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KEY ECONOMIC SECTORS FOR GREEN JOB CREATION IN POLAND – AN EMPIRICAL ANALYSIS

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ABSTRACT: In this study, we employed a stepwise empirical approach to identify economic sectors and analyze the regional potential for green job (GJ) creation in Poland. We used the operating register of economic entities (REGON) and Polish Labor Force Survey (BAEL) data for the period between 2015 and 2022. The changes in REGON reflect a proxy of changes in GJ stock in sectors of economic activity (PKD-2007) and regions. We estimated trends and spatial diversification of green employment. The results revealed that Mazowieckie, Wielkopolskie, Małopolskie, and Śląskie are the most attractive regions for GJ creation. The polarization of green employment declined during the analyzed period, but spatial disparities were still significant. Most sectors noted increases in GJ, except for agriculture, where the downward trend in employment has a significant influence on the green labor market. Our findings may be useful when formulating policy recommendations for educational institutions, employment institutions, local governments, government institutions, investors, and employers.

KEYWORDS: green jobs, regional and sectoral potential for green job creation, sections of PKD-2007, REGON, BAEL, Polish voivodeships

Introduction

Unemployment is one of Europe's most pressing problems. More than 13 million Europeans, i.e., more than 6% of the active population, were unemployed as of December 2022. In Poland, the number of registered unemployed reached 812,300, with the unemployment rate edging toward 5.2 percent. The highest unemployment rates were recorded in Spain (13.1%) and Greece (11.6%) (Eurostat, 2023). At the same time, the climate and environmental crisis is becoming increasingly serious. Europe has been warming at a faster rate than the global average (the global 1.1°C increase is already affecting natural and human systems) (IPCC, 2022). In 2020 in the European Union (EU), 96% of the urban population was exposed to levels of fine particulate matter above the health-based guideline level set by the World Health Organization (WHO). Taking no action will generate more morbidity and healthcare costs (European Environmental Agency, 2022). Activities aimed at reducing the economy's negative impact on the natural environment have been a priority for the European Union for years. More recently, this priority has been reinforced by the European Green Deal, which adopted the goal of achieving climate neutrality by 2050 (European Commission, 2021), the COVID-19 pandemic, and the outbreak of conflict in Ukraine. These events have influenced the dynamics of the green transition (Konfederacja Lewiatan, 2022). However, the post-pandemic recovery programs emphasize the role of green investors in returning economies to a path of sustainable economic growth. There is a growing body of evidence which shows that, when optimally allocating recovery funds between emission reduction and employment creation objectives, most European countries would invest over 50% of their energy-focused green recovery packages in financing solar photovoltaics and over 10% in the onshore wind (van de Ven et al., 2022). Moreover, in May 2022 the European Commission (EC) adopted the REPowerEU Plan. The program is the EU's response to Russian aggression and an opportunity to realize the green transition. It aims to rapidly reduce dependence on Russian fossil fuels by 2027, by putting a strong emphasis on greater use of renewable energy sources and pointing out the necessity to save on energy consumption. The EC's modeling of the plan suggests a pathway to meet the targeted 45% renewable energy share in overall total final energy consumption. Accounting for all renewable energy sectors, achieving the REPowerEU aims will require the creation of over 3.5 million jobs (including GJ) by 2030 (European Commission, 2023a).

Greening the economy provides high-quality green jobs to fight unemployment, while simultaneously combating climate change and environmental decline. The UN Environment Program defines the green economy as

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low-carbon, resource-efficient, and socially inclusive (UNEP, 2011). The International Labour Organization (ILO) broadly defines a green job as any decent job that helps preserve or restore the quality of the environment, whether it is in agriculture, industry, services, or administration (UNEP, 2008). It includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high-efficiency strategies; decarbonize the economy; and minimize or altogether avoid generating all forms of waste and pollution. The U.S. Bureau of Labor Statistics (BLS) defines green occupations more specifically, but not exclusively, as jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources. They include jobs in which workers' duties involve making production processes more environmentally friendly or ones using fewer natural resources (BLS, 2023a).

The impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements, thus generating new occupations. From a broad conceptual perspective, employment will be affected in at least four ways as the economy is oriented toward greater sustainability: 1) additional jobs will be created, 2) some employment will be substituted, 3) certain jobs may be eliminated without a direct replacement, and 4) many existing jobs will be transformed and redefined as day-to-day skill sets, work methods, and profiles are greened (UNEP, 2008). Therefore, there is a growing demand for both statistical data and conceptual guidelines on measuring green jobs (in terms of the size, composition and contribution of the specific groups of workers and economic sectors to the green economy).

This paper aims to identify the key economic sectors for creating green employment and assess the regional potential for creating green jobs in Poland. We use a replicable stepwise method to accurately gauge the green economy's size and rate of growth, and to identify the jobs associated with it.

An overview of the literature

The literature on green jobs presents a broad catalog of key terms associated with the concept. Green jobs are most often associated with sustainable development (Sulich & Zema, 2018), the circular and green economies (Battaglia et al., 2018; Sulich & Sołoducho-Pelc, 2021), welfare, the labor market, and green business (Song et al., 2021; Vesere et al., 2021), the renewable energy sector, and environmental protection (Martínez-Cruz & Núñez, 2021; Dell'Anna, 2021; Kozar et al., 2022). In those studies, a tool for effectively measuring green job creation was proposed, and green human resources management was conceptualized. Questionnaire-based research was also

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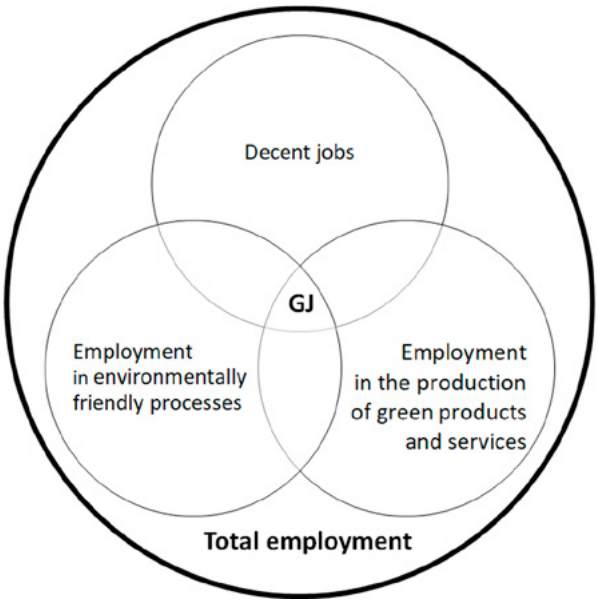
conducted to determine the barriers and socio-economic benefits that can guide policies relevant to attracting skills in green jobs and measuring the level of participation of women compared to men in green jobs (Afolabi et al., 2018).

