimulates local development and regional markets. One of the most commonly used arguments in favour of the development of obtaining energy from renewable sources is their significant positive impact on the labour market. Thanks to the development of the sector, new, durable, green jobs are created directly related to the production and servicing of equipment as well as indirectly related to the creation of markets for new products and raw materials.

The study assumes that green jobs should be understood as those that contribute to reducing energy consumption and natural resources. In the direction of the conducted research, those jobs were classified as green jobs that are related to the renewable energy sector.

The aim of the article is to determine the impact of RES on the number of green jobs in Poland, which was analyzed against the observed trends in the sector in the Visegrad Group countries. The implementation of the purpose was supported by: a synthetic presentation of the specificity of green jobs, analysis of changes in employment, the Polish renewable energy sector against the background of V4, and empirical analysis – an attempt to construct an econometric model describing the impact of socioeconomic variables on the development of green jobs. The survey was based on EuroObserv'Er reports on renewable energy for the years 2010-2016.

THE CONCEPT OF GREEN JOBS

The transition of global economy from the so-called “brown economy” to “green economy” has become in recent years a necessity that is closely related to permanent sustainable development as well as requires limited human impact on the surrounding environment. The pragmatism of these situations requires taking into account activities that are the basis for protecting the quality of the environment and limiting the negative impact on the ecosystem. Such activities can be considered, for example, as: increasing energy and material efficiency, minimizing the amount of waste, saving natural resources or increasing environmental awareness among the public. These activities, which are present in almost every type of business activity, are mainly accompanied by the creation of green jobs (Kryk, 2018).

In the literature on the subject there is no universally valid definition of green jobs. Most often they are referred to as initiatives that support sustainable development (Ryszawska, 2013). However, it should be emphasized that these places are created in connection with the development of the concept of green economy, which the European Commission defines as resource-efficient and low-carbon. Such a targeted economy is to ensure economic growth while respecting the natural environment, low energy consumption, protection of natural capital, eradication of poverty and creation of decent jobs (European Commission, 2011). The Polish Institute for Sustainable Development states that all workplaces that arise in connection with projects that result in reducing the negative impact on the natural environment on the part of the economy should be considered as green (Kassenberg & Śniegocki, 2014). Green jobs are created in the EU mainly as a result of environmental solutions related to combating climate change (Stoyanova & Harizanova, 2015).

By clarifying the concept, the authors consider all jobs that are priority in the field of environmental protection to be green jobs. Specifying the term, all employees who undertake activities that reduce the material and energy intensity of the economy, which in turn contributes to the reduction of environmental pressure and decarbonisation of the economy, and contribute to the protection and renewal of biodiversity are called green. The above definition covers the issue in a broad context, because any workplace that has less impact on the environment on average and improves overall productivity may be considered green (Kryk, 2014).

An interesting, slightly different from the above definition of green jobs, is the one given by the Organization for Economic Cooperation and Development (OECD), according to which these places should be characterized by very specific features, called “green skills”, i.e. green competences. These are above all such skills and competences that are required to properly adapt products, knowledge, services and other activities resulting from changes in regulations and requirements in terms of environmental impact, including climate change. The examples of such green competences may include: water treatment techniques, reclamation planning, installation of solar panels, or the production of healthy food (Kryk, 2018).

An equally broad context of green jobs is presented by the United States Department of Labor. The organization identifies green jobs as jobs that produce goods or services that take into account environmental interests or the protection of natural resources and employees performing their responsibilities in the production process in an environmentally friendly manner and ending the production process using smaller natural resources (United States Department of Labor, 2013). In the narrow approach to green jobs, only those positions that directly affect the condition of the natural environment should be included, and in the broad approach also those impacting the environment indirectly (Kryk, 2014). The International Labor Organization (ILO) also took the floor in the discussion in the analyzed area. According to it, the concept of “green jobs” does not qualify for a strict definition. However, according to the representatives of this organization, the scope of the term covers direct employment in sectors reducing the negative impact on the environment, leading to the development of environmentally, socially and economically sustainable enterprises and economies (ILO, 2011). According to this definition, “green” jobs can be identified in the RES sector.

Sectors that can be considered green according to the National Technical Assistance Registry (NTAR) are sectors equipped with environmental priorities and with special business conditions; green jobs can result from traditional sectors such as production, infrastructure, tourism and logistics (National Technical Assistance Registry, 2008). The United Nations Environment Program (UNEP) agenda also emphasizes the positive impact on the environment. According to this organization, the presented jobs protect ecosystems and contribute to maintaining biodiversity, minimizing energy consumption, material resources and water, while maintaining high production efficiency and "declining" the economy, thus reducing CO_2 emission (UNEP, 2011). Green jobs find their important place also in the implemented German energy transformation plan Energieewende. As the example of this country shows, already in 2011, the number of people employed in the renewable energy sector in Germany was more than twice as high as in the conventional energy sector and approached the level of nearly 400.000 employees. Hence, the development of the RES sector can be considered one of the basic instruments for the implementation of one of the most important EU objectives, which is the state of full employment (Graczyk & Kaźmierczak-Piwko, 2014).

