Barometr Regionalny
Tom 15 nr 3

The Impact of Renewable Energy Production on Employment

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Abstract

The aim of the executed research is to determine the influence of harvesting renewable energy on the labour market. Eurostat Databases provided a source of empirical data concerning the amount of produced energy. The number of the employed and the performance of the installed equipment were determined thanks to reports drafted by EurObserv'ER or International Renewable Energy Agency. The following sectors were considered: solid biofuels, biogas, liquid biofuels, geothermal, hydropower, municipal waste, solar photovoltaic, solar thermal and wind power. The research concerned 28 member states of the EU between 2009 and 2015. Such a scope was established due to significant changes on the renewable energy market triggered by the Climate and Energy Package passed by the European Parliament and the Council of the European Union. The number of the working people (directly in the enterprises operating in the field of producing raw energy materials and energy from renewable sources, as well as providing equipment and services within this field) in relation to 1 000 tonnes of oil equivalent of the primary energy obtained in particular sectors of renewable energy sources was used as the performance indicator. Panel estimation was used as means of empirical indication of relations between the variables.

Keywords: renewable energy sources, employment

JEL: O13, P18, Q42, Q54, Q58

Introduction

The use of renewable energy provides many benefits on the global, regional and local scale. The improvement of the environment condition (Czaja and Becla 2002, 72–109; Folmer et al. 1995, 308; Meadows et al. 1973) and the improvement of energy safety (Li 2005; Molo 2013; Valentine 2011) are the most frequently highlighted.[1] Distributed power prevents major disturbances in the event of power grid or power provider failure. Moreover, such a strategy minimises costs of constructing and using transmission lines, as well as enhances provision of power, especially to areas with poor power infrastructure. The development of the use of renewable energy sources results in increased employment.[2] This observation has provided motivation for increasing funding for renewable energy

1. See also: Renewable Energy... into the Mainstream. IEA Renewable Energy Working Party, by Rodney Janse, the Netherlands, October 2002, [@:] http://library.umac.mo/ebooks/b1362376x.pdf; Contribution of Renewables to Energy Security. IEA Information Paper, by Samantha Oelz, Ralph Sims, and Nicolai Kirchner, OECD/IEA, April 2007, [@:] http://www.iea.org/publications/freepublications/publication/so_contribution.pdf; Energy Costs of Goods and Services in 1967: Including Solar Energy Inputs and Labor and Government Service Feedbacks. By Robert Costanza, Center for Wetlands, University of Florida. Department of Environmental Engineering Sciences, University of Illinois at Urbana-Champaign. Energy Research Group, University of Illinois at Urbana-Champaign, 1978, pages 8–12.

2. See: Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate? Report of the renewable and appropriate energy laboratory by Daniel M. Kammen, Kamal Kapadia, Matthias Fripp of the Energy and Resources Group Goldman School of Public Policy, 13 April 2004 (corrected 1/31/06), [@:] http://www.eci.ox.ac

production time and time again. The White Paper entitled "Energy for the Future: Renewable Sources of Energy"[3] states that the doubled share of renewable energy in total energy use in the EU may result in creation of 500–900 thousand of job positions. Similar data was presented in such documents as "Resource Efficient Europe"[4] or "The Roadmap for Moving to a Competitive Low-Carbon Economy in 2050."[5] Within the EU, research concerning the evaluation of effects of conducting a support policy in terms of renewable energy and the development of the RES technologies on the labour market has been conducted from the early 1990s in the framework of such projects as ECOTEC([6]), ALTENER([7]) or EmployRES([8]). The net effect was estimated to amount to 545–656 thousand job positions, which is almost equal to the data included in the White Paper of 1997. According to the report drafted by Greenpeace, the net employment in Poland (considering changes in mining and conventional energy sources) shall increase by 155 thousand until 2020, comparing to 2010.[9] It is significant to mention that such jobs are usually created in rural areas characterised by a high unemployment level and may be suitable for candidates with low qualifications. The importance of using RES, primarily bio-mas, for the labour market reflects Schumacher's views, namely that: "workplaces should be created exactly where people currently live, not in cities or places where people migrate to; the applied methods of creating such jobs should be simple in order to minimise the demand for high qualifications not only in the sector of direct production bud also in the sector of material supply, organisation system, financing, marketing, etc.; goods should be produced with locally produced materials and they should suit the needs of the local markets." (Schumacher 1981, 198–199)

1 Research material and methodology

The paper presents results of the research aiming at the analysis of the influence of harvesting renewable energy on the labour market. The number of the working people (directly in the enterprises operating in the field of producing raw energy materials and energy from renewable sources, as well as providing equipment and services within this field) in relation to 1 000 tonnes of oil equivalent to the primary energy obtained in particular sectors of renewable energy sources was used as the performance indicator.

