SPATIAL DIFFERENTIATION OF RENEWABLE ENERGY SOURCES USE IN THE EUROPEAN UNION COUNTRIES IN THE YEARS 2001-2013

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Abstract

The author of the present paper have conducted an analysis of energy production coming from its renewable sources in the European Union countries, with the division into its basic sources: wind, water, solar power, geothermal power, biomass and municipal waste. The level of their concentration has been determined in it. The authors have also evaluated development of national markets of renewable energy with the use of synthetic development measures coming from the Multivariate Statistical Analysis methods. Spatial autocorrelation has been evaluated in the paper with the use of Moran coefficient. The conducted research allowed the authors to do the following things: determine the existent differences in the development level of regional renewable energy markets, classify the European Union's countries in terms of renewable energy sources use, verify the hypotheses on lack and existence of spatial autocorrelation, evaluate concentration level of chosen renewable energy sources in Europe.

Key words: *renewable energy market, spatial correlation, Herfindahl-Hirschman Index, cluster analysis*

1. INTRODUCTION

In the world economy and social-economic development of particular countries, both on regional and local level, more and more frequently attention is paid to the principles of balanced development defined as a kind of compromise between the need to protect the environment and the needs of the economy as well as the social ones. This is also reflected in the EU policy, where the concept of balanced development determines directions of all economic activities. One of them being energy production based on renewable sources.

In 2012 the total energy demand of the EU, expressed as gross national consumption, was covered from the following sources: 35% oil, 23% petroleum gas, 17% fossil fuels such as coal, 14% nuclear energy and 11% renewable energy sources, such as hydroenergy or wind power. The above shares are subject to substantial differentiations in particular countries and they evolve due to their geographical conditioning, such as natural resources distribution and access to them, shape of the policy accepted by particular countries, e.g. decisions concerning the use of nuclear energy, changes of financial incentives, technological progress, decarbonisation requirements and internal market development (Wyzwania i polityka w zakresie energii 2013).

According to the assumptions accepted by the European Union, until the year 2020, 20% of the energy produced should come from renewable sources. The new directive (2009/28/WE) on renewable energy sources was finally adopted in April 2009. This directive defines an individual percentage level of energy production coming from renewable energy sources for each of the 27 membership countries, which has to be attained in the year 2020, taking into consideration different starting points (treating 2005 as the basis), energy sources structure and the potential of particular countries. Wind power is supposed to be most important in this aspect, which should constitute 11,6% - 14,3% of the produced energy in the energy balance (Romero, Santos & Gil 2012).

Europe has set itself one goal: energy coming from renewable energy sources has to constitute a fifth of the energy used in the European Union in the year 2020. Thanks to promoting renewable energy sources on European scale their production capacity has risen evidently within recent years - far quicker than the capacity obtained in traditional power plants.

Renewable energy sources are in the centre of attention of long-term European energy policy as they ensure low level of greenhouse gasses emission and the possibility to limit import. This flourishing economy sector confirms that Europe is in the vanguard of modern energy technologies, provides "green workplaces" and exports the product of a great added value.

2. RENEWABLE ENERGY SECTOR IN EUROPE

Renewable energy sources, according to the definition adopted by the European Union, include sources different than fossil fuels, that is:

- wind power,
- solar radiation,
- geothermic,
- waves,
- tides,
- water power plants of power below 10 MW,
- from biomass (products from agriculture and forestry, waste coming from agriculture, forestry and food production industry and non-processed wood and cork waste)

The scope of using energy coming from renewable sources in the member countries of the European Union is regulated by proper documents and normative acts of the EU, determining general and detailed goals concerning the obligation of attaining defined participation indexes of energy coming from renewable energy sources in the general use of this energy. The basic documents and legislative acts of the EU in this respect are:

- the directive of the European Parliament and the Council 2009/28/WE of the 23 April 2009 on promoting the use of energy coming from renewable energy sources, amending and in the consequence repealing the directives 2001/77/WE and 2003/30/WE
- the decision of the Commission of the 1 March 2013 establishing the guidelines for the member states concerning counting renewable energy from heat pumps with reference to different technologies of heat pumps on the basis of article 5 of the directive of the European Parliament and the Council 2009/28/WE
- the White Book - Energy for the Future: Renewable energy sources (1997),
- the Green Book - Towards European strategy of energy security (2001),

The adopted on 23 April 2009 by the European Parliament and Commission Directive 2009/28/WE on promoting the use of energy from renewable sources determines a series of tasks for the EU member states, and in particular (Jager-Waldau, Szabo, Scarlat & Monforti-Ferrario 2011):

- common framework for promoting energy from renewable sources;
- obligatory national general goals with reference to the total share of energy from renewable sources in the gross final energy use and with reference to the share of energy from renewable sources in transport;
- rules concerning: statistical transfers of defined energy from RES among member countries, joint projects among member countries and with third countries, the guarantee of origin, administrative procedures, information and trainings, admission of energy from renewable sources to electro-energy networks;
- criteria of balanced development for biofuels and bio-fluids.

The structure of energy from renewable sources acquisition in the European Union's countries in the years 2007-2012 presents Table 1.

Table 1. The structure of acquiring energy from renewable sources in the European Union's countries in the years 2007-2012 [%].