RENEWABLE ENERGY SOURCES

Nowadays, the acquisition of energy sources is very important to ensure the survival of own state and society. However, traditional energy sources that are de facto non-renewable ones, challenge governments to find such sources, which will not need to worry about the reserve. Such sources are Renewable Energy Sources (RES). Renewable energy is obtained during natural processes, thus allowing the replenishment of its resources through natural and recurring cycles (Ignarska, 2013). The International Energy Agency (IEA) dealt with the clarification of the concept of renewable energy sources as well as the determination of the methodology for assessing existing and potential sources of these sources. The Working Group on Renewable Energy Working Parties, established by IEA (The Renewable Energy Working Party – REWP), has adopted a definition that serves as a basis for further clarifying the above mentioned issues. It referred to the fact that "*renewable energy is the amount of energy that is obtained in natural renewable processes that are constantly renewable. Occurring in various forms, it is generated directly or indirectly by solar energy or heat from the Earth's core. The scope of this definition includes energy generated by solar radiation, wind, biomass, geothermal watercourses and ocean resources as well as biofuel and hydrogen obtained using these renewable energy sources*" (Norwisz & Musielak & Boryczko, 2006).

Such a broad definition means that renewable energy sources include such carriers and sources of energy as (Norwisz & Musielak & Boryczko, 2006):

- **renewable energy carriers and combustible waste, which includes:** solid biomass, products of animal origin, gases and liquid fuels obtained from biomass, municipal combustible waste from the use of their biodegradable components,
- **energy of watercourses (hydro),**
- **geothermal energy,**
- **solar energy,**

- **wind energy,**
- **the energy of the movement of sea waves and tides.**

Renewable sources are not only the hope of slowing down the consumption of fossil resources, but also help to protect the environment and are an investment in the future from the economic perspective of each country. Unfortunately, the development of renewable energy is also associated with certain restrictions, which due to different operational parameters of renewable sources, carry various profits and dangers (Dmowski & Rosłaniec, 2009).

MATERIAL AND METHODOLOGY OF RESEARCH

The aim of the study was to assess the level and pace of employment development in the renewable energy sector in the Visegrad Group countries in 2004-2016. The purposefulness of choosing the V4 countries was dictated by the similarity of the location, level of development and economic history as well as a similar socio-economic model and the objectives of integration with Europe adopted within the Visegrad Group.

The size, dynamics and structure of employment in individual sectors of the renewable energy sector were assessed.

Moreover, the impact of economic and social variables on the number of green jobs in the RES sector was determined. Cross-temporal data was analyzed. The relative number of green jobs was considered to be a dependent variable (the number of jobs divided by the number of inhabitants of the country (in millions)). Employment directly related to individual energy sources has been accepted as green jobs: solid biomass, biogas, liquid biofuels, photovoltaics, geothermal energy, municipal waste, solar, wind and hydropower (EurObserv'ER 2017). The data for the years 2000-2017 from the reports of EurObserv'ER, the International Renewable Energy Agency (for 2016) and the EUROSTAT database were used for the analysis. To achieve this goal, a panel regression model with fixed effects was used.

Independent variables after the selection based on statistical criteria and analyzes of results of other authors' research were: X_1 – primary energy consumption (Mtoe), X_2 – energy productivity (PPS/kgoe), X_3 – energy intensity of the economy (kgoe/1000 euro), X_4 – GDP per capita (euro/person), X_5 – consumption of resources (t/person). Among the variables mentioned are stimulant and destimulant factors. The determination coefficient R^2 was used to assess the quality of regression models. The necessary calculations were made using the Gretl 2016d program.

The analytical form of the model used presents the following equation (Maddala, 2007):

$$y_{it} = \alpha_i + \delta_t + \beta' x_{it} + \varepsilon_{it} \quad (1)$$

where:

i – object index (region),

t – period (year),

α_i – individual effect, constant over time, different in space for individual regions in the panel,

δ_t – a permanent periodic effect, having the same value for all units in the panel in the same period, but is different in each period,

β' – vector of variable coefficients,
x_{it} – cross-sectional variables

THE IMPORTANCE OF RES IN CREATING GREEN JOBS

One of the European Union's priorities is to increase the share of energy from renewable sources in the balance of primary energy carriers for the Union as a whole. The share of energy from traditional resources is also decreasing in all Visegrad Group countries. In 2014, compared to 2005, it was almost 30% in the Czech Republic, 21% in Poland and 9% in Hungary and Slovakia. Depletion of conventional energy sources and the growing level of pollution associated with their combustion increase the use of energy from renewable sources. This is mainly due to ecological arguments and energy security considerations.

Taking into account the above arguments, the Visegrad Group countries systematically increase the share of renewable energy and diversify sources of renewable energy.

Moreover, the development of this sector is part of the concept of creating a European low-carbon economy, more resource efficient, more environmentally friendly and competitive. The framework for supporting the development of green energy of the EU was adopted in 2008, the climate and energy package (Directive 2009/28/EC 2009), commonly known as “3x20%”. One of the objectives of the package is to increase the share of energy from renewable sources (RES) to 20% in the total energy balance of the European Union. In individual countries, individual RES share targets have been set, taking into account the RES countries' potential and the level of economic development (see Table 1).

The share of energy obtained from RES increased in the Czech Republic in comparison to 2004 by 7,5% and it was the highest among the analyzed countries. The other three countries also showed an upward trend, but the increase in value in 2014 was about 5%. The value of energy produced from RES in particular years in the case of Poland increased on average by 151 thousand of ktoe. Lower growth was recorded by the Czech Republic, where each year 67 thousand of ktoe were produced energy more. The lowest average increase was recorded in Slovakia and Hungary, where the increase amounted to approx. 16 thousand of ktoe annually.

