THE STATE OF DIFFERENT TYPES OF RENEWABLE ENERGY SOURCES IN POLAND

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Abstract
Poland's economy relies on energy derived from fossil fuels, which are subject to depletion and whose extraction and use have been linked to adverse environmental impacts. It is therefore vital to take notice of renewable energy sources (RES), which include wind, solar, hydro, wave & tidal, geothermal, biomass, biogas, and liquid biofuel energy. Poland's geography allows the use of wind, solar, hydro and biomass energy. Natural gas is viewed as a "bridge" in a transition towards RES-based energy generation, and especially such non-conventional sources as shale gas, whose prospecting is currently under way in Poland. This article discusses the state of various types of renewable energy sources in Poland.

Keywords: renewable energy, biogas, wind energy, photovoltaics, shale gas

JEL Classification: O1, O13, O33, Q42, Q47

Introduction

Poland's energy policy is largely influenced by the requirements imposed by the European Union. Much of EU legislation has been transposed into the Polish national law in conformity with Poland's obligations as a member state. The country is struggling to cope with a number of other challenges that are specific for the energy industry. Expected to comply with EU regulations and adjust to changing economic conditions, the energy sector requires modifications which include energy demand and the development of the overall fuel and energy generation and transportation infrastructure. One should also emphasize the need to diversify energy sources to ensure that Poland becomes more independent of out-of-country supplies of natural gas and oil.

Rather than an option for boosting the world's economy, green energy has become a necessity. Changes in the energy generation system irreversibly affect the types of fuels that are being acquired. As a member state of the European community, Poland is obliged to adopt such changes. As coal deposits in the ground run out, its extraction becomes increasingly less profitable. According to the 2016 data from the International Energy

Agency (IEA), many Polish power plants have grown obsolete and are harming the environment. More than 62% of the country's coal-fired power plants have been operated for more than three decades [IEA 2017]. In 2013, Poland imported PLN 76 billion worth of fuel, of which fuel from Russia accounted for ca. 60 billion. In 2014, fuel imports fell to PLN 54 billion, due mainly to global declines in crude oil, gas and coal prices [CSO, 2016a]. It is therefore essential to diversify energy sources by promoting the growth of the local domestic market to ensure the largest possible independence of conventional fuel imports in an uncertain global economic and political circumstances.

In 2004, having ratified the Kyoto Protocol and as a member of the European Community, Poland committed to increasing the share of renewables in its energy mix. By 2020, Poland's share of renewables and green energy consumption is expected to rise to at least 15% of its gross final energy consumption[*]. In addition to the gross final consumption of energy from renewables in overall power generation (25%), other targets apply such as the share of the gross final consumption of energy from renewable sources in the overall energy consumption in transportation (21%) as well as the heating and cooling sectors (54%) [Ministry of Environment, 2010]. Should Poland fall short of the targets laid down in Directive 2009/28/EC, it will be forced to either transfer statistical green energy from other EU member states which have produced excess renewable energy or face sanctions and monetary penalties for violating its EU obligations.

The gross consumption of renewable energy between Poland's accession to the European Union and 2015 rose by the annual average of 5% [CSO, 2016b]. Notably, the fastest growth in such consumption was observed between 2007 and 2008. The trend leveled off between 2008 and 2013 and subsequently declined in 2014. These tendencies reflect trends in politics and a change of the government's views on renewable energy sources. The big question is whether Poland will succeed in attaining the 15% RES share target by 2020, as required under Directive 2009/28/EC. If the current pace of growth is maintained, achieving the target may become problematic. While data trends since 2005 suggest the objective is achievable, an extrapolation of the trend seen in the last three years (2013 – 2015) shows that Poland will fall short at a 12.5% share. One major problem is the transportation fuel sector which has lately shown declines due to the need to withdraw first generation fuels from market while experiencing problems in its transition to second generation fuels [Schnell, 2016]. In 2015, the share of renewable energy sources in transportation amounted to 6.33% [CSO, 2016a], i.e. a half of the desired 14% share of RES in transportation by 2020. RES energy comes from sustainable natural processes that produce renewable non-fossil sources of energy. Such sources include wind, solar, hydro, marine wave, tidal & sea current, geothermal, biomass, biogas and liquid biofuel energy. Poland's geography makes the country suitable for harnessing wind, solar, hydro and biomass energy sources.

The aim of this article is to outline the current state of a range of renewable energy sources as well as shale gas in Poland.