Information on power production was acquired from the Eurostat Database, while the number of the employed and the performance of the installed equipment were determined thanks to reports drafted by EurObserv'ER or International Renewable Energy Agency.[10] The following sectors were

.uk/publications/downloads/kapadia04-puttingrenewables.pdf.

3. See: Communication from the Commission. Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan. COM(97)599 final (26/11/1997), page 12, [@:] http://europa.eu/documents/comm/white_papers/pdf/com97_599_en.pdf.

4. See: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Resource-Efficient Europe — Flagship Initiative under the Europe 2020 Strategy. COM(2011)21 final, Brussels, 26.1.2011.

5. See: Opinion of the European Economic and Social Committee on the 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on a roadmap for moving to a competitive low carbon economy in 2050' COM(2011) 112 final, OJ C 376, 22.12.2011, p. 110–115.

6. See: The Potential Contribution of Renewable Energy Schemes to Employment Opportunities. Report No. ETSU K/PL/00190, ECOTEC Research and Consulting Ltd. for the Energy Technology Support Unit on Behalf of the Department of Trade and Industry, ETSU, Harwell OX11 0RA, Birmingham, UK, 1995.

7. See: Meeting the Targets & Putting Renewables to Work. Overview Report, Monitoring & Modelling Initiative on the Targets for Renewable Energy (MITRE), [@:] http://www.ewea.org/fileadmin/ewea_documents/documents/policy/external_documents/040330_MITRE_overview_-_Meeting_the_targets_and_putting_renewables_to_work.pdf.

8. See: Employment and growth effects of sustainable energies in the European Union — Final Report. Contract no.: ENER/C1/428–2012, by Vicki Duscha etal., Karlsruhe, August 2014, [@:] https://ec.europa.eu/energy/sites/ener/files/documents/EmployRES-II%20final%20report_0.pdf.

9. See: Pracując dla klimatu. Zielone miejsca pracy w Polsce. Report by Hu Wei, Greenpeace, 2011, [@:] http://www.greenpeace.org/poland/PageFiles/351912/pracujac-dla-klimatu.pdf.

10. See: Renewable Capacity Statistics 2016. By Adrian Whiteman, Tobias Rinke, Javier Esparrago, and Samah Elsaye, The International Renewable Energy Agency (IRENA), March 2016, [@:] http://www.irena.org/-/media/

considered: solid biofuels, biogas, liquid biofuels, geothermal, hydropower, municipal waste, solar photovoltaic, solar thermal and wind power. The research concerned 28 member states of the EU between 2009 and 2015. Such a scope was established due to significant changes on the renewable energy market triggered by the Climate and Energy Package passed by the European Parliament and the Council of the European Union. As a result, a balanced panel of the maximum number of 196 observations was acquired for each sector.[11] According to the Hausman's test in order to empirically identify the relation between the variables, the fixed specific effects power panel model was applied:

$$Y_{it} = \alpha_0 X_{it}^{\alpha_1} e^{\gamma_i + \varepsilon_{it}}, \tag{1}$$

where:
Y_{it} — employment measured by the number of people working in i-th country in the year t,
X_{it} — primary energy produced in i-th country in the year t expressed in thousands of toe,
α_1 — flexibility of employment in relation to the primary energy,
γ_i — cross-sectional individual effect for i-th country,
ε_{it} — residuals,
$t = 1, 2, \ldots, n$ — (where n is number of years),
$i = 1, 2, \ldots, m$ — (where m is number of countries).

Taking the natural logarithms of dependent and independent variables, we obtain the fixed specific effects linear panel model

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln X_{it} + \gamma_i + \varepsilon_{it}, \tag{2}$$

whose parameters were estimated through the panel least squares method. The obtained economic models were verified. Their quality as well as accuracy of their specification were tested.

