RENEWABLE ENERGY IN THE SYSTEM OF SPATIAL PLANNING IN POLAND*

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Abstract

Global energy demand is continuously increasing and forces mankind to search for new sources of alternative energy, since conventional energy resources are depleting and the natural environment is faced with the ever-growing problem of their extraction. As a result, renewable energy sources, including geothermal energy, wind power, solar power, hydropower and biomass, are more and more frequently being heard of.

The European Union's requirement is that by 2020 the share of energy from renewable sources in the final gross domestic energy consumption in Poland will have reached 15%. Meeting this objective, however, requires the use of appropriate support systems that must be based on well-prepared planning.

Therefore, this publication aims to verify whether renewable energy sources are adequately prominent in the Polish system of spatial planning and whether the provisions on renewable energy sources set out in the Polish planning documents are sufficient to adapt Polish power industry to the European Union requirements.

Key words: renewable energy sources, spatial planning, Energy and Climate Package

Introduction

Spatial planning is a set of systematic, creative and decision-making activities, preceded by studies and analyses, based on scientific facts, related to the distribution of objects in a given planning space at different levels of detail (Bieda et al. 2012). These activities are aimed at efficient use of space, reconciling interests of its various users, as well as meeting social and economic objectives.

There is no doubt that most of the planned development activities are associated with energy consumption since global demand for energy is continuously increasing (Fig. 1).

Unfortunately, conventional energy sources used at such a fast rate are depleting and the natural environment is faced with the ever-growing problem of their extraction (Gonet et al. 2011). Their utilization also results in increasing environmental pollution. It forces mankind to look for methods to change the existing energy policy. One of the solutions is the Energy and Climate Package adopted by the European Parliament in December 2008. Its assumptions are that, by the year 2020, all member states of the European Union: will have reduced greenhouse gas emissions, will have increased the share of renewable energy, will have increased energy efficiency and the share of biofuels in total transport fuel consumption. Accordingly, it is estimated that the energy demand of the whole European Union will be decreasing over the next 30 years. Unfortunately, Poland's demand will continue to rise (Fig. 2).

As a result, with the growing demand for energy, the share of renewable energy sources, such as geothermal energy, wind power, solar power, hydropower and biomass, will also have to increase in Poland. From the obligations under the Energy and Climate Package, by 2020, Poland should gain 15% of

* This work is financed from funds science realized at AGH University of Science and Technology, allocated for the year 2017, no 11.11.150.006.
its energy from renewable sources (Direct 2009). The target share of renewable energy in the final gross energy consumption in 2020 in individual EU countries has been illustrated in Fig. 3.

**Fig. 1.** Primary energy consumption in the world, in the European Union and in Poland in the years 1965-2016. Source: own study based on (www.bp.com, access: 15.04.2017).

**Fig. 2.** Predicted primary energy consumption in the European Union and Poland by 2050. Source: own study based on (ec.europa.eu, access: 15.04.2017).

**Fig. 3.** Share of renewable energy produced in the individual European Union countries in the final gross energy consumption in 2005 and the target share of renewable energy in the final gross energy consumption in 2020. Source: own study based on (Direct 2009) and (Direct 2013).
Taking into account the current growth rate (Fig. 4), Poland shall not have a great problem to meet the objective set out in the Energy and Climate Package.

Fig. 4. Share of renewable energy in total primary energy supply in the European Union and in Poland in the years 2002-2014. Source: own study based on (stat.gov.pl, access: 15.04.2017).

Due to high investment costs, pursuit of the increased share of renewable energy sources in the country’s electrical energy generation balance requires the use of appropriate support systems, which guarantee their systematic development. This support must start with proper planning, therefore this publication aims to verify whether renewable energy sources are adequately prominent in the Polish system of spatial planning and whether the provisions on renewable energy sources set out in the Polish planning documents are sufficient to adapt Polish power industry to the EU requirements in 2020.

Renewable energy sources in Poland

Renewable energy is energy derived from natural, repetitive natural processes. Renewable energy sources are an alternative to traditional energy carriers (fossil fuels). Renewable resources replenish by natural processes and thus they may be treated as inexhaustible.