Renewable energy is becoming a pillar of low-carbon growth around the world, as evidenced by the growing number of jobs in this sector. According to forecasts, decarbonisation of the global energy system may contribute to the development of the global economy and significantly affect the labour market. Employment forecast published by the International Renewable Energy Agency (IRENA) in the report “Global Energy Transformation: A Roadmap to 2050” indicates that the number of jobs in the renewable energy sector may increase to 12,5 million people by 2030 (see Figure 1) and 14,9 million in 2050, from the current level of 9,8 million (IRENA, 2017).

Table 1
National shares of energy from renewable sources in total energy consumption in 2005 and in 2020

Country	Share of energy from renewable sources in total energy consumption in 2005 (in%)	Fixed share of energy from renewable sources in total energy consumption in 2020 (in%)
Austria	23,3	**34**
Belgium	2,2	**13**
Bulgaria	9,4	**16**
Cyprus	2,9	**13**
Czech Republic	6,1	**13**
Denmark	17,0	**30**
Estonia	18,0	**25**
Finland	28,5	**38**
France	10,3	**23**
Greece	6,9	**18**
Spain	8,7	**20**
Netherlands	2,4	**14**
Ireland	3,1	**16**
Lithuania	32,6	**40**
Luxemburg	0,9	**11**
Latvia	32,6	**40**
Malta	0,0	**10**
Germany	5,8	**18**
Poland	7,2	**15**
Portugal	20,5	**31**
Romania	17,8	**24**
Slovakia	6,7	**14**
Slovenia	16,0	**25**
Sweden	39,8	**49**
Hungary	4,3	**13**
United Kingdom	1,3	**15**
Italy	**5,2**	**17**

Source: own study based on: National Overall Share and Targets for the Share of Energy from Renewable Sources in Gross Final Consumption of Energy in 2020.

According to EurObserv'ER, in 2017 the renewable energy sector employed directly and indirectly 9.8 million people in the world, an increase of 1.1% compared to 2016. The number of employees in European countries amounted to 1 million 150 thousand, almost one quarter in Germany (see Figure 2). For the EU 28, these figures indicate a high level of consolidation, and even a slight increase – which is a remarkable statement, because it reverses the tendency of recent years. The other three countries with the largest renewable energy consumption in Europe are Spain, France and the United Kingdom.
The number of green jobs in the Visegrad Group in 2017 was 153800 people. The share of people employed in the RES sector in the V4 countries accounted for 6,03% of the total employed in this sector in the European Union.

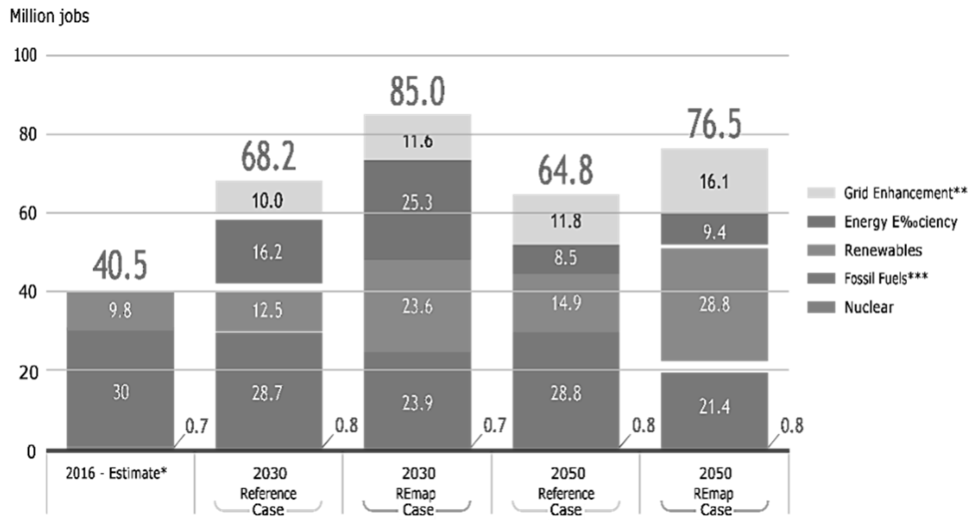

Fig. 1 Employment forecast in the general energy sector, 2016, 2030 and 2050 (million jobs)

Source: IRENA (2018), Global Energy Transformation: A roadmap to 2050, International Renewable Energy Agency, Abu Dhabi, p.11.