2 Description of the renewable energy sources sector in the EU

The increase of share of RES in the EU is determined by its policy. The Climate and Energy Package stipulates that the share of RES in the total gross energy use in 2020 shall reach 20%.[12] However, the starting point in terms of renewable energy production and the ability to collect it are different among the member states. The EU defined bounding targets for each country — from 10% for Malta to 49% for Sweden. The analysis of the fulfilment of these targets (December 31, 2015) suggests that as for France, Luxemburg, Malta, Netherlands, Great Britain and, to a smaller degree, for Belgium and Spain, the achievement of the established share of the renewable energy is in danger. On the other hand, Austria, Sweden, Denmark and Latvia have already fulfilled targets for 2020 (fig. 1). In 2015, Germany, France, Italy, Spain, Great Britain and Sweden were the largest renewable energy producers (fig. 2).

The structure of acquiring renewable energy in EU indicates that up until recently, bio-mass was the most important source. As it is easily available and may be used in such processes as direct combustion (e.g., wood, straw, sewage sludge); transformation into liquid fuel (e.g., rapeseed oil ester, alcohol) or gas fuel (e.g., agricultural biogas, biogas from sewage treatment plants, waste gas). In comparison to photovoltaic power plants and wind farms, biomass is one of the RES which does not require the so-called "hot backup" in the system of power disposition. Such a requirement provokes discussions on power and impedes key legislative processes concerning the development of renewable energy sources. Biomass is mainly used in heat engineering, electrical power engineering, biogas plants and bio-fuel production. The share of biomass in the total RES energy balance varied among the countries — from 38,2% in Spain to 89,5% in Poland.[13] However, its share decreased

Files/IRENA/Agency/Publication/2016/IRENA_RE_Capacity_Statistics_2016.pdf.

11. In the case of some sectors, a smaller number of observations was analysed due to the lack of data.

12. See: Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC (Text with EEA relevance). OJ L 140, 5.6.2009, p. 16–62.

13. [In the journal European practice of number notation is followed — for example, 36 333,33 (European style)

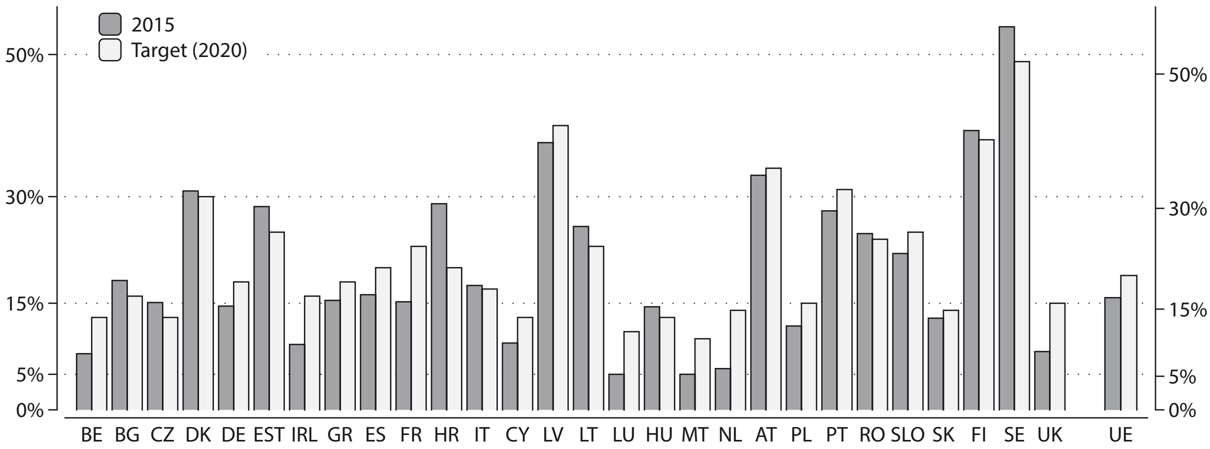

Fig. 1. Share of energy from renewable sources in the EU Member States (in % of gross final energy consumption)