At the academic level, the recent debate explores the ongoing green transition in selected economic sectors (Stanef-Puică et al., 2022). A fairly general discussion of the factors that influence the creation of green jobs is also discernible in the literature (Kozar et al., 2022). At the enterprise level, green jobs can produce goods or provide services that benefit the environment. They can also be distinguished by their contribution to more environmentally friendly processes (van der Ree, 2019). However, green jobs defined through production processes do not necessarily produce environmental goods or services (Sulich & Zema, 2018). Analysis of the ILO concept (ILO, 2016) of green jobs (Figure 1) which measures jobs in green economic sectors (sections) from an output perspective and job functions in all sectors from an environmentally friendly process perspective remains limited (ILO, 2022). Few researchers have investigated the Polish sectors that have the greatest potential to create green jobs.



Note: GJ – green jobs.

Figure 1. Green jobs in the ILO concept

Source: authors' work based on ILO (2016).

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For example, based on the current Polish Classification of Activities (PKD) (GUS, 2023a). Sulich et al. (2020) defined the green sectors as A, C, D, E, and O therefore identifying. Possible ways in which green jobs can be used to solve youth unemployment problems in Poland, the Czech Republic and Belgium. Kryk (2014) and Kozar (2016) distinguished (sub)sections of the economy that are particularly important for creating green jobs with the PKD-2007 (Kryk: A, D, E, M, N, S and Kozar: A, C, D, E, F, H, I, M, N, P, S). However, these studies suggest theoretical case study research or actions necessary to stimulate the creation of green-collar workers.

In turn, the European Union (2016) proposed relatively general compilation methods to account for the environmental goods and services sectors (EGSS). They suggest using existing data sources to produce estimates for European countries over several years. However, their guide focuses only on the compilation approach, in particular, top-down techniques (European Union, 2016). They provide an ideal framework to collect data on employment that directly depends on the production of outputs intended to protect the environment and manage natural resources (extracted sections: A, C, D, E, F, M, O).

Identifying sectors with the greatest potential to create green jobs in Poland remains high on the list of priorities for Regional Operational Programs, for example, in the Śląskie (UMWŚ, 2015), Podlaskie (WUPB, 2012) and Warmińsko-Mazurskie voivodeships (UMWWM, 2017). The data were collected during a survey of selected entrepreneurs from green sectors and the results indicate that support for the development of qualifications of people in green jobs is particularly important from the point of view of developing these Polish regions properly.

The literature review reveals wide academic interest in defining and analyzing green jobs, both in macro and microeconomic terms. Research makes it possible to draw extremely valuable, but general conclusions for the economy. However, from the perspective of the problems that plague the Polish green labor market, it seems to be insufficient.

Research methods

After combining the aforementioned scientific discussion, EU regulations (Regulation, 2015), and ILO (2008) and BLS (Dierdorff et al., 2009) data presented in Figure 1, we suggest a detailed structural identification of selected sectors and class codes for green jobs in Polish voivodeships based on PKD-2007 (Table 1).

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Table 1. Economy codes according to PKD-2007 for green jobs in Poland

ECONOMY SECTORS	PKD 2007 – SECTIONS (S)	PKD 2007 - CLASSES (C)	DESCRIPTION
AGRICULTURE	A	AGRICULTURE, FORESTRY, HUNTING AND FISHING	
		01	crop and animal production, hunting, including service activities
		02	forestry and logging
		03	fishing and aquaculture
INDUSTRY	C	MANUFACTURING	
		26	manufacture of computer, electronic and optical products
		27	manufacture of electrical equipment
		28	manufacture of machinery and equipment not elsewhere classified
		29	manufacture of motor vehicles, trailers and semi-trailers, excluding motorcycles
		33	repair, maintenance and installation of machinery and equipment
	D	ELECTRICITY, GAS, STEAM, HOT WATER AND AIR CONDITIONING MANUFACTURING AND SUPPLY	
		35	electricity, gas, steam, hot water and air conditioning manufacturing and supply
	E	WATER SUPPLY; SEWERAGE, WASTE MANAGEMENT AND REMEDIATION ACTIVITIES	
		36	water collection, treatment, and supply
		37	sewage disposal and treatment
		38	waste collection, processing, and neutralizing activities; materials recovery
		39	remediation activities and other waste management services
	F	CONSTRUCTION	
		41	construction of buildings
		42	works related to the construction of civil engineering
		43	specialized construction activities
SERVICES	I	ACCOMMODATION AND FOOD SERVICE ACTIVITIES	
		55.20	holiday and other short-stay accommodation
		56.29	other food service activities

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ECONOMY SECTORS	PKD 2007 – SECTIONS (S)	PKD 2007 - CLASSES (C)	DESCRIPTION
SERVICES	M	PROFESSIONAL, SCIENTIFIC, AND TECHNICAL ACTIVITIES	
		71	architectural and engineering activities; technical testing and analysis
		72	scientific research and development
		73.11Z	advertising agencies activities
		73.20Z	market research and public opinion polling
		75	veterinary activities
	N	ADMINISTRATIVE AND SUPPORT SERVICE ACTIVITIES	
		81.30	landscape service activities
	O	PUBLIC ADMINISTRATION AND DEFENSE; COMPULSORY SOCIAL SECURITY	
		84	public administration and defense; compulsory social security
	P	EDUCATION	
		85.31B	general upper secondary schools
		85.31C	specialized upper secondary schools
		85.32A	technical secondary schools
		85.32B	basic vocational schools
		85.32C	special job-training schools
		85.41Z	post-secondary schools
		85.42A	initial teacher training institutions and colleges of social work
		85.42B/Z	higher education institutions
	R	ARTS, ENTERTAINMENT AND RECREATION ACTIVITIES	
		91.04	botanical and zoological gardens and nature reserves activities
	S	OTHER SERVICE ACTIVITIES	
		94.99	activities of other membership organizations not elsewhere classified
		95	repair and maintenance of computers and personal and household goods

Source: authors' work based on Polish Classification of Activities (GUS, 2023a).

The approach presented in Table 1 identifies categories of green jobs. It also evaluates the volume of employment in them based on BAEL and comparable classification schemes, i.e., Statistical Classification of Economic

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Activities in the European Community (NACE), Polish Classification of Activities (PKD) and the International Standard Industrial Classification of All Economic Activities (ISIC), (Figure 2). The identified sectors were also compared with the current list of occupations (existing or new) relative to the national and international occupational taxonomy (BLS, 2023b; European Commission, 2023b). Therefore, the classifications for green sections (Table 1) have established a link with the main standardized classifications for occupations of the ILO and BLS (Mannetje & Kromhout, 2003).