Renewable energy sources include renewable, non-fossil energy sources including wind power, solar power, aerothermal energy, geothermal energy, hydrothermal energy, hydropower, wave energy, energy of marine currents and tides, energy from biomass, biogas, agricultural biogas and bioliquids (Act 1991).

Spatial distribution of naturally occurring renewable energy sources in Poland (Fig. 5) allows to generate energy from a variety of sources in different regions of the country (Resolution 2011). The southern and northern parts of Poland are characterized by the best conditions for hydropower (Fig. 5a). The most favorable wind conditions occur in the northern part of the country and in the latitudinal lane of the central part of the country (Fig. 5c). The western part is characterized by the best geothermal conditions (Fig. 5b), whereas the eastern and middle parts - the best conditions for the development of solar energy (Fig. 5d).

Apparently, on land, the zones with the most favorable conditions for the development of specific types of renewable energy sources overlap only slightly, which creates favorable conditions for the development of distributed renewable energy generation for local or regional needs. They are supplemented by marine energy (Fig. 6), related to atmospheric and hydrological processes.

Wind and waves are environmental factors which can become renewable energy sources in the near, or in the distant future (Study 2015). Polish maritime areas are characterized by good wind resources with an even spatial distribution of energy and a rising tendency with increased distance from the shore. At present, due to lower parameters, energy resources from currents should not be considered as prospective.

Moreover, Poland can become a major producer of biomass energy due to the widespread availability of its sources. Biomass and its derivatives, such as biofuels (biogas and bioliquids), belong to relatively cheap renewable energy carriers.
Fig. 5. Renewable energy resources in Poland: a) hydropower, b) geothermal energy, c) wind power, d) solar power. Source: [RESOLUTION 2011].
Renewable energy sources in Polish planning documents

In Poland, spatial planning processes have a hierarchical nature, which is manifested by three levels of detail: national, regional and local (BIEDA et al. 2012). At all three levels, relevant planning documents are prepared. The most important of them are described in Table 1.

Table 1. Planning documents prepared in Poland.

<table>
<thead>
<tr>
<th>type of document</th>
<th>range</th>
<th>form of issuance</th>
<th>nature of document</th>
<th>main requirements</th>
<th>legal consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Spatial Development Concept of the Country</td>
<td>country</td>
<td>resolution of the Council of Ministers</td>
<td>obligatory</td>
<td>-</td>
<td>yes</td>
</tr>
<tr>
<td>land use plan for the province</td>
<td>province</td>
<td>resolution of the regional council</td>
<td>obligatory</td>
<td>consistent with the National Spatial Development Concept of the Country</td>
<td>yes</td>
</tr>
<tr>
<td>study of conditions and directions of spatial development of a commune</td>
<td>commune</td>
<td>resolution of the commune council</td>
<td>obligatory</td>
<td>consistent with the planning documents prepared at national and provincial levels</td>
<td>no</td>
</tr>
<tr>
<td>local land use plan for a commune or part of commune</td>
<td>commune or part of commune</td>
<td>resolution of the commune council</td>
<td>optional, although regulations for certain areas may make it obligatory</td>
<td>consistent with a study of conditions and directions of spatial development of a commune</td>
<td>yes</td>
</tr>
</tbody>
</table>

Source: own study based on (Act 2003).

In addition, in relation to maritime areas of internal waters, the territorial sea and the exclusive economic zone, pursuant to the Act on Maritime Areas and Maritime Administration of the Republic of Poland (Act 1991), a land use plan shall be drawn up for the internal sea waters, the territorial sea and the exclusive economic zone, or parts thereof.
Spatial planning at national level

According to the provisions of the National Spatial Development Concept of the Country (RESOLUTION 2011), the desired attributes of the Polish space in 2030 are competitiveness and innovation, abundance and biodiversity, security, internal cohesion and spatial order. In order to achieve this, the following objectives should be met:

1. Increased competitiveness of Poland’s major urban centers in the European space through their functional integration while preserving a polycentric structure of a settlement system, which facilitates cohesion.
2. Improved internal cohesion and territorial balanced development of the country by promoting functional integration, creating conditions for the distribution of development factors, multifunctional rural development, and utilizing the internal potential of all territories.
3. Improved territorial accessibility of the country in different spatial scales through developing transport and telecommunications infrastructure.
4. Shaping of spatial structures supporting the achievement and maintenance of high quality natural environment and landscape values of Poland.
5. Increased resilience of spatial structure to natural hazards and loss of energy security, as well as shaping spatial structures supporting the state’s defense abilities.
6. Restoration and consolidation of spatial order.

Determinants (Table 2) and justification for the implementation of detailed objectives (Fig. 7) are extensive, therefore they also include arguments for propagation of renewable energy sources. The need for development of infrastructure related to renewable energy sources is included in Objectives 2, 5 and 6.

Table 2. Determinants of spatial development of Poland related to renewable energy, according to the National Spatial Development Concept of the Country.

<table>
<thead>
<tr>
<th>type</th>
<th>detailing</th>
<th>solution related to renewable energy sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>political</td>
<td>insufficient level of energy security</td>
<td>diversification of raw materials for electricity generation as well as development and modernization of energy infrastructure</td>
</tr>
<tr>
<td>historical</td>
<td>main functions of rural areas</td>
<td>raised innovation and civilization level of rural areas by enhancing e.g. development of technical infrastructure</td>
</tr>
<tr>
<td>technological</td>
<td>development of energy-saving technologies</td>
<td>new technologies, which reduce the unit cost of their use, will allow to expand the spectrum of energy sources by e.g. solar energy</td>
</tr>
<tr>
<td></td>
<td>development of technologically-advanced power industry</td>
<td>development of technologies related to clean or low emission combustion of fuels such as biomass</td>
</tr>
<tr>
<td>natural</td>
<td>natural resources</td>
<td>renewable energy gain is important in the context of climate change; the main sources of renewable energy are wind and biomass; other sources, including surface waters, are marginal; barriers to the development of wind power; sudden changes in wind strength, a need to take into account airways of bird migration and protection of landscape values; energy generation from biomass is possible due to the widespread availability of its sources; low-temperature geothermal energy resources can be utilized mainly in heating engineering and tourism; specific zones with the most favorable conditions for the development of particular types of renewable energy sources overlap only slightly, which creates favorable conditions for the development of distributed energy generation.</td>
</tr>
</tbody>
</table>

Source: own study based on (RESOLUTION 2011).

2. Improved internal cohesion and territorial balanced development of the country by promoting functional integration, creating conditions for the distribution of development factors, multifunctional rural development, and utilizing the internal potential of all territories.

- 2.2. Regional functional integration, supporting the distribution of development processes to the areas outside main cities, and building potential for territorial specialization.
- 2.2.3. Spatial and functional integration of rural areas.

5. Increased resilience of spatial structure to natural hazards and loss of energy security, as well as shaping spatial structures supporting the state’s defense abilities.

- 5.1. Counteractions against a threat of loss of energy security and adequate reaction to such a threat.
- 5.1.6. Increased generation of renewable energy.

6. Restoration and consolidation of spatial order.

- 6.1. Introduction of integrated (coherent and hierarchical) socio-economic and spatial planning, capable of effective coordination of public entities’ activities, as well as public policies, which have the greatest influence on spatial development at various management levels.

Fig. 7. Objectives of the National Spatial Development Concept of the Country in relation to renewable energy.

Source: own study based on (RESOLUTION 2011).
First of all, attention was paid to spatial and functional integration of rural areas (Objective 2). It was assumed that one of the conditions for running business and a decisive factor regarding quality of life is availability of local energy infrastructure of an appropriate standard. Energy infrastructure in rural areas, transmission and distribution networks as well as connections of transmission networks between regions should be modernized, also to support dynamic development of using renewable energy sources.