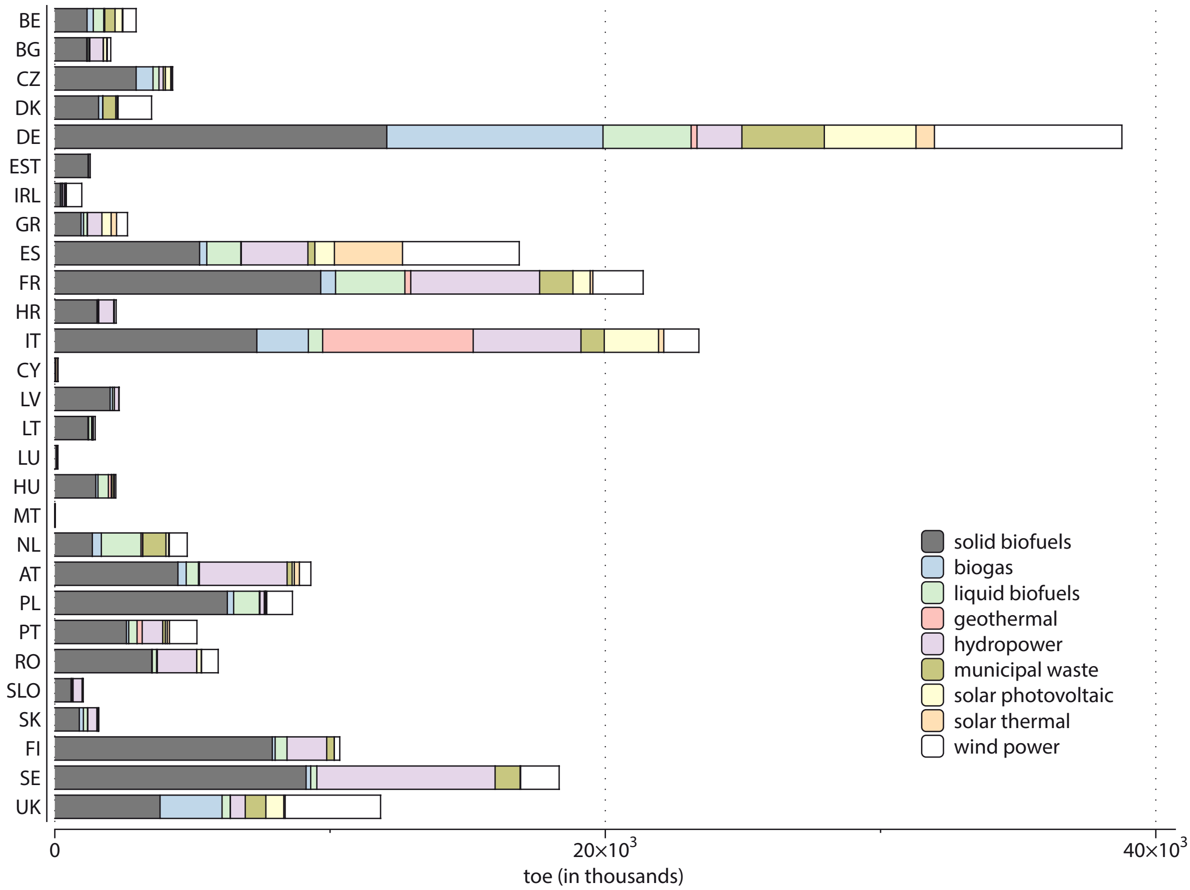

Fig. 2. Primary energy production from renewable sources in the EU Member States in 2015

from 67,7% in 2005 to 64,1% in 2015. At the same time, due to subsidies from the funds guaranteed by the countries, wind and solar energy gained importance.

The development of renewable energy sources led to improved employment — in 2015 it was 1 017,2 thousand of people: 332,3 thousand in the wind power sector, 314,7 thousand in solid biomass, 110,6 thousand in photovoltaic energy, 95,5 thousand in the production of biofuels and 63,9 thousand in the production of biogas. The data include people working directly in the enterprises operating in the field of producing raw energy materials and energy from renewable sources, as well as providing equipment and services within this field. The number of the employed is correlated

= 36 333.33 (Canadian style) = 36,333.33 (US and British style). — Ed.]