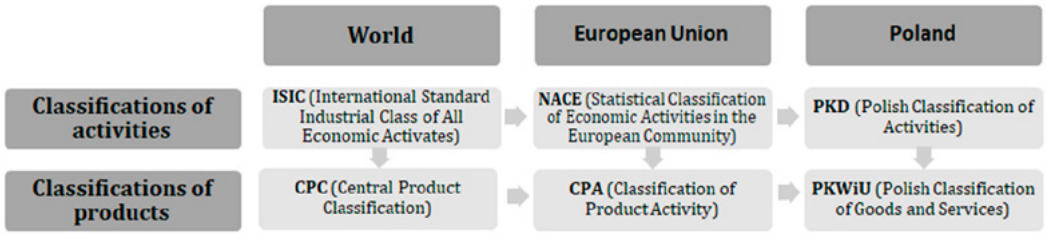

Figure 2. The system of statistical correspondence among economic classifications

Source: authors' work based on GUS (2023a).

The second stage of the empirical research was to estimate the values of green employment in the extracted classes and sectors of the economy. We based our analysis on statistics concerning the operating register of public economic entities of the national economy entered in the National Official Business Register (GUS, 2022a) classified into individual sectors and divisions (classes) of PKD-2007, as the REGON number in the sector is a direct determinant of employment (Grzywińska-Rąpca & Markowski, 2018). The employment values were extracted from the Labor Force Survey database (GUS, 2022b). We took the classification status from 1 January 2016, when there were 16 voivodeships (i.e., NUTS-2 regions) (GUS, 2023b). The volume of green jobs (GJ) in divisions and voivodeships was allocated according to the formula:

$$GJ_{c,v,t} = \frac{REGON_{c,v,t}}{REGON_{s,v,t}} \cdot E_{s,v,t}, \quad (1)$$

where: $REGON_{c,v,t}$ *and* $REGON_{s,v,t}$ are the numbers of entities in classes (c) and s (s) of PKD-2007, $E_{s,v,t}$ is the volume of employment, *index v* denotes the voivodeship, t is the time period.

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We conducted the research for the available period between 2015 and 2022. Employment for 2022 was estimated based on the REGON data. To compare trends in the data, we estimated the average annual least-squares growth rate (AGR) (World Bank, 2023). Finally, to take into account the uncertainty and sensitivity inherent in the analysis, robustness was checked by linking our outcomes with results from previous research using the Pearson correlation, as our data are normally distributed. To test the significance of correlation coefficients (6), we employed the t-distribution formula (Atoum, 2019). The collected data were analyzed using SPSS v. 20.

The study was based on the following research questions:

- What are the green employment trends in Poland?
- How are green jobs geographically diverse (regionalized)?
- What is the regional and sectoral potential for creating green jobs in Poland?

Answering these questions can help estimate and assess the potential for green jobs for the Polish economy from the regional and sectoral perspectives.

Research results

The average number of green employees in Poland in 2015-2022 was more than 5.5 million people, i.e., a 33.9% share of total employment (from over 16 million employed people). At the end of 2022, green sectors employed 5.55 million people (33.7%) – 74,078 fewer than in 2015. From a sectoral view, in 2015 and 2022, the greatest share of green employment was observed in sectors A (32.5% and 24.9%), F (22.2% and 24.9%), and O (19.0% and 20.3%). A decrease in employment from 2015 to 2022 was noted in sectors A, E, and P. The biggest decrease was in agriculture (7.6 pp), while the biggest rise was in construction (2.7 pp) (Figure 1).

Most sectors noted statistically significant annual increases in green job values during the period analyzed (2015-2022) and the coronavirus outbreak (2019-2022) (Table 2). Between 2015 and 2022, the strongest downward trend (AGR) in the GJ value was noted for sectors A (-3.5%) and P (-2.4%), but there was a growing positive slope in I (4.8%), S (3.5%) and D (2.8%). The highest peak in 2022 compared to 2015 was noted in I (62.8%). Agriculture and education saw the biggest drop: for A, it was -24.3%, and for P, it was -17.0%. We also observed that for the period 2019-2022, some sections (D, M, N, O, R and S) noted stronger positive changes in GJ compared to 2015-2018.

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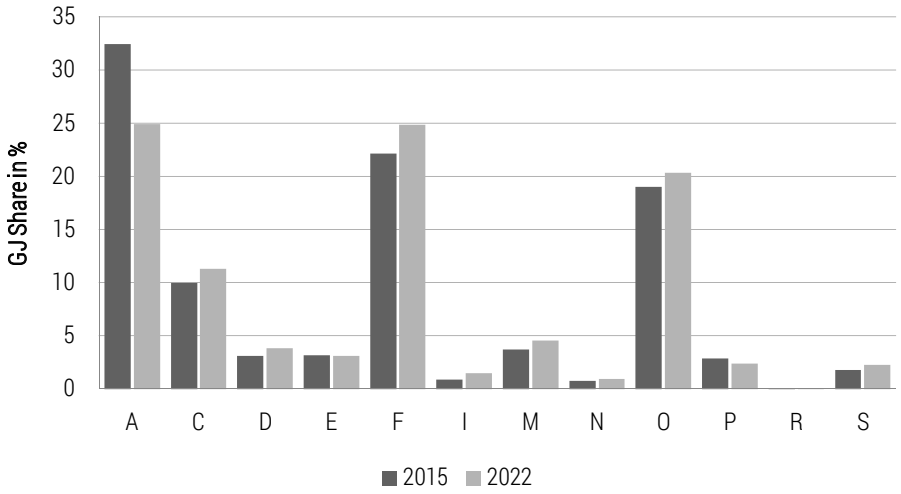

Figure 3. GJ employment shares in the economic sectors in 2015 and 2022 in %

Table 2. Sectoral changes in the number of green jobs between 2015 to 2022

Section	AGR in %		
	2015-2022	2019-2022	Change in % 2022/2015
A	-3.5***	-3.8**	-24.3
C	0.9*	1.2*	11.6
D	2.8**	9.4***	21.9
E	-0.5	-3.1***	-3.5
F	1.5**	0.6	10.7
I	4.8**	7.8*	62.8
M	2.6***	3.3***	20.7
N	2.1*	11.8***	17.2
O	0.1	4.7**	5.4
P	-2.4***	-2.2***	-17.0
R	-0.9	4.5**	2.2
S	3.5***	3.9***	25.0

Note: significance levels of the statistically significant slopes: * α = 0.10, ** α = 0.05; *** α = 0.01.