Specification	2007	2008	2009	2010	2011	2012
Fossil biofuels	50,2	49,5	49,3	48,3	48,1	47,2
Solar power	0,9	1,2	1,7	2,2	3,7	5,1
Water power	19,9	19,8	19,0	18,9	16,3	16,3
Wind power	6,7	7,2	7,7	7,7	9,5	10,0
Biogas	5,2	5,1	5,5	6,6	6,3	6,8
Liquid biofuels	7,3	7,7	7,9	8,0	7,1	6,5
Geothermal energy	4,3	4,0	3,9	3,5	3,8	3,2
Municipal waste	5,4	5,3	5,0	4,7	5,2	4,9

Sources: Energia ze źródeł odnawialnych w 2012 r., 2013, Energia ze źródeł odnawialnych w 2013 r., 2014.

Presently it is biomass (the share of which is supposed to grow) and water power that are the largest sources of renewable energy, but solar and wind power are characterized by the highest annual growth rate of the installed power.

Table 2. Share (%) of energy produced from renewable energy sources (RES) in total energy consumption in the EU countries in 2001-2012

Country	**2001**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2020***
EU 28	-	8,1	8,5	9,0	9,7	10,4	11,6	12,5	13,0	14,1	**20,0**
Austria	21,7	22,8	23,8	25,3	27,2	28,3	30,2	30,6	30,9	32,1	34,0
Belgium	1,2	1,9	2,3	2,6	2,9	3,2	4,4	4,9	4,1	6,8	13,0
Bulgaria	3,6	9,2	9,2	9,4	9,0	9,5	11,7	13,7	13,8	16,3	16,0
Croatia	-	15,2	14,1	13,8	12,5	12,2	13,3	14,6	15,7	16,8	20,0
Cyprus	1,9	2,7	2,6	2,8	3,5	4,5	5,0	5,4	5,4	6,8	13,0
Czech Republic	3,5	6,0	6,1	6,5	7,4	7,6	8,5	9,2	9,4	11,2	13,0
Denmark	9,7	14,9	16,0	16,4	17,8	18,6	20,0	22,0	23,1	26,0	30,0
Estonia	10,4	18,4	17,5	16,1	17,1	18,9	23,0	24,6	25,9	25,2	25,0
Finland	22,2	29,0	28,6	29,8	29,4	30,7	30,4	31,4	31,8	34,3	38,0
France	6,3	9,3	9,5	9,6	10,2	11,3	12,3	12,8	11,5	13,4	23,0
Germany	2,8	5,2	6,0	7,0	8,3	8,4	9,2	10,7	12,3	12,4	18,0
Greece	4,5	7,1	7,2	7,4	8,4	8,3	8,5	9,8	11,6	15,1	18,0
Hungary	3,3	4,4	4,5	5,0	5,9	6,5	8,0	8,6	9,1	9,6	13,0
Ireland	1,7	2,4	2,8	3,1	3,6	4,0	5,2	5,6	6,7	7,2	16,0
Italy	5,8	5,1	5,1	5,5	5,5	6,9	8,6	9,8	11,5	13,5	17,0
Latvia	31,8	32,8	32,3	31,1	29,6	29,8	34,3	32,5	33,1	35,8	40,0
Lithuania	9,1	17,3	17,0	17,0	16,7	18,0	20,0	19,8	20,3	21,7	23,0
Luxembourg	1,0	0,9	1,4	1,5	1,7	1,8	1,9	2,9	2,9	3,1	11,0
Malta	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,4	1,4	10,0
Netherlands	1,6	1,8	2,1	2,3	3,0	3,2	4,0	3,7	4,3	4,5	14,0
Poland	4,5	7,0	7,0	7,0	7,0	7,9	8,8	9,3	10,4	11,0	15,0
Portugal	15,9	19,3	19,8	20,9	22,0	23,0	24,6	24,4	24,9	24,6	31,0
Romania	9,2	17,0	17,6	17,1	18,4	20,3	22,3	23,4	21,4	22,9	24,0
Slovenia	12,3	16,1	16,0	15,6	15,6	15,0	19,0	19,6	18,8	20,2	25,0

Slovakia	2,7	6,7	6,6	6,9	8,2	8,1	9,7	9,4	9,7	10,4	14,0
Spain	5,6	8,3	8,4	9,1	9,7	10,8	13,0	13,8	15,1	14,3	20,0
Sweden	30,9	38,7	40,4	42,4	43,9	45,0	47,7	47,9	46,8	51,0	49,0
United Kingdom	1,0	1,2	1,4	1,6	1,8	2,4	3,0	3,3	3,8	4,2	15,0

* Target for share of energy from renewable sources in gross final consumption of energy in 2020
Source: Own calculations based on Eurostat data and Directive 2009/28/EC of The European Parliament and of The Council 2009.

The (%) share of energy created from renewable sources (RES) in total energy consumption in particular countries of the European Union is very differentiated (Fig. 1, Table 2). In 2012 ten countries of the European Union already exceeded the 20% share of energy produced in RES in total energy consumption. They include: Austria, Denmark, Estonia, Finland, Latvia, Lithuania, Portugal, Romania, Slovenia, Sweden. These countries keep investing into RES increasing their share in energy production. Bulgaria and Croatia will achieve this goal soon. Unfortunately, many countries did not even exceeded 5% threshold of RES share in total consumption. These countries include: United Kingdom, the Netherlands. Luxembourg and Malta.