Secondly, it was stated that counteractions against a threat of loss of energy security and adequate reaction to such a threat (Objective 5) is an essential element of the development policy and has a strong impact on the country’s spatial development. Adequate actions which are undertaken should be both of investment and planning character. Investments developing energy infrastructure should also increase the use of renewable energy sources. Their development zones at the country and provincial levels will be determined in spatial planning procedures. Directions of the actions aimed at Poland’s energy security, associated with renewable sources of energy, have been presented in Figure 8.

![Fig. 8. Directions of actions related to renewable energy sources, aimed at ensuring energy security of Poland. Source: (RESOLUTION 2011).](image)

The authors also came to a conclusion that introduction of planning for areas defined by their main functions is designed to facilitate the restoration and consolidation of spatial order in these areas (Objective 6). A specific type of a functional area is land at the contact zone between land and sea (Fig. 9). The National Spatial Development Concept of the Country recommends the introduction of combined maritime and coastal planning that will ensure adequate integration between them, including e.g. generation of renewable energy in these areas.

![Fig. 9. Special areas on a macroregional scale. Source: (RESOLUTION 2011).](image)
Spatial planning at the regional level

Poland does not have a maritime development plan yet, but currently a draft plan is subject to consultation. According to (ACT 1991), it will decide on:

a) intended use, including basic functions of maritime areas,
b) prohibitions or restrictions on the use of these areas, taking into account requirements of environmental protection,
c) distribution of public purpose investments,
d) development directions of transport and technical infrastructure,
e) areas and conditions of:
   - environmental protection and cultural heritage,
   - fisheries and aquaculture,
   - renewable energy generation,
   - exploration of mineral deposits and extraction of minerals from deposits.

The draft plan submitted for consultation takes into account a possibility of emergence of new, currently non-existing maritime functions. One of them is operation of wind farms (MATCZAK and PSUTY 2017). Their location is possible only after ensuring safety and efficiency of navigation and minimizing conflicts with other forms of marine space utilization (e.g. linear infrastructure, fisheries, national defense, tourism, extraction, etc.). In addition, analyses of the plan include a possibility of connecting offshore wind farms to the national power system. Fig. 10 presents the areas which are predisposed to the location of offshore wind farms.

![Fig. 10. Areas predisposed to the location of offshore wind farms. Source: (MATCZAK and PSUTY 2017).](image)

Due to the fact that the Act (1991) prohibits the construction and use of wind turbines on inland and territorial sea waters, the decisions locating them which have already been issued (Fig. 11) must omit the areas which are particularly useful for this purpose.

![Fig. 11. Decisions issued to locate offshore wind farms. Source: (MATCZAK and PSUTY 2017).](image)

As far as regional land development is concerned, land use plans for the provinces are binding. Since they are obligatory, each of the 16 Polish provinces has such a plan. Provisions regarding renewable
energy sources are implemented in these plans in different ways. Nevertheless, they always refer to the National Spatial Development Concept of the Country. Their authors always see a possibility to develop renewable energy in individual regions. Fig. 12 illustrates examples of graphic attachments defining renewable energy sources in selected provinces.

**a)**

- areas with the highest in the region biomass renewable energy potential
- areas with the highest in the region wind renewable energy potential
- areas with the highest in the region solar renewable energy potential
- areas with the highest in the region geothermal renewable energy potential

**b)**

- wind turbines
- agricultural biogas
- hydroelectric power plants
- potential hydroelectric power plants
- areas with wind technical potential > 600kMh/m²/year
- areas with wind technical potential of 400-600kMh/m²/year
- areas with favorable geothermal conditions
- areas with favorable conditions for the generation of energy from biomass
- areas with favorable conditions for the generation of energy from agricultural biogas

**Fig. 12.** Various cartographic methods to define renewable energy resources in the provinces: a) Mazovia Province, b) Province of Silesia. *Source: *Resolution 2014* and *Resolution 2016*. 

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Provisions on renewable energy sources in planning documents prepared at regional levels may be less (Fig. 12a) or more (Fig. 12b) detailed. However, they must always be included in the local spatial planning and the areas intended for renewable energy investments must be specified in great detail.