Data for the entire country show a weak downward trend (R^2=0.16) in green employment (-0.3%). However, data in Figure 3 and Table 2 indicate that the negative GJ slope is determined by a very strong, decreasing trend

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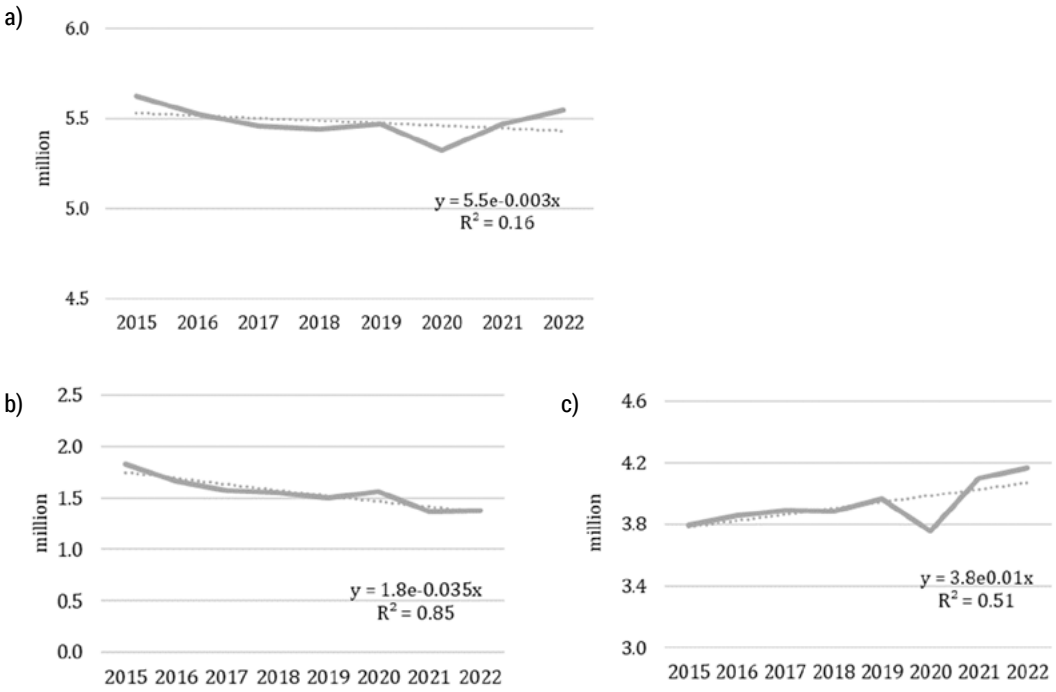
for the agriculture sector (R^2=0.85, AGR=-3.5%), with a much slower trend for P and R. The value of the slope for the trend without section A points to significant annual growth (1.0%) in green employment (R^2=0.51) (Figure 4).



Note: The average annual growth rate (expressed as a percentage) is the coefficient of b estimated from $y=ae^{bx}$, obtained as [exp(b)– 1]*100 (WB, 2023).

Figure 4. Green job trends in Poland, 2015-2022, in million people; a) green employment, b) green employment in section A, c) green employment without section A

The level of green jobs in Poland is spatially diverse (Figure 5). In 2015 and 2022, the highest shares of green employment were noted in Mazowieckie, Wielkopolskie, Małopolskie and Śląskie; the lowest were observed in Opolskie and Lubuskie. The regional disparities of green employment stock declined over the analyzed period, as the coefficient of variation decreased over time (from 55% in 2015 to 51% in 2022).

The highest positively growing slopes were observed in Zachodniopomorskie (2.7%), Warmińsko-Mazurskie (2.5%) and Wielkopolskie (2.1%) (Table 3). When analyzing data without section A, the strongest GJ growth trend was in Podkarpackie (4.4%). The greatest annual drop in GJ was noted in Łódzkie (with or without section A). Compared to 2015, the greatest

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increases in green jobs in 2022 were in Zachodniopomorskie (30%), Wielkopolskie (21%) and Śląskie (17%), while the highest decreases were in Łódzkie and Świętokrzyskie (-19%). During and after the COVID-19 pandemic (2019-2022), the annual decline for those years was noted in nine voivodeships, with the highest recorded in Łódzkie (including section A) and in Pomorskie, without employment in agriculture. In some regions, the pandemic diametrically changed the green employment market and determined the upward trend in GJ – positively in Lubelskie and Śląskie and negatively in Małopolskie and Podkarpackie.

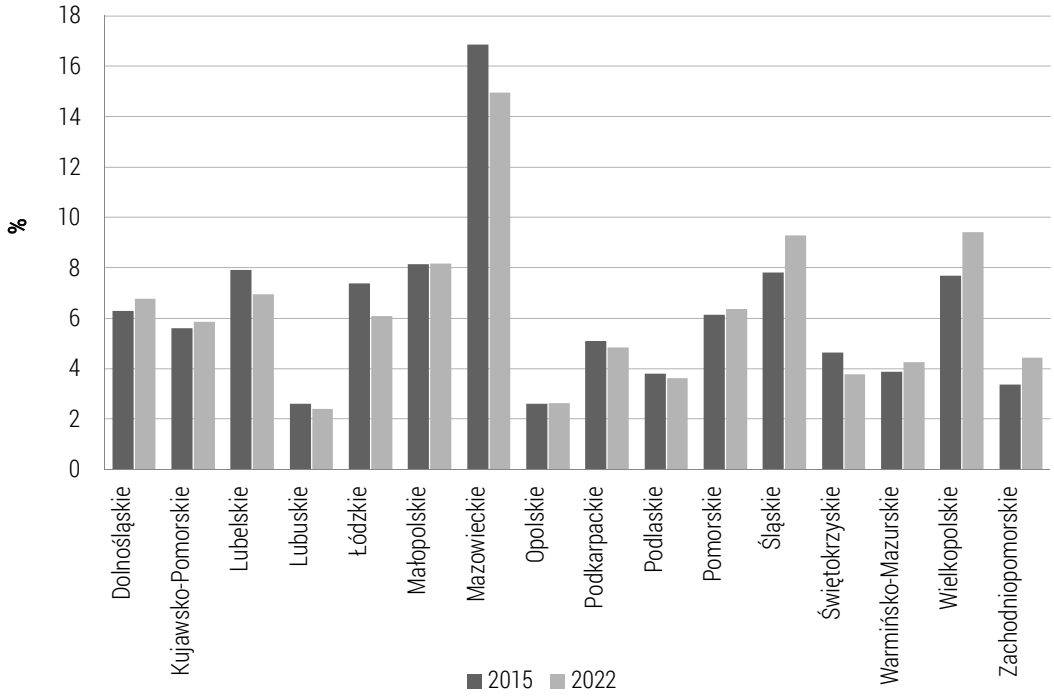

Figure 5. Share of green employment in voivodeships in 2015 and 2022, in %

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Table 3. Regional changes in values of green jobs between 2015 and 2022, in %