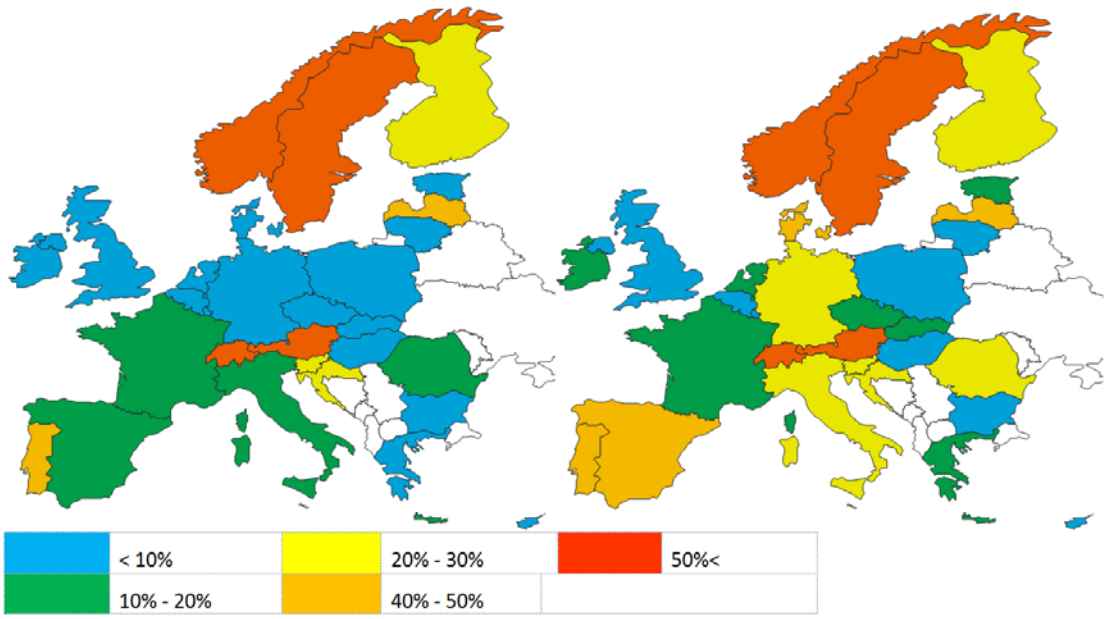


Fig 1. Share of energy from renewable sources in European countries in 1990 and 2013.

Source: Own calculations based on Eurostat data, 2014.

Installed power in the wind energy sector at the end of 2013 enabled the production of 257 TWh of electricity, which constituted 8% of the Union's consumption. The largest share of wind power in satisfying the demand for electricity among the member states of the European Union had: Denmark (33,8%), Portugal (24,6%), Spain (20,9%), Ireland (17,3%), Germany (7,9%) and United Kingdom (7,7%) (Wind in Power: 2013 European statistics, 2014).

In the European countries the level of wind power has been very dynamic for many years. The leaders are Germany, Spain, Great Britain, Italy and France (Table 3). An interesting fact is that Italy which has fairly poor wind conditions is high in the rank of electricity production from wind farms. Within the last few years wind power in Europe was the technology which recorded the highest annual increase of installed power among all technologies of electricity production (renewable and conventional ones). Only in 2011 and 2012 photovoltaic sector recorder a higher increase. At the end

of 2013 in Europe functioned wind farms of joint power of 121 474 MW. In comparison to the year 2012 the increase in power amounted 11 159 MW. There were 12 030 MW of wind power installed in Europe in 2012, where 11 159 MW took place in the European Union itself. Of 11 159 MW of installed power 9 592 MW constituted the one on land, the rest of it was situated on the sea. With reference to the highest power increase in 2013 Germany came first, 3 238 MW of wind power was installed there. Great Britain was second with 1 883 MW, before Poland with 894 MW. Next positions belonged to Sweden (724 MW), Romania (695 MW), Denmark (657 MW), France (631 MW) and Italy (444 MW) (Global Wind Report 2013).

Hydroenergy, constituting another element of the renewable energy market structure, is currently a leader among renewable energy resources in electricity production in the European Union. The total theoretical power potential of rivers flowing in Europe is estimated to be 1300 TWh a year (Gaudard & Romerio 2014). The biggest theoretical power potential of rivers among the EU countries possess: Italy, France, Sweden, Austria, Spain and Germany and the smallest one possess: Malta, Luxembourg, Denmark, Belgium and the Netherlands. The biggest real potential of technical hydroenergy resources which can be used exists in Sweden and France, and the smallest one in Malta, Luxembourg, Denmark, the Netherlands and Estonia. The power installed in hydroelectric plants constitutes 16% of the total power installed to produce electricity in the EU. The biggest share of its use can be observed in France, Sweden, Spain, Italy and Austria (Table 4).

Table 3. Power of wind power stations in the EU countries in 2005-2013 (MW)