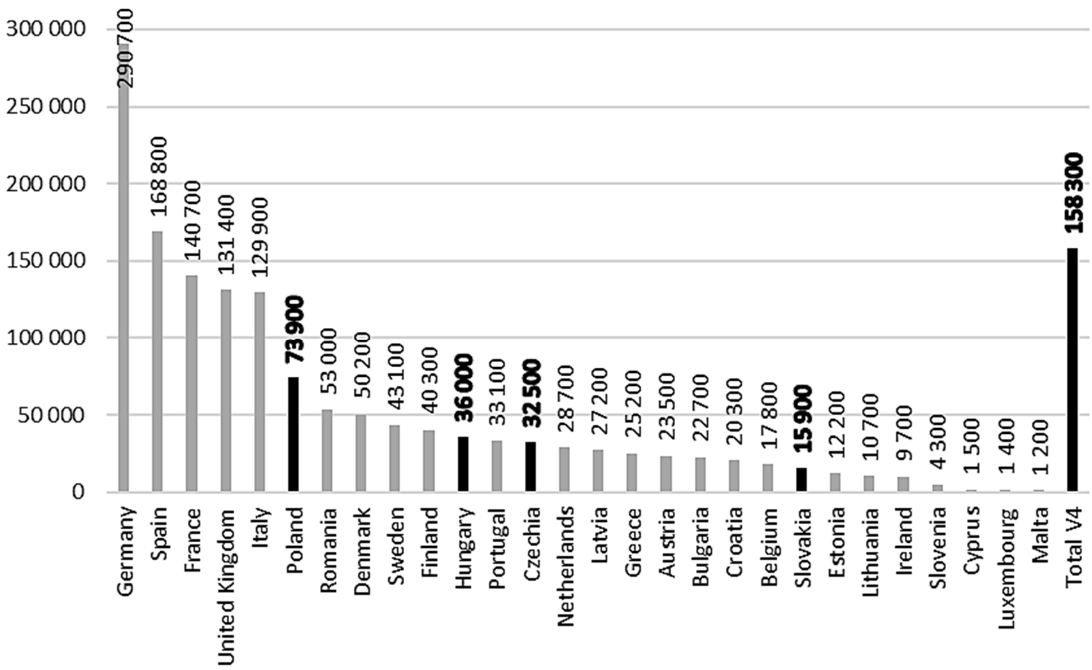

Fig. 2 Employment level in the renewable energy sector in the European Union in 2017

Source: own study based on: 18th EurObserv'ER Report (2018).

In Poland, the number of green jobs in 2017 was set at 73900. Hungary came second, employing a total of 36000 people. In the Czech Republic, the employment level in renewable energy amounted to 32500 employees in the period under consideration. The smallest density of green workplaces was recorded in Slovakia – 15900 people. The largest employers of renewable energy in the Visegrad Group countries are enterprises dealing in energy production from biomass and wind energy. Employment in these two sectors accounted for more than half of green jobs in renewable energy sources (see Figure 3).

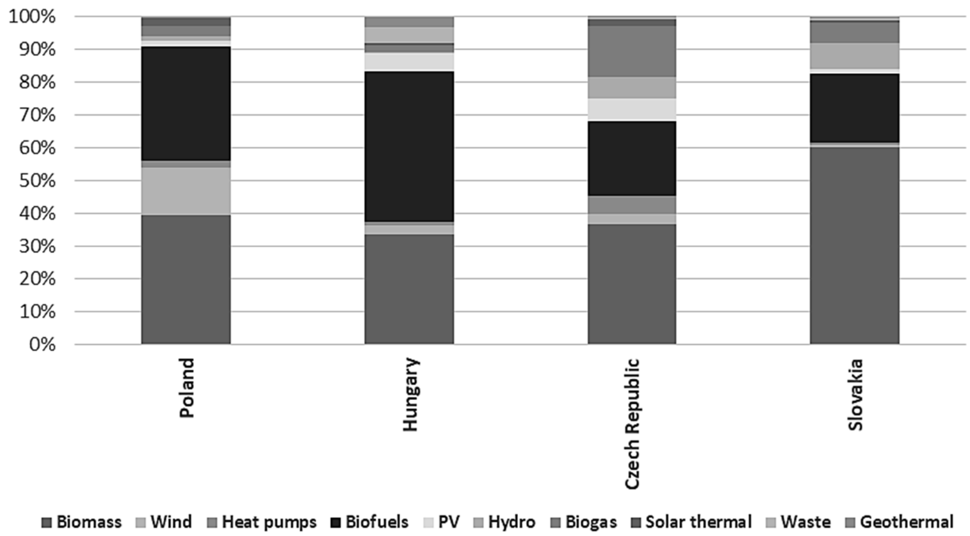

Fig. 3 Breakdown of renewable energy employment in the V4 countries in 2017 (%)
Source: 17th EurObserv'ER Report (2018).

ANALYSIS OF EMPLOYMENT CHANGES IN RENEWABLE ENERGY

In 2010, a total of 67230 employees were employed in the renewable energy sector in the Visegrad Group countries, which accounted for 6.03% of the total number of employees in the RES sector in the European Union. In Poland, the number of employees was at the level of 28450 people, which constituted 2.5% of all employees in a paticular sector in the EU and 42.31% in the Visegrad Group. Over 7 years, employment in all analyzed countries increased. In total, the RES sector employed 158300 people in the V4 countries. The number of employees employed in the RES sector in 2010 and in 2017 in individual countries of the European Union is presented in Table 2.

In the Polish sector, employment increased by 45450 people (over 260%), in the Czech Republic there was an increase of 12300 jobs (161% – the lowest in the countries in the Group), in Slovakia by 8870 (226%) and Hungary by 24450 (312%). The effect of the change in the employment level was a higher share of V4 in EU employment – in 2017 it was at the level of 10.95% (increase by 3.92 percentage points).