NUTS-2	With A sector in %			Without A sector in %		
	AGR		Change 2022/2015	AGR		Change 2022/2015
	2015-2022	2019-2022		2015-2022	2019-2022	
Dolnośląskie	0.3	1.5**	6.2	-0.2	2.4	4.3
Kujawsko-Pomorskie	0.4**	0.4*	3.0	2.0***	-0.3**	16.1
Lubelskie	-1.3*	2.7***	-13.4	-0.2	2.8*	-8.5
Lubuskie	-0.9**	-1.1*	-9.3	0.8*	1.7***	-1.6
Łódzkie	-2.6***	-4.2***	-18.5	-1.0*	1.9**	-9.2
Małopolskie	-0.3	-2.5*	-1.0	2.9***	-1.7***	25.1
Mazowieckie	-1.3*	1.3***	-12.5	-0.1	5.5**	-2.9
Opolskie	-0.2	2.8***	-0.3	0.1	2.0**	0.3
Podkarpackie	-0.9*	-2.4**	-6.1	4.4***	-1.3***	36.4
Podlaskie	-1.0**	-0.8*	-6.2	0.2	3.1**	3.1
Pomorskie	0.2	-0.1	2.2	1.3**	-1.9*	10.4
Śląskie	1.9**	4.9***	17.3	2.2**	1.3***	19.9
Świętokrzyskie	-1.5*	-1.1	-19.5	0.8	5.5*	-3.2
Warmińsko-Mazurskie	2.5**	2.5**	8.8	2.1**	2.0**	10.3
Wielkopolskie	2.1**	-1.0**	21.0	2.1*	1.9	25.9
Zachodniopomorskie	2.7**	-0.7*	29.9	3.2**	-0.1	36.0

Discussion

A detailed analysis of the results leads to interesting conclusions. The Mazowieckie region records the highest amount of green employment in Poland, confirming its leading role (especially that of Warsaw, the capital of Poland) in the domestic and regional labor market, as well as in the green employment structure (Kacprzak, 2019; Sulich et al., 2020). On the other hand, this region noted one of the steepest declines in GJ in 2022 compared to 2015 among the NUTS-2 regions. We also observed a great decrease in the value of green employment in Łódzkie, Świętokrzyskie, Lubuskie and Lubelskie. However, when excluding section A from the data, there was a growth in values of green employment in Polish regions (besides the Dolnośląskie).

The downward trend in the agriculture labor market greatly determined the volume of green employment in Podkarpackie, Świętokrzyskie, Mało-

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polskie, and Kujawsko-Pomorskie, i.e., regions with a strong concentration of agricultural production (Kopiński, 2018). The number of people working in agriculture in the total number of employed decreased dramatically in almost all voivodeships in 2022. The highest decreases were noted in Podkarpackie (-59%), Małopolskie (-57%), Lubuskie (-42%), and Świętokrzyskie (-39%). The reason for these decreases is the employment structure in Poland inherited from the times of the centrally-planned economy (Usabiaga et al., 2022). Therefore, in the context of green jobs, the employment in section A should be analyzed separately, especially due to the relatively high share of agricultural workers in total employment, the significant role of agriculture in the Polish economy and the still-small share of ecological crops (3.5%) in agricultural production compared to the EU-27 average (which is 8.5%) (Antczak, 2021).

The Polish green labor market is unevenly distributed across the voivodeships. For example, in manufacturing (C), the percentage varied between 2% in Podlaskie and 15% in Śląskie, while in section P, it varied between 2.8% in Opolskie to 17% in Śląskie and 11% and in Mazowieckie. However, the highest disparities in green employment were noted in M (professional, scientific and technical activities), from 1.6% in Lubuskie to 23% in Mazowieckie, and in I (accommodation and food service activities), from 0.9% in Opolskie to 19% in Małopolskie. This atypical polarization pattern may stem from the employment structure in Poland, but also from technical change, educational upgrading, and institutional reforms (Arendt & Gajdos, 2018). For example, the Warmińsko-Mazurskie and Podlaskie voivodeships are regions with a relatively low share of industry and the best advantageous conditions for organic production (Antczak, 2021; Podawca & Dąbkowski, 2020; Kociszewski, 2022). Meanwhile, Śląskie has a large cluster of traditionally industrial – and, therefore, environmentally harmful – industries. However, it is experiencing systematic progress in the green economy (Godlewska & Sidorczuk-Pietraszko, 2019).

In Śląskie, the green economy's efficiency has increased significantly, e.g., due to the dynamic development of the green service sector – employment in that sector is higher by 0.7 pp than the national average (UMWŚ, 2023). Moreover, in 2002, the Śląskie Ecosystem for Innovation was developed, and the Regional Innovation Strategy for 2013–2020 was adopted. Since then, the smart specializations of the Śląskie voivodeship comprise energy, medicine, information and communication technologies, green economy, and emerging industries (Pietrzykowski et al., 2022).

In turn, the Wielkopolskie, Zachodniopomorskie, and Kujawsko-Pomorskie regions have the highest total electrical capacity for renewable energy (RE) installations (Pietrzak et al., 2021). This constant possibility for further

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development of the RE sector in voivodeships generates more green jobs (Sidorczuk-Pietraszko, 2015).

The end of 2019 and the beginning of 2020 were marked by the outbreak of the COVID-19 pandemic. It had significant consequences for labor markets around the world but, simultaneously, it shaped employment policies that support a green recovery and green transition. In Poland, there was a drop in green jobs in 2020 compared to 2019, although the annual trend between 2019 and 2022 was still upward. We also noted that the impact of the COVID-19 crisis was highly heterogeneous by locality and sector. The significant downward trend of employment in Lubuskie, Łódzkie, Małopolskie, Podkarpackie, Podlaskie, and Świętokrzyskie (Table 3) was mainly determined by a very strong, negative slope for the agriculture section and a much slower trend for education, water supply, sewerage, and waste management and remediation activities. The reasons behind the collapse during the pandemic period can be attributed to disruptions in supply chains and lockdowns, which reduced the activity in sectors that require high social interaction (Rosak-Szyrocka et al., 2021). The situation could also be caused by the job market›s response to the pandemic, which manifested in a so-called reallocation shock; where some industries experienced a rapid decline, while others grew significantly. These conclusions correspond to most of the studies in Polish literature (e.g., Kaszowska-Mojsa & Włodarczyk, 2020; Kwiatkowski & Szymańska, 2022). The pandemic accelerated production automation, the digitalization of the economy and social life, as well as the implementation of new production and communication technologies (Adamowicz, 2022). Sections D and N noted an above-average upward trend in green employment from 2019 to 2022. The growth in these PKDs can be explained by the importance of services that were provided to secure the essential needs of the population and enterprises (Kwiatkowski & Szymańska, 2022).

One of the limitations of this study is that the availability of employment data collected posed a major problem. It was impossible to obtain statistical information for all analyzed sections and classes of economic activity in the NUTS-2 regions. Hence, the values of green jobs were analyzed at the most detailed level, but derived from the BAEL. We based our estimations on the assumption that the number of entities is directly related to the employment generated in a region. The Pearson correlation between labor force data and the number of entities was between 0.96*** in 2015 and 0.98*** in 2022, depending on the region and section. For this reason, changes in REGON-s explained the diversity of changes in employment. However, to account for the uncertainty and sensitivity inherent in the green employment data, we performed a robustness check by comparing our results with the outcomes from the benchmarking literature (Table 4).