Country	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
EU 27 (28 from 2012)	48027	48069	56517	64719	75090	84278	94352	106454	117289
Austria	819	965	982	995	995	1011	1084	1377	1684
Belgium	167	194	287	415	563	911	1078	1375	1651
Bulgaria	10	36	57	120	177	375	516	674	681
Croatia	-	-	-	-	-	-	-	180	302
Cyprus	0	0	0	0	0	82	134	147	147
Czech Republic	28	54	116	150	192	215	217	260	269
Denmark	3128	3136	3125	3163	3465	3752	3956	4162	4772
Estonia	32	32	59	78	142	149	184	269	280
Finland	82	86	110	143	147	197	199	288	448
France	757	1567	2454	3404	4574	5660	6807	7623	8254
Germany	18414	20622	22247	23903	25777	27214	29071	30989	33730
Greece	573	746	871	985	1087	1208	1634	1749	1865
Hungary	17	61	65	127	201	295	329	329	329
Ireland	495	746	795	1027	1310	1428	1614	1738	2037
Italy	1718	2123	2726	3736	4849	5797	6878	8118	8551
Latvia	27	27	27	27	28	31	48	60	62
Lithuania	6	48	51	54	91	154	179	263	279
Luxemburg	35	35	35	35	35	42	45	58	58
Malta	0	0	0	0	0	0	0	0	0
Netherlands	1219	1558	1747	2225	2215	2237	2272	2391	2693
Poland	83	153	276	544	725	1107	1616	2496	3390
Portugal	1022	1716	2150	2862	3535	3898	4379	4529	4724
Romania	1	3	8	11	14	462	982	1905	2599
Slovenia	0	0	0	0	0	0	0	0	2
Slovakia	5	5	5	3	3	3	3	3	3
Spain	10028	11623	15131	16689	19160	20676	21674	22784	22959
Sweden	509	571	788	1048	1560	2163	2899	3582	4470
United Kingdom	1332	1962	2406	2974	4245	5204	6556	8649	10531

Source: Own calculations based on Cumulative installed capacity per EU Member State 1988-2009, Wind in Power: 2011 European statistics and Wind in Power: 2013 European statistics

In majority of the EU countries there are no proper conditions to build solar power stations, heliothermal power stations and solar furnaces. However, in almost all of them there is a possibility of using solar energy to heat buildings, air-condition rooms and heat municipal water. The leading countries in this area are the ones somehow privileged due to their geographical location, i.e. Italy and Spain, but undoubtedly the leader in this case is Germany (Table 4).

Waters and geothermal energy are in Europe primarily used in heating - in central heating systems for rooms and preparing hot municipal water and individual installations, in recreation and balneation, in agriculture (for heating greenhouses, crops under aluminium foil cover and for soil heating). Moreover, also in a smaller extent in water farming - mainly fish, sometimes alga in industrial processes (among other drying and pasteurization) and sometimes for melting snow and ice from pavements and roads or heating runways at the airports. We retrieve carbon dioxide, table salt and other chemicals from geothermal waters. They are used in production of cosmetics or are bottled and treated as mineral and curative waters (Kępińska 2009). Geothermal heat resources in the EU are large. The most abundant in geothermal energy countries of the European Union include: Germany (temperatures in wells range from 20,0 to 115,0 ^{o}C, Italy (22-99 ^{o}C), France (24-76 ^{o}C), Hungary (45-150 ^{o}C), Poland, Greece (25-82 ^{o}C), Portugal (20-76 ^{o}C), Austria (20-96 ^{o}C), Great Britain (24-74 ^{o}C), Ireland (22,5 ^{o}C), Belgium (20-73 ^{o}C) and Denmark (46 ^{o}C) (Motowidlak 2010).

Table 4. Power installed in hydroenergy, geothermal energy, heat energy and photovoltaic solar energy and electricity production from biogas, biomass and municipal waste in the EU countries in 2012 and 2013

Country	**Solar thermal [MWth]**	**Hydroelectricity [MW] in 2012**	**Geothermal [MWth] in 2012**	**Photovoltaic [MWp]**	**Biogas [ktoe]**	**Municipal Waste [ktoe]**	**Solid biomass [Mtoe]**
Austria	3538,3	12 541	97,0	690,4	196,8	129,9	4,749
Belgium	374,2	1 427	7,0	2983,4	141,9	299,8	1,408
Bulgaria	58,5	3 129	3,5	1019,2	0,1	21,0	1,300
Croatia	98,4	2 139	37,2	21,7	18,0	-	0,700
Cyprus	476,8	0	-	34,8	12,0	-	0,005
Czech Republic	680,6	2 029	4,5	2132,8	571,1	82,9	2,293
Denmark	550,2	9	21,0	531,4	100,0	482,7	1,518
Estonia	5,5	8	-	0,2	7,2	-	1,067
Finland	32,5	3 003	-	11,2	59,5	193,5	8,117
France	1802,5	25 000	365,0	4697,6	465,0	1246,0	10,842
Germany	12055,4	11 185	171,0	36013,0	6716,8	2728,9	10,902
Greece	2914,8	3 236	104,9	2585,8	88,4	-	0,847
Hungary	137,3	56	714,0	15,4	82,2	40,7	1,454
Ireland	196,3	529	-	1,0	56,0	48,7	0,195
Italy	2590,0	21 752	778,7	17614,0	1815,4	827,6	7,452
Latvia	12,1	1 573	0,0	1,5	52,0	-	1,750
Lithuania	7,7	876	48,0	68,1	15,5	11,0	1,041
Luxemburg	27,4	1 132	-	100,0	12,8	17,0	0,055
Malta	35,0	0	-	24,7	0,0	1,0	0,001
Netherlands	615,6	37	39,0	665,0	302,8	855,3	1,118
Poland	1039,5	2 350	115,4	4,2	251,2	32,5	6,497
Portugal	716,8	5 711	27,8	281,0	65,3	96,7	2,347
Romania	110,2	6 455	176,0	1022,0	30,0	-	4,233
Slovenia	148,1	1 138	66,8	254,8	34,7	7,4	0,583
Slovakia	112,7	2 493	163,9	537,1	66,6	19,4	0,818
Spain	2238,2	13 280	22,3	4705,5	256,1	147,3	5,443
Sweden	341,6	16 411	48,0	43,1	136,6	753,9	9,211
United Kingdom	475,2	4 215	2,0	2739,3	1824,4	683,7	2,153

Source: Own calculations based on The State of Renewable Energies in Europe 2014.