Employment in the renewable energy sector was different in individual RES types. In Poland, throughout the analyzed years, employment increased in all types of energy. Photovoltaics (an increase by 2200%) and energy from waste (an increase by over 1400%) showed the highest dynamics of employment changes, while the smallest thermal solar panels (increase by 24%) and geothermal energy (an increase by 50%). In the Czech Republic, the most dynamic development of green jobs was recorded by enterprises dealing with obtaining energy from waste (an increase of 1400%). The sector in which there was the smallest increase in employment in the Czech Republic was photovoltaics (14%) and thermal solar panels (16%). In Slovakia, the most dynamic increase in employment took place at positions obtaining energy from biomass (an increase by 1125%) and biogas (a 10-fold increase in employment). The smallest increase in the number of employees was marked by the photovoltaic sector (an increase of 20%). In turn, in the Hungarian energy sector, photovoltaics was the most dynamically developing sector in terms of the number of employees. In the 7-year period, there was a 13-fold increase in employment. At similar high level, employment in biogas plants was growing (increase by 1000%). Wind energy was the least dynamic in terms of employment (an increase by half in relation to the employment level in 2010).

Table 2
Employment in the RES sector in the Visegrad Group in 2010-2017

Type	2010				2017				Dynamics 2017/2010			
	PL	Cz	SL	H	PL	Cz	SL	H	PL	Cz	SL	H
Biomass	7500	3500	800	2000	25900	12300	9000	13300	345	351	1125	665
Wind	7000	350	0	1400	8000	900	2100	800	114	257	-	57
Heat pumps	1500	800	50	400	3000	2600	200	400	200	325	400	100
Biofuels	9600	5800	4500	6600	31400	8400	3800	18200	327	145	84	276
PV	<50	8000	1000	100	1100	1300	200	1300	2200	16	20	1300
Hydro	300	300	300	<50	1100	1500	1200	100	367	500	400	200
Biogas	1000	0	<50	<50	2300	4500	500	600	230	-	1000	1200
Solar thermal	1250	1400	130	150	300	200	100	200	24	14	77	133
Waste	<50	50	<50	50	700	700	100	400	1400	1400	200	800
Geothermal	200	b.d.	150	750	100	<100	700	700	50	-	467	93
Total	28450	20200	7030	11550	73900	32500	15900	36000	260	161	226	312

Source: own study based on reports of EurObserv'ER published in the years 2011–2018, http://www.energies-renouvelables.org/, http://www.eurobserv-er.org/, http://www.ieo.pl/, (accessible on 28.06.2019).

Despite the differences in employment dynamics both in Poland and in other V4 countries in the sectors of renewable energy, the number of employed increased, while the employment growth rate in the renewable energy sector in Hungary was higher than in the Community.

Assuming that the increase in employment is accompanied by an increase in the production of energy from renewable sources, it should be emphasized that the above changes positively affect the implementation of the EU's objectives in the field of energy policy, improvement of energy efficiency and meeting environmental protection requirements by the Visegrad Group. A supplement to the above considerations is the assessment of changes in the employment structure for all types of RES (see Table 3). In addition to significant temporal changes in the analyzed years, the change in the employment structure is evident.

Table 3
Employment structure in renewable energy – the Visegrad Group countries, 2010-2017 (in%)

ES sectors	2010				2017			
	PL	CZ	SL	H	PL	CZ	SL	H
Biomass	26,36	17,33	11,38	17,32	35,05	37,85	56,60	36,94
Wind	24,60	1,73	0,00	12,12	10,83	2,77	13,21	2,22
Heat pumps	5,27	3,96	0,71	3,46	4,06	8,00	1,26	1,11
Biofuels	33,74	28,71	64,01	57,14	42,49	25,85	23,90	50,56
PV	0,18	39,60	14,22	0,87	1,49	4,00	1,26	3,61
Hydro	1,05	1,49	4,27	0,43	1,49	4,62	7,55	0,28
Biogas	3,51	0,00	0,71	0,43	3,11	13,85	3,14	1,67
Solar thermal	4,39	6,93	1,85	1,30	0,41	0,62	0,63	0,56
Waste	0,18	0,25	0,71	0,43	0,95	2,15	0,63	1,11
Geothermal	0,70	b.d.	2,13	6,49	0,14	0,31	4,40	1,94
Together	100,00	100	100,00	100,00	100,00	100,00	100,00	100,00

Source: own study based on reports of EurObserv'ER published in the years 2011–2017, http://www.energies-renouvelables.org/, http://www.eurobserv-er.org/, http://www.ieo.pl/, (accessible on 28.06.2019).

In 2010 in Poland the largest share of employees in the total number of employees in RES was employed in biofuels (33.74%), biomass (26.36%) and wind energy (24.60%). The smallest percentage were employees related to the photovoltaic sector and energy recovery from waste (0.18% each). In the Czech Republic, the highest percentage of employees were employees connected with photovoltaics (39.60%) and in the biofuels section - almost 1/3 of the total number of people employed in RES and on positions associated with obtaining energy from biomass (17.33%). The country did not have biogas plants, while the smallest share of employees was in the energy sector from waste (0.25%). The Slovak renewable energy sector employed over 60% of employees in biofuels (64.01%) and in photovoltaics (14.22%) and biomass (11.38%) respectively. The smallest share was in the employment of wind energy (0%) and heat pumps, biogas and waste utilization (0.71% each). The Hungarian RES sector employed more than half of people in biofuels (57.14%). Other significant sectors were biomass and wind energy. In total, almost 30% of all employees associated with renewable energy were employed in both departments. The smallest percentage of green jobs were those related to hydropower, biogas and energy from waste (0.43% each).