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Table 4. Pearson correlations between calculations of green employment by methods suggested in the scientific literature

References	Sulich et al. (2020)	Kozar (2016)	Kryk (2014)	EGSS (2016)	Arent and Gajdos (2018)
Sulich et al. (2020)	1				
Kozar (2016)	0.33	1			
Kryk (2014)	0.62**	0.80***	1		
EGSS (2016)	0.68**	0.88***	0.79***	1	
Arent and Gajdos (2018)	0.56	0.73***	0.45	0.90***	1

Based on the correlations, we noted that some green job estimations generate quantitatively similar results (e.g., EGSS (2016) and Kozar (2016), or Arent and Gajdos (2018) and EGSS (2016)). However, some could be applied to obtain diverse and case-specific falls in green employment at the regional and sectoral levels (e.g., Sulich et al. (2020) and Arent and Gajdos (2018), or Sulich et al. (2020) and Kozar (2016)). These dissimilarities depend on the definition of green jobs. The definition based on the NACE and PKD categories (Table 1) is more specific than the general concept of the EGSS.

This background serves as a basis for more refined and improved accounts based on more detailed national data sources. The outcomes allow for further assessment of the green jobs concept in Poland. As the extracted data on employment accurately approximate the real number of green jobs, these results are a starting point for a series of publications concerning empirical research using the BAEL database. We plan to quantify the green potential by extracting the green groups of occupations from BAEL, and then following a questionnaire-based approach, we will attempt to define the accurate values of green jobs in Poland.

Conclusions

The aforementioned literature mainly analyzed and defined the relevant economic sectors for creating green jobs according to a theoretical framework. Using a stepwise approach enabled us to extract the key economic sectors for creating green jobs and assess the stock of green jobs for the period between 2015 and 2022. After analyzing data from regional and temporal perspectives, this research determined the leading voivodeships and sections with future green competitiveness and green growth potential.

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The outcomes led us to interesting conclusions. Firstly, the level of green employment in Poland is spatially diverse. Mazowieckie, Wielkopolskie, Małopolskie and Śląskie are the most attractive regions for GJ creation. In contrast, the less competitive voivodeships with the lowest green employment levels are Opolskie and Lubuskie. Regional polarization of green employment declined over the analyzed period, although the spatial disparities were still significant. Therefore, geographical differences should be considered when investigating the empirical concept of green jobs in different economic sectors.

Secondly, most sectors noted statistically significant annual increases in green job values during the period analyzed and during the coronavirus outbreak, except for agriculture, education, arts, and entertainment. The strong downward trend in agricultural employment greatly determined the volume of green employment and, when section A was excluded from the data, there was growth in GJ in all NUTS-2 regions (apart from Dolnośląskie). The data for the entire country without agriculture also showed a growing trend in green employment. The disparities in employment structure by industry and region have a significant influence on labor demand and, therefore, on the green labor market development. Therefore, in this context, green jobs and employment in section A should be analyzed separately.

Thirdly, while 2020 (i.e., the onset of the COVID-19 outbreak) saw a strong decline (-2.7%) in green jobs compared to 2019, our findings show that the COVID-19 pandemic might have increased the rates of green job creation, depending on the economic sector. The outbreak had significant consequences for labor markets around the world, but simultaneously, it shaped employment policies that support a green recovery and green transition. Hence, the full impact of the pandemic on green jobs and the demand for this creation is not yet known, as COVID-19 has undoubtedly had a long-term effect on labor markets.

Identifying sectors and analyzing the regional potential for GJ creation provides a better understanding of the impact of "greening the economy" on the Polish labor market. The approach presented in this study will, at a minimum, allow a preliminary evaluation of core environment-related employment and of green jobs, clearly outlining assumptions and limitations. The results should be therefore relevant when developing national green jobs assessments and formulating strategic labor, economic and educational policies. They can be useful policy-recommendations especially for: education (e.g., new directions of education, training, and courses), employment (e.g., to identify surplus and deficit areas in terms of qualifications and professions), local governments (to verify the local potential and formulate new development directions), government institutions (to ensure that effective policy measures and tools are formulated to respond to the shift to a greener

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economy and to better set up intervention funds), investors (to assess the market potential of local economies), and for employers (to analyze labor supply in green areas). Since we suggested a stepwise approach based on real data over a fairly long period, decision-makers or researchers can test different policy scenarios which will provide an opportunity to examine the economic impacts of policy changes or other interventions to promote green jobs, including identification of which sectors are likely to "win" or "lose" under the scenarios modeled. However, policymakers should pay attention to important sectors (agriculture, construction, public administration), as the greatest changes in the number of workers may occur there, which could have a key impact on the development of Poland's green economy.

Finally, the way the methodology was carried out and described in this study means it can be replicated to identify the regional and sectoral potential of green jobs, estimate the stock of green jobs, and assess the equity issues in the labor market. The robustness check provided evidence that our estimations, based on the integrated system of international economic classifications, also present a valid approximation to evaluate and monitor green job stock and inequality in European economies.

The contribution of the authors

Conception, E.A. and A.G.; literature review, E.A. and A.G.; acquisition of data, E.A. and A.G.; analysis and interpretation of data, E.A. and A.G.

References

Adamowicz, M. (2022). COVID-19 Pandemic as a Change Factor in the Labour Market in Poland. Sustainability, 14(15), 9197. https://doi.org/10.3390/su14159197

Afolabi, A. O., Ojelabi, R. A., Tunji-Olayeni, P. F., Fagbenle, O. I., & Mosaku, T. O. (2018). Survey datasets on women participation in green jobs in the construction industry. Data in Brief, 17, 856-862. https://doi.org/10.1016/j.dib.2018.02.009

Antczak, E. (2021). Analyzing Spatiotemporal Development of Organic Farming in Poland. Sustainability, 13(18), 10399. https://doi.org/10.3390/su131810399

Arendt, Ł., & Gajdos, A. (2018). Shifts in occupational structure in Poland till 2022 – is labour market heading towards polarisation? Social Policy Issues, 42, 71-94.