Spatial planning at the local level

If a commune is to indicate areas intended for the location of renewable energy generation equipment with a capacity exceeding 100 kW, as well as their protection zones related to restrictions on development, management and use of the site, then the study of conditions and directions of spatial development in a commune should provide for their specific location (ACT 2003). Similarly, as in the case of provincial plans, these provisions are variously implemented in practice (Fig. 13).

a) – areas for energy generation using photovoltaic cells

b) – existing wind farms

– boundaries of the locations of renewable energy generation equipment with a capacity exceeding 100 kW, with their protection zones
c) – areas where renewable energy generation equipment with a capacity exceeding 100 kW will be located, where it is allowed to locate sources converting solar energy

**Fig. 13.** Various cartographic methods to identify renewable energy sources in communes: a) town of Bukowno, Olkusz district, Małopolska Province, b) commune of Kłodawa, Koło district, Wielkopolska Province, c) municipality of Suwałki, Suwałki district, Podlasie Province. *Source: (RESOLUTION 2013), (RESOLUTION 2016) and (RESOLUTION 2016).*

Moreover, if the local plan provides for a possibility to locate buildings in specific areas, then it is also allowed to locate wind energy generating equipment in this area (ACT 2003). This installation, however, can not have a capacity greater than 40 kW and it can not be connected to a power grid with a rated voltage higher than 110 kV, or a combined heat output of no more than 120 kW (ACT 2015).

The legislation does not mention anything about the necessity to include provisions regarding the so-called micro-installations (with the parameters mentioned above) in the planning documents, which would be related to other renewable energy sources. This means that they can be established, unless the local land use plan prohibits their construction, or restricts it otherwise.

**Current utilization status of renewable energy sources in Poland**

The use of renewable energy sources in Poland is gradually increasing. Over the past 10 years, the amount of renewable energy generated has increased more than eightfold (from around 1,000 MW in 2005 to almost 8500 MW in 2015). A graph in Fig. 14 illustrates this very well-defined trend.

**Fig. 14.** Energy produced in Poland from renewable sources in 2005-2016. *Source: own study based on (www.ure.gov.pl, access: 15.04.2017).*
Over the years, the share of specific renewable energy sources in overall renewable energy generation has been changing. The amount of energy generated in hydroelectric power plants has remained almost constant. On the other hand, the amount of energy generated from other sources has been increasing. At present, most of renewable energy is generated from wind power. Solar power is the least used (cf. Table 3).

### Table 3. Number and capacity of renewable energy installations – as of 31.12.2016.

<table>
<thead>
<tr>
<th>Type</th>
<th>Number of installations</th>
<th>Capacity [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biogas power plants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>generating power from biogas from sewage treatment plants</td>
<td>301</td>
<td>233.967</td>
</tr>
<tr>
<td>generating power from agricultural biogas</td>
<td>107</td>
<td>66.110</td>
</tr>
<tr>
<td>generating power from landfill biogas</td>
<td>95</td>
<td>103.234</td>
</tr>
<tr>
<td>generating power from mixed biogas</td>
<td>97</td>
<td>62.919</td>
</tr>
<tr>
<td><strong>Biomass power plants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>generating power from mixed biomass</td>
<td>41</td>
<td>1281.065</td>
</tr>
<tr>
<td>generating power from biomass from forest, agricultural and garden waste</td>
<td>20</td>
<td>1116.448</td>
</tr>
<tr>
<td>generating power from biomass from wood-based and cellulose-paper industrial waste</td>
<td>17</td>
<td>28.517</td>
</tr>
<tr>
<td><strong>Solar power plants</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind power plants</td>
<td>473</td>
<td>99.098</td>
</tr>
<tr>
<td><strong>Hydroelectric power plants</strong></td>
<td>1193</td>
<td>5807.416</td>
</tr>
<tr>
<td>ROR hydroelectric power plant with a capacity of up to 0.3 MW</td>
<td>583</td>
<td>44.627</td>
</tr>
<tr>
<td>ROR hydroelectric power plant with a capacity of up to 1 MW</td>
<td>97</td>
<td>58.703</td>
</tr>
<tr>
<td>ROR hydroelectric power plant with a capacity of up to 5 MW</td>
<td>66</td>
<td>158.555</td>
</tr>
<tr>
<td>ROR hydroelectric power plant with a capacity of up to 10 MW</td>
<td>5</td>
<td>38.466</td>
</tr>
<tr>
<td>ROR hydroelectric power plant with a capacity exceeding 10 MW</td>
<td>7</td>
<td>310.964</td>
</tr>
<tr>
<td>Pumped-storage hydroelectric power plants or ROR hydroelectric power plants with pumped storage</td>
<td>3</td>
<td>382.680</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2769</td>
<td>8415.541</td>
</tr>
</tbody>
</table>