In the recent years we can observe a distinct growth of biogas production in all the countries of the European Union. Currently the leaders in biogas production are Germany, Italy and Great Britain, which jointly produce over 70% of total biogas production in the EU.

Energy obtained from waste is not only a precious source of renewable energy, but also a very useful and cost-effective method of reducing the amount of municipal waste stored on garbage dumps. The amount of this waste is growing and it is more and more difficult to get rid of it, but it can be the same fuel as coal, gas or heating oil, which have to be bought, transported and earlier mined, and no mining process remains indifferent to the environment. Experience of the countries having long tradition and high technological culture show that it is not possible to collect and recycle more than 2/3 of the produced litter. The European leader in the field of recycling and composting which is Austria recycles in this way 70% of its litter, Germany: 62%, Belgium: 62%, Netherlands: 61%, Sweden: 50%. (Corselli-Nordblad 2010).

Biomass is the oldest and third as to the size in the world natural energy source. It includes both rubbish from households as well as remains after trimming urban greenery. As biomass is organic matter its resources are available on each continent. As an electricity source it is more reliable than solar or wind power. In addition, its resources may be stored and transported without posing any threat to the environment. The share of solid biomass (wood, agricultural, waste) in heat and electricity production in the European Union is growing. According to the EurObserv'ER (*The State of Renewable Energies in Europe 2014)* estimates production of primary energy in the EU was growing since the year 2000 yearly average by 4.7%, from the level of 52,5 Mtoe to 91,5 Mtoe in 2013. One-time production drop was recorded in 2011, due to unusually mild winter. In 2013 the solid biomass sector recorded annual production growth by 2.9 Mtoe.

Published in 2014 data indicate that the share of renewable energy sources constituted 14,1% of total energy consumption in the European Union countries in 2012. In comparison with the results from the years 2011 (13,0%), 2010 (12,5%) and 2004 (7.9%) it turns out that members of the community are near reaching the assumed goal - 20% in the year 2020.

3. CONCENTRATION OF RENEWABLE ENERGY MARKET

Concentration measures are numerical characteristics which are used to determine the distribution unevenness level of the examined feature. The concentration phenomena manifests in focusing a significant percentage value of the examined feature in a relatively small percentage of group units. The lack of concentration occurs when all units have the same value of the feature (Zeliaś 1991). A complex concentration index has been permanently sought after in the competition state research. This index would reflect not only the final number of subjects functioning on the market, but also their relative size. Until now, the only and best concentration measure has not been developed. Depending on the needs and data accessibility scientists use mainly the CR concentration index, the Herfindahl-Hirschman index of average concentration on the market, the Grossack index of concentration dynamics and the Gini concentration coefficient illustrated usually by the Lorenz curve (Devereux, Griffith & Simpson 2004). The Herfindahl- Hirschman index (HHI) is the most frequently used measure to analyze concentration on the energy market (Chuang et al., 2013). It is defined as the sum of market share squares and calculated according to the formula:

$$HHI = \sum_{i=1}^{n} u_i{}^2 \quad (1)$$

where u_i means value share of the examined feature for *i*-nth object in total value of the examined feature for all *n* analyzed units..

The HHI index takes the values from (1/n; 1) range, while the higher its value is, the stronger the competition is. According to recommendations of FERC (*Federal Energy Regulatory Commission*) in the USA the value of the index [8]:

- below 0,10 indicates lack of concentration,
- from 0,10 to 0,18 indicates fairly high concentration,
- above 0,18 indicates high concentration.

However, the use of concentration measures does not provide the full picture of energy market functioning as these measures do not include all information indispensible in full market analysis (Zawada 2009).

Analyzing the information presented in Table 5 we can state that only in case of two out of eight examined variables the HHI index is lower than 10% or oscillates around this value. Thus, we can think that there was no distinct concentration within the analyzed period for solid biomass and hydroelectricity. In case of municipal waste we can conclude that the concentration level was medium. For the remaining variables characteristic of the renewable energy sources market in the EU we can observe high concentration. It is worth stressing that the highest concentration is observed for geothermal energy and the energy using solar radiation in order to produce electricity (photovoltaic one). The concentration in case of wind power shows an evidently falling trend in the analyzed period.

Table 5. HHI concentration indexes for chosen variables characteristic of the renewable energy sources market in the EU countries in the years 2001-2013

Variable	**2001**	**2004**	**2007**	**2010**	**2013**
Hydroelectricity	0,1292	0,1154	0,1219	0,1110	0,1162
Geothermal	0,8448	0,8500	0,7924	0,7510	0,7231
Biogas	0,2272	0,2162	0,2696	0,2997	0,2995
Photovoltaic	0,4044	0,5979	0,6831	0,3625	0,2371
Solar thermal	0,1719	0,1859	0,1805	0,1672	0,3224
Municipal waste	0,1384	0,1432	0,1701	0,1487	0,1624
solid biomass	0,0845	0,0827	0,0915	0,0896	0,0875
wind	0,2490	0,2751	0,2286	0,1738	0,1337

Source: Own calculations based on Eurostat Data 2014.