Atoum, I. (2019). Scaled Pearson's Correlation Coefficient for Evaluating Text Similarity Measures. Modern Applied Science, 13(10), 26. https://doi.org/10.5539/mas.v13n10p26

Battaglia, M., Cerrini, E., & Annesi, N. (2018). Can environmental agreements represent an opportunity for green jobs? Evidence from two Italian experiences. Journal of Cleaner Production, 175, 257-266. https://doi.org/10.1016/j.jclepro.2017.12.086

DOI: 10.34659/eis.2023.85.2.599

BLS. (2023a, February 10). *Measuring Green Jobs.* https://www.bls.gov/green/home.htm#definition

BLS. (2023b, February 10). *Occupational Employment and Wage Statistics.* https://www.bls.gov/oes/current/oes_stru.htm

Commission Implementing Regulation (EU) 2015/2447 of 24 November 2015 laying down detailed rules for implementing certain provisions of Regulation (EU) No 952/2013 of the European Parliament and of the Council laying down the Union Customs Code, Pub. L. No. 32015R2447, 343 OJ L (2015). https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R2447

Dell'Anna, F. (2021). Green jobs and energy efficiency as strategies for economic growth and the reduction of environmental impacts. Energy Policy, 149, 112031. https://doi.org/10.1016/j.enpol.2020.112031

Dierdorff, E., Norton, J., Drewes, D., Kroustalis, C., Rivkin, D., & Lewis, P. (2009). *Greening of the world of work: Implications for O* NET®-SOC and new and emerging occupations.* https://www.onetcenter.org/dl_files/Green.pdf

European Commission. (2021). *European green deal: delivering on our targets.* https://data.europa.eu/doi/10.2775/373022

European Commission. (2023a, June 6). Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and The Committee of the Regions. REPowerEU Plan. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2022%3A230%3AFIN&qid=1653033742483

European Commission. (2023b, February 10). *Occupations*. https://esco.ec.europa.eu/en/classification/occupation_main

European Environmental Agency. (2022). *Air quality in Europe 2022.* https://www.eea.europa.eu/publications/air-quality-in-europe-2022

European Union. (2016). *Environmental goods and services sector accounts*. EGSS. https://ec.europa.eu/eurostat/documents/3859598/7741794/KS-GQ-16-011-EN-N.pdf/3196a7bc-c269-40ab-b48a-73465e3edd89?t=1479717329000

Eurostat. (2023, February 10). *Unemployment statistics.* https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Unemployment_statistics

Godlewska, J., & Sidorczuk-Pietraszko, E. (2019). Taxonomic Assessment of Transition to the Green Economy in Polish Regions. Sustainability, 11(18), 5098. https://doi.org/10.3390/su11185098

Grzywińska-Rąpca, M., & Markowski, L. (2018). Employment and economic entities in the Polish financial sector from 2005-2016. Econometrics, 22(1), 79-93. https://doi.org/10.15611/eada.2018.1.06

GUS. (2022a). *Structural changes of groups of the national economy entities in the REGON register, 2021.* https://stat.gov.pl/en/topics/economic-activities-finances/structural-changes-of-groups-of-entities-of-the-national-economy/structural-changes-of-groups-of-the-national-economy-entities-in-the-regon-register-2021,2,6.html

GUS. (2022b). *Information of Statistics Poland concerning the results of the Badanie Aktywności Ekonomicznej Ludności recalculated for the years 2010-2020. (BAEL – the Polish equivalent of the European survey on the labour force – Labour Force Survey/LFS).* https://stat.gov.pl/en/topics/labour-market/working-unemployed-economically-inactive-by-lfs/information-of-statistics-poland-concerning-the-results-of-the-badanie-aktywnosci-ekonomicznej-ludnosci-recalculated-for-the-years-2010-2020-bael-the-polish-equivalent-of-the-european-survey-on-,24,1.html

DOI: 10.34659/eis.2023.85.2.599

GUS. (2023a, February 10). *Classifications.* https://stat.gov.pl/en/metainformation/classifications/#Polish%20Classification%20of%20Activities%20(PKD)

GUS. (2023b, February 10). *The NUTS classification in Poland.* https://stat.gov.pl/en/regional-statistics/classification-of-territorial-units/classification-of-territorial-units-for-statistics-nuts/the-nuts-classification-in-poland/

ILO. (2008, May 11-13). Global Challenges for Sustainable Development: Strategies for Green Jobs [Paper presentation]. ILO Background Note for G8 Labour and Employment Ministers Conference, Niigata, Japan. https://www.ilo.org/empent/Publications/WCMS_167810/lang--en/index.htm

ILO. (2016, April 13). *What is a green job?* https://www.ilo.org/global/topics/green-jobs/news/WCMS_220248/lang--en/index.htm

ILO. (2022a). *Social and Employment Impacts of Climate Change and Green Economy Policies in Türkiye. Application of the Green Jobs Assessment Model for Türkiye*. https://www.undp.org/turkiye/publications/social-and-employment-impacts-climate-change-and-green-economy-policies-turkiye

ILO. (2022b). *Guidelines for shaping employment policies that support a green recovery and a just transition. https://www.ilo.org/employment/Whatwedo/Publications/WCMS_854548/lang--en/index.htm*

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Kacprzak, M. (2019). Unemployment in the mazowieckie voivodeship – effects and methods of limitations. Acta Scientiarum Polonorum. Oeconomia, 18(4), 49-57. https://doi.org/10.22630/aspe.2019.18.4.44

Kaszowska-Mojsa, J., & Włodarczyk, P. (2020). To Freeze or Not to Freeze? Epidemic Prevention and Control in the DSGE Model Using an Agent-Based Epidemic Component. Entropy, 22(12), 1345. https://doi.org/10.3390/e22121345

Kociszewski, K. (2022). Perspectives of Polish organic farming development in the aspect of the European Green Deal. Ekonomia I Środowisko – Economics and Environment, 81(2), 154-167. https://doi.org/10.34659/eis.2022.81.2.461

Konfederacja Lewiatan. (2022). *Zielone kompetencje i miejsca pracy w Polsce w perspektywie 2030 roku.* https://lewiatan.org/wp-content/uploads/2022/09/RAPORT_zielone_kompetencje-1.pdf (in Polish).

Kopiński, J. (2018). Regional Variation in Changes in Agricultural Production in Poland in the Context of Environmental Impact. Economic and Regional Studies, 11(1), 59-75. https://doi.org/10.29316/ers-seir.2018.05

Kozar, Ł. (2016). „Zielone" miejsca pracy w ujęciu sektorowym gospodarki. In R. Dziuba, M. Szewczyk & E. Okraszewska (Eds.), *Ekonomia Zrównoważonego Rozwoju. Społeczeństwo, Środowisko, Innowacje w Gospodarce* (pp. 53-64). Łódź: Wydawnictwo Uniwersytetu Łódzkiego. https://doi.org/10.18778/8088-490-8.06 (in Polish).

Kozar, Ł. J., Matusiak, R., Paduszyńska, M., & Sulich, A. (2022). Green Jobs in the EU Renewable Energy Sector: Quantile Regression Approach. Energies, 15(18), 6578. https://doi.org/10.3390/en15186578

Kryk, B. (2014). Czas na zielone kołnierzyki. Ekonomia i Środowisko, 3(50), 10-20. (in Polish).