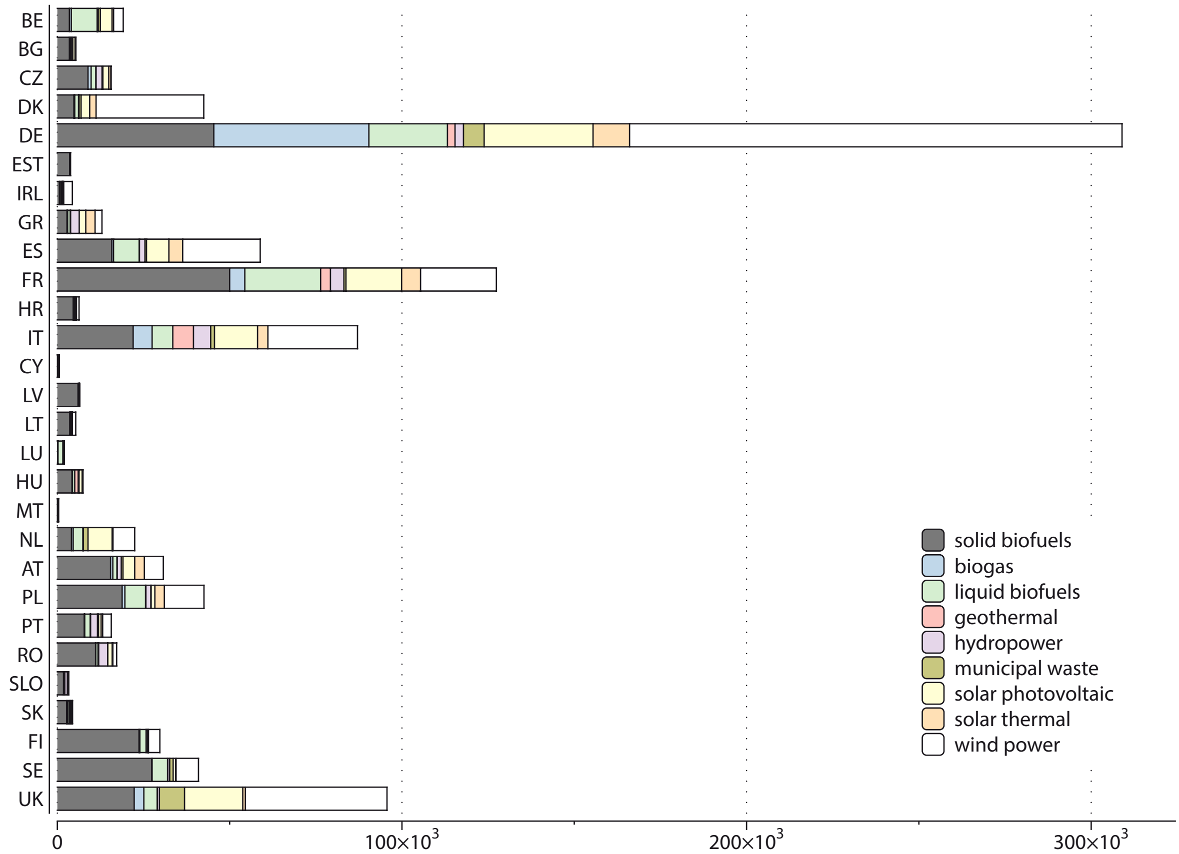

Fig. 3. Employment — direct and indirect jobs by RES sectors in the EU Member States in 2015

with the amount of produced power and the value of investments thus, approximately 30% of working people is attributed to Germany (309 thousand) mainly in wind, photovoltaic and biomass power. In Poland the number was ten times smaller, even despite the similar technical potential of RES (fig. 3).

3 Results

The conducted research shows that the largest number of working places in relation to generated power appears in the wind, solar and photovoltaic energy sectors (tab. 1). A lower amount of produced energy per installed capacity unit in relation to other RES constitutes a key factor influencing such values of employment levels in these sectors. Disproportions are caused by the nature of wind and solar power. In comparison to biogas, these both types of energy may be used only in proper weather conditions, which affects the effective working time of the installed equipment, which is lower than in the case of other renewable energy sources (Gradziuk and Gradziuk 2017). Moreover, wind and solar power require the so-called "hot backup" in the system of power disposition (Żylicz 2012). Apart from relatively low effective work time, the main reasons for such high employment rates include the dynamic development and innovative character of these sectors. Between 2009 and 2015, the production of energy through photovoltaic systems increased by 730%, through solar systems — by 322%, through wind systems — by 227% and through water systems by 1,6%.