4. SPATIAL CORRELATION

In the paper the authors attempt to examine a possible spatial autocorrelation among the EU countries in the scope of renewable energy sources. To measure autocorrelation in this grasp the authors used the Moran coefficient I expressed by the correlation (Ord & Getis 1995):

$$I = \frac{1}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \circ \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (2)$$

where:
w_{ij}- dependence weight among *i*-nth and *j*-nth country,
x_i, x_j - values of the examined feature,
$\bar{x}$ - average values of the examined feature.

The value of Moran statistics I is included in the range [-1,1] and it informs us about the kind of spatial correlations. A plus value indicates similarity of neighbouring spatial units with reference to the analyzed feature. A negative value indicates dispersion of the examined value feature.

Table 6. Evaluation values of Moran I statistics with reference to particular renewable energy sources (data for 2012)

Source: \ Approach:	distance		border		Distance and border	
	I	p	I	p	I	p
all	0,277	0,879	0,491	0,877	0,439	0,877
biomass	0,017	0,802	-0,021	0,793	-0,029	0,793
wood	0,039	0,836	-0,006	0,826	-0,048	0,826
solar	-0,186	0,688	-0,234	0,681	-0,183	0,681
geothermal	-0,132	0,626	-0,110	0,621	-0,048	0,621
biogas	-0,110	0,655	-0,115	0,649	-0,104	0,649
hydro	0,113	0,740	0,143	0,732	0,097	0,732
wind	-0,116	0,725	-0,151	0,717	-0,086	0,717
solar photovoltaic	0,215	0,415	-0,000	0,647	-0,000	0,641

Source: Own calculations based on Eurostat Data 2014.

In order to examine the occurrence of spatial (global) autocorrelation it is necessary to determine distance or neighbourhood array and weight array. In the present paper the array was created in three grasps: including length of boarders between neighbouring countries and combination of both these categories. The results are presented in Table 6.

The conducted research did not confirm the relevance of spatial correlation in shaping the level of particular renewable energy sources use in chosen European countries. What is more, frequent negative correlation indicates the systems of greater dispersion. Thus, we can presume, that in the scope of policy of using renewable energy sources European countries conduct separate policies. This may result from geographical conditionings as well as existing potential or investment capabilities.

5. TAXONOMIC ANALYSIS

The basic aim of multivariate comparative analysis (MCA) is ordering the set of objects described by certain diagnostic variables according to a defined criterion. Before the ordering begins it is necessary to know the division of diagnostic variables due to the nature they take. We distinguish the following variables: stimulants, destimulants and nominants Stimulants are variables whose high values are desirable from the point of view of the general nature of the examined phenomenon. Destimulants are variables whose values are undesirable from the point of view of the general nature of the examined phenomenon. Nominants are variables whose deviations from normal level are undesirable from the point of view of the general nature of the examined phenomenon (Młodak 2006).

The tool used for ordering objects in this way is the synthetic development measure (SDM) being a certain function aggregating partial information included in particular variables and determined for each object from their set. It is realized in three stages:

- The development model is determined of variables values : z_{01}, z_{02}, …, z_{0m}, where:

$z_{0j} = \max_i z_{ij}$, if j-nth variable is a stimulant,

$z_{0j} = \min_i z_{ij}$, if j-nth variable is a destimulant;

- Distance of each i-nth object from the model is determined by means of the following formula:

$$d_i = \sqrt{\frac{1}{m}\sum_{j=1}^{m}| z_{ij} - z_{oj} |^2} \quad (3)$$

where:

m – number of variables,

z_{ij} – value of *j*-nth diagnostic variable for *i*-nth object

The smaller the value of this measure is, the smaller the distance of the given object from the model is.

- So called relative taxonomic development measure is determined for each object:

$$z_i = 1 - \frac{d_i}{d_0}, \quad (4)$$

where: d_0-the norm ensuring taking by z_i values from the range <0,1>

$$d_0 = \bar{d} + 2S_d \quad (5)$$

S_d - standard deviation of d_i variable.

The closer to one the synthetic development measure is, the closer to the model the object is. Constructed in such a way synthetic development measure objectively determines changes undergoing in the examined sets of diagnostic variables. Its biggest advantage is the fact that in further analysis we just deal with one synthetic variable, which informs us on direction and the range of changes taking place in the process described by sets containing any number of diagnostic variables (Zawada, 2008).

In the research conducted in the present paper the objects are the EU's countries and diagnostic variables in turn are variables characteristic of renewable energy market in these countries, that is: power installed in hydroenergy, geothermal energy, heat and photovoltaic solar energy, as well as energy production from biogas, biomass and municipal waste, and the share (%) of energy produced from renewable sources (RES) in total energy consumption. These variables calculated for one resident create so called intensity indexes. Majority of multivariate statistical analysis methods may be applied only when values of all variables have the same measurement unit of similar order of magnitude. This happens because gathered input variables are usually expressed in different measurement units, they also have different variation areas, thus, it is impossible to perform direct mathematical operations on them or comparing them. Due to this fact normalization aims at unification of variables' measurement units and eliminating differentiation of variables with reference to their location and volatility for the examined group. Normalization of variables has been performed according to the following formula:

$$x_i' = \left(\frac{x_i - A}{B}\right)^p \qquad (i = 1, \ldots, n), \quad (6)$$

taking as A the average of each feature, as B standard deviation, and p=1. Thus, the most frequently applied normalization procedure has been used, which is known as standardization (Grabiański et al., 1989).