Over the analyzed years there were changes in the employment structure in the renewable energy sector of all types of RES. After 7 years in Poland, the largest indicator of share in total employment was characterized by energy related to biomass (index increased by 2/3 to 42.49% and was by 15.8 percentage point higher than the average in the group) and wind energy (increase by 2% to the level of approx. 27%, i.e. close to V4), while the smallest (and decreasing) – thermal solar energy (0.41%) and geothermal energy (0.14%).

The increase in employment participation rates occurred in 5 out of 10 analyzed branches of renewable energy (biofuels, biomass, photovoltaics, energy use of waste and hydroelectric plants), in others the indicator decreased. In the Czech Republic, biomass energy (up by 20.52% to over 37%) and biofuels (indicator decreased by 2.86% compared to 2010) were the largest indicator of share in total employment. The smallest share of the indicator is similar to that in Poland - geothermal energy (0.31%) and thermal solar energy (0.61%). The increase in shares took place in seven of the ten analyzed sectors. In three countries there was a decrease (photovoltaics, biofuels and thermal solar energy). The largest decrease in employment was recorded by the photovoltaic sector - a decrease in the employment level by over 35%. Slovakia showed significant changes in the employment structure. In 2017, the departments employing the largest number of employees were biomass and biofuels. In total, both sectors employed almost 80% of all employees in the RES sector. The industry related to the use of energy from biomass increased employment 5 times compared to 2010.

Biofuels, on the other hand, despite a significant share in total employment in 2017, showed a declining trend (a decrease of about 42%). The employment rate increased in six out of ten departments. The lowest share of employees showed industries related to thermal solar and energy use of waste (0.63% each).

In the case of Hungary, the employment structure was similar. The most dynamically developed section related to biomass (an increase by 19.5 pp) – in 2017 over 1/3 of all employees came from this department. Biofuels were characterized by an even larger share. The sector was responsible for employing over 50% of all employees.

As in other countries, the lowest levels of employment were found in Hungarian thermal solar energy (0.56%) and hydroelectric plants (0.28%). Changes in particular departments, especially in photovoltaics, wind energy or thermal solar energy, may be due to the fact that these are industries characterized by a high level of innovation and the use of scientific and technological progress.

FINDINGS

Economic development brings consequences in the form of increased energy use in production processes at every stage and in households (Stoevska, Hunter, 2012). Ensuring sustainable development of the country requires effective energy management. Irrational consumption of energy resources results in high costs of industrial production, lower profits of enterprises, limited national product competitiveness in the international arena and problems with environmental pollution (National Energy Conservation Agency, 2008). Therefore, it is important to assess the rationalization of its use. The level of industrial production efficiency was determined by the first variable (X1) – primary energy consumption. A higher level of energy consumption indicates a worse location of the object, i.e. the variable is destimulant. The higher the level of energy consumption, the lower the production efficiency. The primary energy consumption in the EU in 2017 was 1561.59 Mtoe (Eurostat, 2019). In the Visegrad Group countries, the highest primary energy consumption was demonstrated by Poland – 99.11 Mtoe- 6th among 28 countries of the European Union. Half the consumption was lower in the Czech Republic – 40.36 Mtoe, followed by Hungary – 24.48 Mtoe and Slovakia – four times lower than in Poland – 16.11 Mtoe (Eurostat, 2019). Energy efficiency improvement programs that allow for better, more economical use of fuels and energy may influence the reduction of energy consumption levels.

Another measure allowing the assessment of the effectiveness of energy policy in the European Union countries is the energy productivity index (Wyszkowska, Rogalewska 2014), constituting the variable X2. It measures the efficiency of energy consumption and presents a picture of the degree of decoupling energy consumption from GDP growth. The energy productivity index included in the study as the ratio of GDP to final energy consumption is a stimulant. It is essential that the amount of energy consumed in relation to the GDP growth increases as slow as possible (Łyś, 2016). A higher value of the productivity index indicates lower energy consumption to produce a GDP unit (Wyszkowska, Rogalewska, 2016).

The level of this indicator for 28 European Union countries in 2016 amounted to 8.7 PPS/kgoe. The highest value of the indicator was recorded by such countries as: Ireland (16.9 PPS/kgoe), Denmark (15.1 PPS/kgoe), Malta (12.4 PPS/kgoe).

In the V4 countries, the level of energy productivity was at a much lower level than the EU average. For Slovakia, it amounted to 4.8 PPS/kgoe. Other countries, i.e. the Czech Republic, Poland and Hungary, had almost the same value of the index – 4.3 PPS/kgoe for Poland and Hungary and 4.2 PPS/kgoe for the Czech Republic. Energy efficiency is one of the main factors in the development of entrepreneurship and innovation, and the pursuit of reducing energy losses is generally a socially accepted measure of sustainable development (EC Commission Communication KOM, 2010). The increase in energy demand and concern for the quality of the natural environment result in a departure from conventional energy carriers and an increase in interest in energy from renewable sources.

To assess the effectiveness of energy policy it is also possible to use the indicator of energy intensity of the final economy – variable X3. The indicator presents the relation between the final energy consumption in the economy and GDP and indicates how much final energy was used to generate a unit of GDP.