The employment does not only differ in terms of various sectors, but is also characterised by a large variation in terms of time. The highest such difference was observed in the case of photovoltaic, solar, wind and liquid biofuel energy. These sectors are highly innovative and implement the latest scientific and technological solutions. That is why within the analysed period of time a rapid decrease in the employment rate in these sectors was observed. In the photovoltaic sector it amounted to 10 times, in solar energy — to 5 times, in wind, biogas and liquid biofuels — by a half. Gostomczyk (2013) obtained similar results, however, in terms of the installed capacity. Research

Tab. 1. Number of employees per 1000 toe of generated energy in RES sectors

RES sector	2009	2010	2011	2012	2013	2014	2015
Hydro power	0,5	0,5	0,8	0,7	0,8	0,8	1,0
Wind power	21,5	19,7	17,9	17,2	15,4	14,9	12,8
Solar thermal	40,9	27,6	22,1	14,4	11,5	9,9	8,7
Solar photovoltaic	120,8	138,4	84,8	43,6	22,4	14,9	12,6
Solid biofuels	3,6	3,3	3,4	3,3	3,4	3,6	3,5
Biogas	7,0	6,6	6,5	5,6	4,9	4,6	4,1
Liquid biofuels	12,7	13,0	10,7	10,0	8,1	8,0	7,2
Municipal waste	3,3	3,2	2,9	2,6	2,5	2,4	2,4
Geothermal	1,8	2,0	1,7	1,9	1,9	1,9	1,9

conducted by Heavner and Churchill suggests that all these changes characterise the investment stage rather than the organisational stage.[14] Sastresa et al. (2010) explain that these processes are caused by automation of RES equipment production, the scale effect and gaining knowledge — they all contribute to gradual decrease of discrepancies concerning employment between the sectors (Gostomczyk 2013, 2015).

The relation between the number of the employed and the quantity of obtained primary energy in the given sectors of RES was also determined with the use of statistics and econometrics. First of all, the analysed variables were statistically characterised (tab. 2).

The logarithmized values of observation of the period between 2009 and 2015 collected from 28 member states of the EU provided the basis for constructing panel models with fixed effects (tab. 3). The obtained models are adjusted to the empirical data, the rectified coefficient of determination equalled, depending on the sector, 0,821 (liquid biofuels) to 0,969 (solid biofuels), while

Tab. 2. Basic statistics on employees (Y) and generated energy (X) in RES sectors

RES sector	Variable	Min	Q_1	Median	Q_3	Max	Skewness	p^a
Hydro power	Y	0,0	22,6	329,9	1 337,2	6 786,9	1,792	$< 0{,}000001$
	X	0,0	65,0	380,0	1 025,0	5 000,0	1,915	$< 0{,}000001$
Wind power	Y	0,0	20,2	167,3	675,9	6 810,5	2,744	$< 0{,}000001$
	X	0,0	150,0	2 000,0	6 400,0	149 200,0	3,922	$< 0{,}000001$
Solar thermal	Y	0,0	4,2	11,7	63,5	2 473,8	5,640	$< 0{,}000001$
	X	0,0	55,0	300,0	1 825,0	15 900,0	2,665	$< 0{,}000001$
Solar photovoltaic	Y	0,0	0,4	7,4	88,5	3 329,9	4,047	$< 0{,}000001$
	X	0,0	75,0	750,0	5 000,0	110 900,0	3,971	$< 0{,}000001$
Solid biofuels	Y	0,0	939,4	1 467,9	4 682,4	12 061,6	1,176	$< 0{,}000001$
	X	0,0	2 500,0	4 200,0	13 850,0	68 100,0	2,103	$< 0{,}000001$
Biogas	Y	0,0	16,7	76,4	227,8	7 854,2	4,527	$< 0{,}000001$
	X	0,0	55,0	165,0	670,0	52 900,0	5,012	$< 0{,}000001$
Liquid biofuels	Y	0,0	24,0	155,4	421,6	3 596,7	2,733	$< 0{,}000001$
	X	0,0	300,0	1 225,0	5 285,0	35 000,0	2,540	$< 0{,}000001$
Municipal waste	Y	0,0	0,0	44,7	469,4	3 037,0	2,947	$< 0{,}000001$
	X	0,0	0,0	50,0	600,0	7 300,0	2,507	$< 0{,}000001$
Geothermal	Y	0,0	0,0	6,9	32,7	5 469,5	4,995	$< 0{,}000001$
	X	0,0	0,0	50,0	200,0	6 000,0	4,028	$< 0{,}000001$