In the further analysis, conducting next stages of synthetic development measure creation, we obtained the rank of countries which is presented in Table 6.

Table 7. Results of linear classification of the EU countries regarding renewable energy market development in the years 2001-2012 on the basis of synthetic development measure value

Country	2001	2002	2004	2006	2008	2010	2012
Austria	2	1	3	1	1	2	3
Belgium	23	24	21	21	21	16	15
Bulgaria	26	26	26	25	25	24	24
Cyprus	11	11	11	12	11	13	12
Czech Republic	19	19	19	19	19	11	10
Denmark	4	4	4	4	5	8	9
Estonia	14	13	13	11	12	14	13
Finland	3	3	2	3	4	6	5
France	15	15	17	18	18	17	20
Germany	5	5	5	5	3	1	1
Greece	13	12	14	14	15	15	14
Hungary	21	21	23	23	22	22	23
Ireland	16	17	18	15	14	18	18
Italy	6	6	7	8	8	7	4
Latvia	10	8	8	7	10	10	11
Lithuania	20	18	20	20	20	21	22
Luxemburg	18	20	6	6	9	12	16
Netherlands	8	9	15	16	16	19	21
Poland	25	25	25	26	26	26	26
Portugal	9	10	10	10	6	5	6
Romania	24	22	22	22	23	25	25
Slovenia	22	23	24	24	24	23	17
Slovakia	12	14	12	13	13	9	8
Spain	7	7	9	9	7	4	7
Sweden	1	2	1	2	2	3	2
United Kingdom	17	16	16	17	17	20	19

Source: Own calculations based on Eurostat Data 2014.

Analysing information included in Table 7 we can observe that the most developed renewable energy market in the years 2001-2012 is characteristic of such countries as Austria, Germany, Sweden and Finland. The lowest value of the synthetic development measure - and what follows last places in the rank belong to Romania, Bulgaria, Poland, Slovenia and Hungary. The highest growth in the summary in the analyzed period achieved Belgium (from 23rd to 15th place) and the Czech Republic (from 19th place to 10th place), the biggest fall in turn concerns the Netherlands (from 9th to 21st place) and France (from 15th place to 20th place).

Grouping methods in turn aim at creating sets of elements similar one to another in some sense. Classical grouping methods only allow to associate unequivocally each element with one of the created groups. Within one group there are objects most similar one to another, and possibly different from object from other groups.

Too many of known in the literature grouping procedures do not allow to present them fully. However, it is worth mentioning here the most often applied group of taxonomic methods, namely agglomeration procedures. According to them subsequent groups of objects are created in a sequencing way through joining presently existing groups. Initially, each object constitutes a separate group, and the classification process finishes the moment when one group comprising all objects of the set is created.

The advantage of agglomeration methods is that they enable us to present classification results in a compact form with the use of dendrogram, which illustrates subsequent connection of groups of higher and higher order together with measures characterizing distances between individual groups.

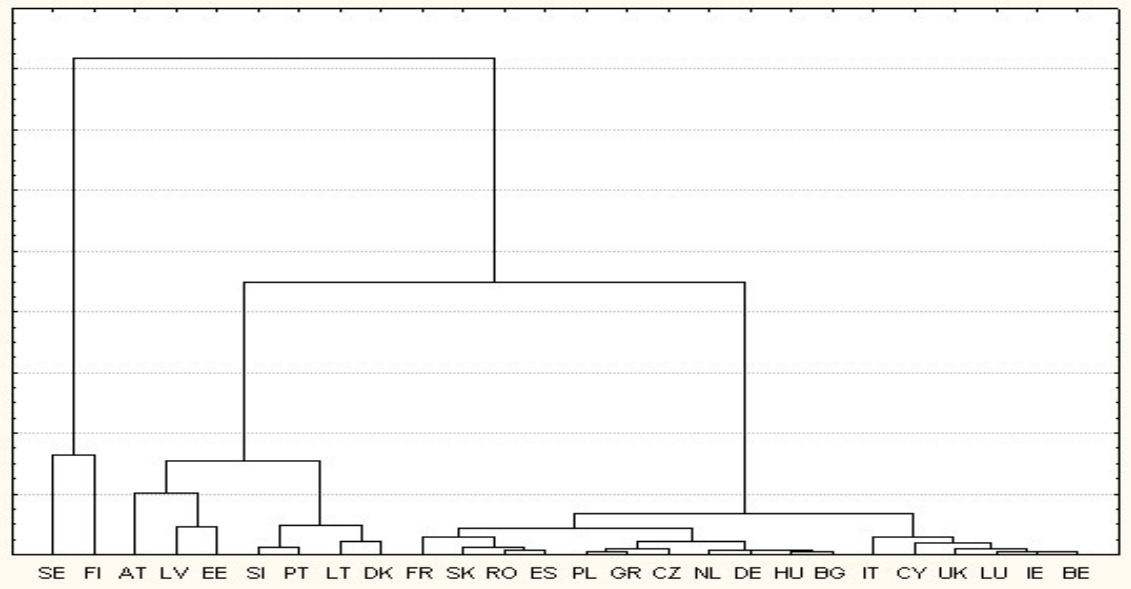


Figure 1. Dendrogram of similarities and differences among the countries analysed from the point of view of development of the power market in respect of renewable energy sources in 2001

where: AT - Austria, BE – Belgium, BG – Bulgaria, CY - Cyprus, CZ - Czech Republic, DK – Denmark, EE – Estonia, FI – Finland, FR- France, DE – Germany, GR – Greece, HU- Hungary, IE- Ireland, IT – Italy, LV – Latvia, LT – Lithuania, LU- Luxembourg, NL – Netherlands, PL – Poland, PT- Portugal, RO – Romania, SK – Slovakia, SI – Slovenia, ES – Spain, SE – Sweden, UK– United Kingdom.