Kwiatkowski, E., & Szymańska, A. (2022). Sectoral changes of employment in Poland during the COVID-19 pandemic: Are reallocation shock effects applicable? Eco-

nomics and Business Review, 8(2), 113-144. https://doi.org/10.18559/ebr.2022.2.7

Mannetje, A. T., & Kromhout, H. (2003). The use of occupation and industry classifications in general population studies. International Journal of Epidemiology, 32(3), 419-428. https://doi.org/10.1093/ije/dyg080

Martínez-Cruz, A. L., & Núñez, H. M. (2021). Tension in Mexico's energy transition: Are urban residential consumers in Aguascalientes willing to pay for renewable energy and green jobs? Energy Policy, 150, 112145. https://doi.org/10.1016/j.enpol.2021.112145

Pietrzak, M., Igliński, B., Kujawski, W., & Iwański, P. (2021). Energy Transition in Poland – Assessment of the Renewable Energy Sector. Energies, 14(8), 2046. https://doi.org/10.3390/en14082046

Pietrzykowski, M., Chodak, M., Woś, B., Pająk, M., & Likus-Cieślik, J. (2022). *Research & Innovation strategy in the field of energy for Upper Silesia*. https://tracer-h2020.eu/wp-content/uploads/2021/09/TRACER-D6.2-5_RI-Strategy_PL_Upper-Silesia.pdf

Podawca, K., & Dąbkowski, N. (2020). Spatial Diversification of Situation of the Organic Farming in the Polish Voivodeships in the Years 2010-2018. Journal of Ecological Engineering, 21(6), 191-200. https://doi.org/10.12911/22998993/123830

Rosak-Szyrocka, J., Abbas, A. A., Akhtar, H., & Refugio, C. (2021). Employment and Labour Market Impact of COVID-19 Crisis – Part 1 – Analysis in Poland. System Safety: Human – Technical Facility – Environment, 3(1), 108-115. https://doi.org/10.2478/czoto-2021-0012

Sidorczuk-Pietraszko, E. (2015). Wpływ instalacji odnawialnych źródeł energii na tworzenie miejsc pracy w wymiarze lokalnym. Ekonomia i Środowisko, 3(54), 26-41. (in Polish).

Song, K., Kim, H., Cha, J., & Lee, T. (2021). Matching and Mismatching of Green Jobs: A Big Data Analysis of Job Recruiting and Searching. Sustainability, 13(7), 4074. https://doi.org/10.3390/su13074074

Stanef-Puică, M. R., Badea, L., Șerban-Oprescu, G. L., Șerban-Oprescu, A. T., Frâncu, L. G., & Crețu, A. (2022). Green Jobs – A Literature Review. International Journal of Environmental Research and Public Health, 19(13), 7998. https://doi.org/10.3390/ijerph19137998

Sulich, A., & Sołoducho-Pelc, L. (2021). The circular economy and the Green Jobs creation. Environmental Science and Pollution Research, 29(10), 14231-14247. https://doi.org/10.1007/s11356-021-16562-y

Sulich, A., & Zema, T. (2018). Green jobs, a new measure of public management and sustainable development. European Journal of Environmental Sciences, 8(1), 69-75. https://doi.org/10.14712/23361964.2018.10

Sulich, A., Rutkowska, M., & Popławski, Ł. (2020). Green jobs, definitional issues, and the employment of young people: An analysis of three European Union countries. Journal of Environmental Management, 262, 110314. https://doi.org/10.1016/j.jenvman.2020.110314

UMWŚ. (2015). *Analiza zapotrzebowania na białe i zielone miejsca pracy w województwie śląskim oraz wskazanie branż kreujących miejsca pracy w odniesieniu do wsparcia oferowanego w ramach RPO WSL na lata 2014-2020. https://rpo.slaskie.pl/media/files/cms/Ewaluacja/Grudzie%C5%84%202015%20/Analiza%20zapotrzebowania%20na%20biale%20i%20zielone%20miejsca%20pracy_%20*

w%20wojewodztwie%20slaskim%20oraz%20wskazanie%20branz%20kreujacych%20miejsca%20pracy%20.....pdf (in Polish).

UMWŚ. (2023). *Potencjały i wyzwania rozwojowe województwa śląskiego w kontekście sprawiedliwej transformacji. Zróżnicowanie obszaru podregionów górniczych.* https://transformacja.slaskie.pl/images/Dokumenty/1646921120_za_C5_82.-2-potencja-c5-82y-i-wyzwania-rozwojowe.pdf (in Polish).

UMWWM. (2017). *Perspektywy rozwoju zielonych miejsc pracy w województwie warmińsko-mazurskim.* http://www.uwm.edu.pl/kpros/images/monografie/7.10_MONO_Perspektywy%20rozwoju.pdf (in Polish).

UNEP. (2008). *Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World (Full report)*. https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf

UNEP. (2011). *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*. https://sustainabledevelopment.un.org/content/documents/126GER_synthesis_en.pdf

Usabiaga, C., Núñez, F., Arendt, L., Gałecka-Burdziak, E., & Pater, R. (2022). Skill requirements and labour polarisation: An association analysis based on Polish online job offers. Economic Modelling, 115, 105963. https://doi.org/10.1016/j.econmod.2022.105963

van de Ven, D.-J., Nikas, A., Koasidis, K., Forouli, A., Cassetti, G., Chiodi, A., Gargiulo, M., Giarola, S., Köberle, A. C., Koutsellis, T., Mittal, S., Perdana, S., Vielle, M., Xexakis, G., Doukas, H., & Gambhir, A. (2022). COVID-19 recovery packages can benefit climate targets and clean energy jobs, but scale of impacts and optimal investment portfolios differ among major economies. One Earth, 5(9), 1042-1054. https://doi.org/10.1016/j.oneear.2022.08.008

van der Ree, K. (2019). Promoting Green Jobs: Decent Work in the Transition to Low-Carbon, Green Economies. Revue internationale de politique de développement, (11), 248-271. https://doi.org/10.4000/poldev.3107

Vesere, R., Kalnins, S. N., & Blumberga, D. (2021). Role of Green Jobs in the Reduction of Waste and Waste Management. Environmental and Climate Technologies, 25(1), 1128-1141. https://doi.org/10.2478/rtuect-2021-0085

World Bank. (2023, February 10). *How Are Aggregate Growth Rates Computed for National Accounts Series?* https://datahelpdesk.worldbank.org/knowledgebase/articles/114952-how-are-aggregate-growth-rates-computed-for-nation

WUPB. (2012). *Analiza zielonego rynku pracy w województwie podlaskim.* http://archiwum.up.podlasie.pl/uploads/upload_i/PnrzZMP/bialystok_analiza_interactive.pdf (in Polish).

DOI: 10.34659/eis.2023.85.2.599