Most solar power plants are located in the south of the country. In the north, wind power plants predominate (cf. Fig. 15). This trend is consistent with the directions described in the National Spatial Development Concept of the Country. This is obviously a natural effect of distribution of renewable energy sources in Poland.

![Fig. 15. Energy obtained from renewable sources in individual provinces – as of 31.12.2016; pie charts – number of installations, cartogram - total capacity of installations [MW]. Source: own study based on [www.ure.gov.pl](http://www.ure.gov.pl), access: 15.04.2017.](image-url)
illustrates the number of installations related to renewable energy gain in individual districts (Fig. 16a), their total capacity (Fig. 16b) and average capacity (Fig. 16c).

![Energy gained from renewable sources in individual districts](image)

*Fig. 16. Energy gained from renewable sources in individual districts - as of 31.12.2016: a) number of installations, b) total capacity of all installations [MW], c) average capacity of all installations [MW]. Source: own study based on (www.ure.gov.pl, access: 15.04.2017).*

Fig. 16 demonstrates that most installations for renewable energy gain are located in central and northern Poland. They also provide the most power. However, there are also a few individual power stations in the south that provide the same amount of energy as several power plants located in other parts of the country.

**Conclusions**

In conclusion, it should be noted that:

1. Provisions regarding renewable energy sources and energy gain are contained in the Polish planning documents, created at all levels of detail (national, regional and local).
2. In the future, as a result of the planned activities, Poland is to withstand various threats related to energy security. The country shall gradually become independent of petroleum. Although coal will remain as the main fuel for power generation, its role as a primary source of energy will continue to decline. In addition, due to the demand for biomass, the structure of land management will gradually change. The use of marine energy can also change the landscape.
3. Wind, biomass, biogas and geothermal energy were declared in the planning documents to be the most important sources of renewable energy in Poland. Hydroelectricity was also considered to have a great potential. Due to climatic conditions, solar energy was claimed to be the least important source of renewable energy.
4. Geothermal energy is the energy accumulated in soil, rocks and liquids filling pores and rock gaps (ŚLIWA et al. 2016). It seems that despite recognizing geothermal energy to be one of the key renewable energy sources in Poland, it has not yet been widely used, since access to it is by far more difficult than in the case of other sources.

5. Polish normative acts regarding spatial planning and renewable energy sources give great freedom to build the so-called micro-installations for generating energy from renewable sources. Besides wind energy generating devices, they can be constructed without restrictions on all developed areas, unless such restrictions will be introduced at the local level.

6. Although the provisions of the Polish planning documents are frequently very general, and those concerning the whole country or regions do not have to be implemented literally, the existing planning documents and the actual renewable energy installations are concurrent. Most of the wind farms are located in the north of the country, and installations that generate energy from solar radiation predominate in the south. Their total capacity, however, is small.

7. The lack of standardized denotations for renewable energy sources in planning documents, even at the same level of detail, results in renewable energy installations being recorded in various ways, sometimes very laconically.

8. The use of renewable energy sources in Poland is steadily increasing. Over the past 10 years, the amount of energy generated from renewable sources has increased more than eightfold. What is important, despite the increase in energy demand, the share of renewable energy in the country’s energy gain has also changed significantly: from about 5% in 2005, to about 12% in 2015. Pursuant to (Directive 2001), by 2020, renewable energy gain should account for 15% of the country’s energy generation.

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