[a] p-value for normality test

14. See: Renewables Work: Job Growth from Renewable Energy Development in California. Report by Brad Heavner and Susannah Churchill, CALPIRG Charitable Trust, June 2002, [@:] http://research.policyarchive.org/5556.pdf.

for hydro power, solar thermal, solar photovoltaic, liquid biofuels and geothermal the parameters of the explanatory variables turned out to be invalid and equalled up to 0,05. Presumably, the lack of relevance of these parameters (up to 0,05) was motivated by the fact that a considerable part of variation Y was caused by the difference between the examined countries — specific fixed effects (see Rho values in table 3).

The flexibility of employment estimated in relation to the primary energy varied greatly among the specified sectors. The greater flexibility was observed in the solid biomass sector (1,60%), then the biogas sector (0,60%), the municipal waste sector (0,42%) and the wind power sector (0,31%).

Tab. 3. Estimated parameters of linear panel models with fixed effects on employment ($\ln Y$) and generated energy ($\ln X$) by RES sectors

RES sector	Variable	Parameter	Stand. error	t	p	R^2	Rho[a]
Hydro power	$\ln X$	−0,264	0,252	1,05	0,296	0,822	0,909
	cons	7,402	1,414	5,23	< 0,000		
Wind power	$\ln X$	0,311	0,080	3,86	< 0,000	0,905	0,846
	cons	6,055	0,429	14,10	< 0,000		
Solar thermal	$\ln X$	0,083	0,103	0,81	0,421	0,949	0,944
	cons	6,016	0,338	17,78	< 0,000		
Solar photovoltaic	$\ln X$	0,056	0,064	0,89	0,379	0,838	0,835
	cons	8,232	0,280	29,39	< 0,000		
Solid biofuels	$\ln X$	1,600	0,200	7,97	< 0,000	0,969	0,942
	cons	−3,305	1,470	2,25	0,026		
Biogas	$\ln X$	0,602	0,085	7,05	< 0,000	0,916	0,698
	cons	2,933	0,384	7,62	< 0,000		
Liquid biofuels	$\ln X$	−0,161	0,142	1,13	0,260	0,821	0,866
	cons	8,508	0,783	10,86	< 0,000		
Municipal waste	$\ln X$	0,416	0,104	4,00	< 0,000	0,916	0,903
	cons	3,650	0,522	6,99	< 0,000		
Geothermal	$\ln X$	−0,073	0,160	0,46	0,649	0,877	0,898
	cons	5,207	0,509	10,22	< 0,000		

[a] The variance due to differences across panels

Conclusions

Currently, energy-related policies implemented by developed countries is characterised by a gradual elimination of the share of traditional non-renewable sources of energy. The stage is taken by the renewable sources. Within the European Union, the production of primary energy from the renewable sources increased by 70% between 2005 and 2015, while by 2020 it shall be doubled. The positive impact on the labour market is one of the main arguments for the development of the renewable energy sources. However, the data concerning the number of the employed and the number of jobs in these sectors available in the literature on the subject are not coherent. It may be caused by application of various tools of estimation (Henriques, Coelho, and Cassidy 2016), or local and technological factors (Gostomczyk 2015). The presented results were developed upon the average data concerning the employment and the quantity of produced primary energy. The analysed models show that throughout the examined period, the solar and wind power sectors were the ones that consumed the larger amount of labour. As it was indicated above, these sectors are considered the most innovative and technologically advanced and thus, the employment rates seem to decrease in the short term. Hence, it is advisable to continue the conducted research on examining tendencies of the changes with consideration of the scale of production and the division between the directly and indirectly employed. The preliminary assumptions show that for some sectors it shall be better to apply the linear models, however, this shall be subject to further analysis.

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