In 2017, the final energy intensity of the economy of the member states of the Community reached the value of 120.99 kgoe/1000 euro. The low level of energy intensity characterized, among others, Ireland (54.60 kgoe/1000 euro), Denmark (69.04 kgoe/1000 euro) and Norway (84.45 kgoe/1000 euro). In the Visegrad Group, the level of energy intensity is about four times higher. All countries recorded energy intensity above 200 kgoe/1000 euro. The highest energy consumption in 2017 was recorded in the Czech Republic (238.51 kgoe/1000 euro), then in Poland (232.22 kgoe/1000 euro) and Hungary (230.66 kgoe/1000 euro). In Slovakia, the level of the index was 211.23 kgoe/1000 euro. The inefficient energy efficiency of electricity and heat generation and transmission as well as high fuel consumption in transport had an impact on a high level of energy intensity. The reduction of energy intensity may in the future be the result of the introduction of energy-saving equipment and technologies as well as the change in the structure of energy consumption carriers, including in particular the increase in the share of hydrocarbon fuels and energy from renewable sources.

Variable X6 (destimulant) represents the sustainability indicator in the area of sustainable consumption and production efficiency expressed in the use of material resources (DMC). The use of material resources is the basis for the functioning of the economy and an important source of income and employment (GUS, 2016). The indicator of domestic material consumption classifies materials in four main categories: biomass, metal ores, non-metallic minerals and fossil energy resources (Bertoldi, 2016).

In processes ranging from extraction, processing as well as the use of resources and the resulting goods, it is necessary to be guided by rationality and economy (Lee, 2017). The complexity of the processes of using material resources causes multidimensional pressure on all components of the environment (Berger, 2011). It is therefore important to manage raw materials in an effective, resource-efficient manner and as least harmful to the environment.

In 2017, the domestic consumption of materials (DMC) in the European Union reached the volume of 6860.3 million tons, which means that on average 1 inhabitant consumed 13,1 tons of raw materials per year. In Poland, the value of the indicator was at the level of 712.34 million tons – the most among the countries of the Visegrad Group. Other countries showed a 6-10 times smaller demand for materials. In the Czech Republic, the value of the index in 2017 was 165.96 million tons, in Hungary 127.92 million tons, and in Slovakia 71.06 million tons. The last variable – X5 (GDP per capita) was an economic component. Employment dependence, including the RES sector, on the dynamics of economic growth is widely recognized and occurs in neoclassical growth models.

The impact of individual components on the number of relative green jobs was estimated using the panel method with fixed effects. The importance of panel models in economic research was emphasized by Baltagi (2005) and Mátyás and Sevestre (2008). The selection of the estimation procedure was conditioned by the assumptions regarding constancy or randomness of group and time effects. In order to choose between the panel model and the classic model, the Breusch-Pagan test was used. It serves to verify the assumption about constancy of variance of a random component. In the case when the variance of the random component of individual effects is different from zero, the more accurate estimator is the estimator with random effects (Grabiński et al., 1990). LM statistics with the value p: Chi-square = 6) = 10.0604 and the obtained value p = 0,033905 showed that the more accurate estimator is the estimator with random/fixed effects than KMNK. A low p value means rejecting the H0 hypothesis that the MNK panel model is correct, against the H1 hypothesis that the random effect model is more appropriate (Stanisz, 2007). Making the right choice between fixed effects and random effects was established thanks to the use of the Hausman test, examining the occurrence of correlations between explanatory variables and random effects. This test allows checking whether the estimators of fixed and random effects coincide with the same point (vector) (Kufel, 2007).

Null hypothesis: The UMNK (GLS) estimator is compatible. Asymptotic test statistic: Chi-square (3) = 10.6401 with p value = 0.01384. The estimated p-value is lower than the accepted threshold of 0.05, therefore it was reasonable to adopt a panel method with fixed effects (Ciecieląg & Tomaszewski, 2003) (see Table 4 and 5).

Table 4
Assessment of matches and statistical tests of the estimated model

The arithmetic mean of the dependent variable	2,114107	Standard deviation of dependent variable	0,244034
Sum of residual squares	0,301268	Standard error of residues	0,129372
LSDV R-square	0,805428	Within R-square	0,762317
Logarithm of credibility	22,37917	Akaike information criterion	-26,75833
Criterion of bayes. Schwarz	-15,09580	Hannan-Quinn criterion	-23,29045
Autocorrelation of residues - rho1	0,102663	Durbin-Watson statistics	1,636208

Source: own study based on Eurostat data using the Gretl 2016d program.

In the panel of V4 countries, the model with permanent effects turned out to be the correct model. This means that individual effects are constant over time, but they cannot be assigned to individual countries. It means that the creation of green jobs is quite homogeneous in this group of countries. The model shows a high matching rate (80%) and the residual variability rate is low (8.05%), which indicates a low degree of impact on the random variable explained.

Several important regularities can be identified on the basis of the conducted analyzes. In the model with fixed effects, the analyzed regressors such as energy productivity, resource consumption of the economy and primary energy consumption showed relevance at the level of 5%. The analysis carried out using the panel method with fixed effects allowed indicating that the economic and social conditions have a significant impact on the number of green jobs in the RES sector in the Visegrad Group countries. Positive correlation was demonstrated by factors such as GDP in current prices per capita and resource consumption and primary energy consumption. The energy intensity of the economy as well as the energy productivity proved to be a negative correlation.