Source: Own calculations

Complementation of the evaluation level of the European Union energy market development in the scope of energy coming from renewable resources is cluster analysis conducted with the use of agglomeration method of the nearest neighbourhood. This enabled us to present - in the form of a dendrogram - depiction of similarities and differences among analyzed countries (see Pictures 1 and 2).

In the year 2001 we can distinguish three distinct clusters of countries. The first one includes Sweden and Finland, the second one includes Austria, Latvia, Estonia as well as Slovenia, Portugal, Lithuania and Denmark. The third cluster constitute the remaining countries of the EU. Thus, we can state that the countries included in these clusters are closest one to another with reference to renewable energy industry development and at the same time they differ substantially from the countries which belong to the remaining groups.

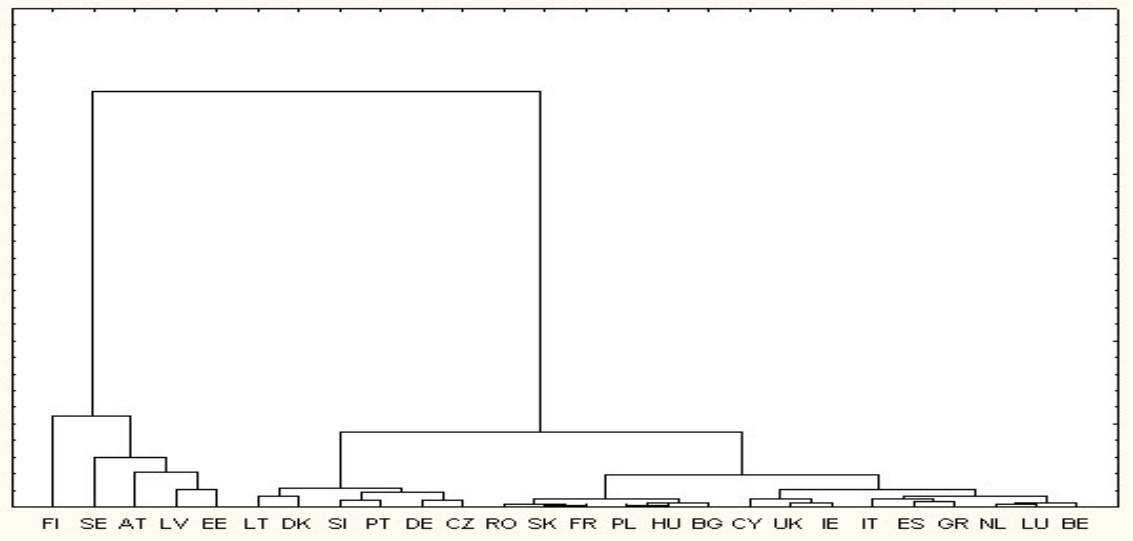


Figure 2. Dendrogram of similarities and differences among the countries analysed from the point of view of development of the energy market in respect of renewable energy sources in 2012

Source: Own calculations

In the year 2012 the structure of groups changed noticeably. Although it is still possible to observe three distinct clusters of countries, their composition is different. The first group includes now apart from Sweden and Finland also Austria, Latvia and Estonia. We can state then, that these countries "caught up with" the leaders through investments into development of renewable energy market. The second group comprises Lithuania, Denmark, Slovenia, Portugal (from the second group in 2001) and Germany and the Czech Republic, which 10 years earlier belonged to the third group.

CONCLUSIONS

On the basis of conducted calculations and analyses we can formulate the following conclusions::

- Energy industry sectors with reference to renewable energy sources of particular countries of the European Union, despite implementing principles of Community's common energy policy, differ as to the level of development. This differentiation results both from the specificity of economic development, population, climate as well as different strategies of investments into energy sources.
- We cannot confirm vital influence on the neighbouring ground in the scope of any unification of energy policy towards RES use.
- The share (%) of energy produced in renewable energy sources in the total consumption in the EU countries in 2012 varied from about 51% in Sweden to merely 1.4% in Malta.
- Currently, it is biomass (the share of which is supposed to grow) and water power that are the biggest renewable energy sources, but solar and wind energy sectors are characterized by the biggest annual growth rate.
- The European renewable energy market is highly concentrated. The exceptions are solid biomass and hydroelectricity.
- The most developed (against other EU countries) renewable energy market in the years 2001-2012 is a characteristic feature of such countries as Austria, Germany, Sweden and Finland. The least developed ones turned out to be the markets of Romania, Bulgaria, Poland, Slovenia and Hungary.

- The most similar countries in respect of renewable energy market development are Sweden and Finland as well as Austria, Latvia and Estonia.

After a noticeable improvement on the market in 2010, when a 30% increase of investments into renewable energy sources was recorded, year 2011 and the beginning of 2012 recorded a series of disturbing information concerning bankruptcies, smaller profits and employment reduction. Moreover, global indexes concerning clean technologies showed downward tendencies. However, despite the short demand drop and challenges connected with financing projects it is predicted that long-term perspectives for the clean technologies market will be positive.

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