Table 5
Macroeconomic model explaining changes in the relative number of green jobs in 2000-2016 in the Visegrad Group countries

Variable	Coefficient	Standard error	t-student	Value p	Relevance
const	51,9125	19,1872	2,706	0,0734	*
Primary energy consumption (Mtoe)	-0,885268	0,427518	-2,071	0,0384	**
Energy productivity (PPS/kgoe)	1,73729	0,745856	2,329	0,0198	**
Energy intensity of the economy (kgoe/1000euro)	0,828957	0,897483	0,9236	0,3557	
GDP per capita (euro/person)	-0,676056	0,341296	-1,981	0,0476	**
Resource consumption (million tons)	0,524333	0,313551	1,672	0,0945	*
Assessment of matches and statistical tests					
Sum of residual squares		Standard error of residues			
Logarithm of credibility		Akaike information criterion			
Between variance		Within variance			
mean theta = 0,697837					
Breusch-Pagan	Asymptotic test statistic: Chi-square(1) = 7.75647 with p = 1.246262e-018 (A low *p*-value implies rejection of hypothesis H0 that the OLS panel model is correct, in favour of hypothesis H1 that the random effects model is more appropriate.)				
Hausman	Null hypothesis: the GLS estimator is correct. Asymptotic test statistic H = 39.945 with p = 3.2865e-006 (A low *p*-value implies rejection of hypothesis H0 that the RE panel model is correct, in favour of hypothesis H1 that the FE model is more appropriate.)				

*Symbol: * p < 0,1; ** p < 0,05; *** p < 0,01*
Source: own study based on Eurostat data using the Gretl 2016d program.

It is worth noting, however, that causality is a more complex issue, which should not be resolved solely by means of regression analysis (Aczel, 2000). The conducted analysis may be a contribution to further reflection on the issue of green jobs. In order to formulate more detailed conclusions, it is important to conduct further analyzes.

CONCLUSIONS

The long-term global trend regarding the decrease in the amount of resources and the increase in prices of energy and raw materials implies the process of transformation of economic models. The necessity of this structural transformation mainly affects the energy production sector, which is responsible in the main part for unfavourable changes observed in the natural environment. In the subject literature as well as in the public discourse, the development of the sector of Renewable Energy Sources RES is indicated as the basic instrument of transformations in this sector. Renewable energy sources are not only an alternative to traditional energy carriers, but as this article proved, an important policy tool striving for full employment. As shown, among others, by the German example quoted in this article, the RES sector generates meaningful more jobs than the conventional energy sector. This may be due to the fact that in the case of conventional energy, there is a phenomenon of concentration of capital and employment in relatively large, few factories. However, in the case of renewable energy, it is possible to observe a greater dispersion of capital allocation, production and workplaces, e.g. in many small local biogas plants or other energy production plants of this type. Thanks to this, jobs are also created in small towns for which the problem of unemployment is definitely a bigger challenge than for large industrial centres, where energy production plants based on conventional sources have generally been allocated.

In the context of the above, the importance of the RES sector in generating the number of green jobs should be emphasized, also during the investment implementation phase. This article attempts to determine green jobs in the renewable energy sector in the Visegrad Group countries. In spite of the similar level of development and economic history as well as the comparable socio-economic model, a different rate of development of green jobs was noted. The diversification of climatic, geographic and geological zones as well as economic activity imply the generic and spatial diversity of renewable energy resources and the level and structure of employment in the RES sector in the Visegrad Group countries.

The level of development was also influenced by socio-economic variables. The pace of development of renewable energy and hence the increase in the number of direct green jobs depends on the country's fossil fuels, innovation and technology prices on the market, regulatory and administrative solutions, energy efficiency of the country, energy intensity, existence of a strong lobby connected with concentration of capital and employment in large companies with a significant market share, and resource intensity of economic processes and the economic situation of the country expressed, among others, by GDP per capita.

Summing up the importance of eco-innovation on the energy generation market as an instrument to improve the eco-efficiency of the national economy, it should be stated that their implementation generates positive economic, ecological and social effects, while taking into account the requirements of sustainable development. The implementation of eco-innovation can also create a positive impact on the labour market – thus realizing an important social goal of EU policy, related to ensuring full employment for the Community's inhabitants.

Due to the importance in EU policy of environmental goals, targeted, among others, at: reducing greenhouse gas emissions, increasing the share of renewable energy in the overall energy production structure of the member states' economies and due to the significant increase in the prices of raw materials and energy, it is possible to expect in the coming years:

- intensification of R&D processes towards searching for new eco-innovation trends for this market;
- greater volume of their implementation in the entire energy sector;
- a positive impact on the implementation of full employment.

At the same time, new concepts and solutions will exert even more “pressure” on searching for comprehensive methods for assessing their ecoefficiency as the basic criterion of their potential impact on the environment, economy and social dimension, even at the planning stage before they are implemented into business practice.

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Abstract. The transformation process towards a low-emission, green economy implies an increase in the demand for new professions and competences. Quality changes of jobs under the influence of the idea of sustainable development are both an opportunity and a challenge for both countries and individual regions. Green jobs are created as a result of the development of eco-innovation, new environmentally friendly technologies. The development of green jobs is particularly noticeable in the renewable energy sector. The article presents the results of empirical research in the field of analyzing the number of green jobs in the renewable energy sector in the Visegrad Group. In order to identify and determine the nature and changes in the impact of individual factors on the development of green jobs, panel regression was used – a model with fixed effects. The dependent variable was the relative number of green jobs per million inhabitants in 2000-2016.

Keywords: renewable energy, green jobs, V4, Visegrad Group, energy market