Biogas production

The current regulations on biogas plants were adopted by amendments to the Renewable Energy Sources Act which took effect on July 1, 2016. The law created excellent

[*] The ratio of the gross final consumption of energy from renewable sources to the gross consumption of energy from all sources, expressed as a percentage (%).

opportunities for the development of biogas plants. First and foremost, biogas plants have been classified as "stable RES" and therefore ones eligible for support, which has been provided for the related installations [Act, 2015]. The new laws not only encourage new investors to build biogas plants but also support existing facilities. Support will be extended especially to agricultural biogas plants which were brought to the brink of bankruptcy by the protracted delay in the adoption of the new Act and due to continuous declines in the value of green certificates.

As for new RES projects, an auction system has been envisioned with separate auction categories for each source, including agricultural biogas plants.

Poland's biogas production relies on three types of installations: agricultural biogas plants, biogas generation installations in waste-water-treatment plants and biogas installations in landfills. The type that is missing is biogas plants that produce biogas for municipal use, as for instance in Sweden where biodegradable municipal waste delivered to municipal biogas plants is used to produce biogas which then fuels city buses and/or public buildings [Hung and Solli, 2012].

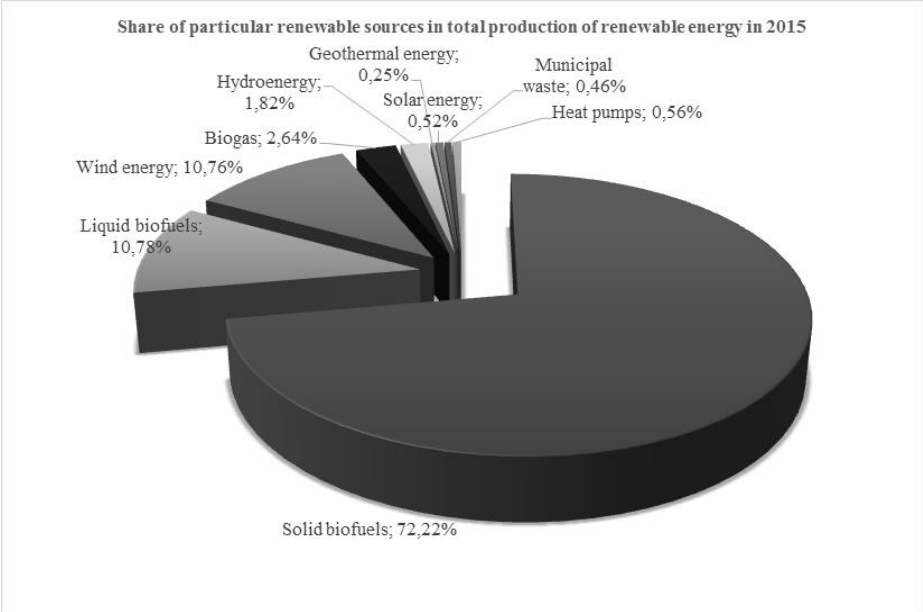
The current condition, potential and perspectives of biogas facilities in Poland have been described by Igliński, Buczkowski and Cichosz [2015]. The technical potential for biogas generation in Poland using various substrates is to produce 82 million cubic meters of biogas from municipal waste, 20 million cubic meters from sewage sludge, 1603 million cubic meters from animal droppings, 551 million cubic meters from maize and 254 million cubic meters of biogas from grass. This brings the total energy obtainable from biogas to 39.44 PJ. Once tapped, the biogas potential would help meet 7.5% of energy demand. The external cost of Poland's biogas energy sector is considerably lower than those of coal. In addition, biogas enjoys more support from local communities and methane fermentation resources are widely available all across the country.

The potential for producing biogas from agricultural waste in rural plants in Poland has been described by Muradin and Foltynowicz [2015]. According to the Energy Regulatory Authority (data as of December 31, 2016), Poland was home to 301 biogas facilities with the combined installed capacity of 233.967 MW. 107 of these operated within waste-water-treatment plants (66.11 MW), 97 in landfills (62.92 MW), and 95 as agricultural biogas plants (103.234 MW) [Energy Regulatory Authority, 2017].

An overview of the three most recent reporting years (2013 – 2015) shows a slight increase in biogas production in waste-water-treatment plants and landfills and a substantial rise in agricultural biogas production [CSO, 2015]. Changes are also observed in the proportions of the individual biogas types used to produce energy. The share of agricultural biogas has been noted to rise from 31% in 2013 to 45% two years later.

Although relatively slow, increases in biogas-based energy production are nevertheless steady. The overall production includes biogas from waste-water-treatment plants, landfills and farms. In 2015, the total electricity produced with the use of biogas amounted to 906 GWh. A breakdown of energy production by renewable energy source in Poland in 2015 is provided in Graph no. 1. The biggest growth was seen in agricultural biogas. This is due to a limited number of biogas production and use installations that can be established in waste-water-treatment plants and landfills. Their potential overall output depends on their number and capacities. On the contrary, the available agricultural biogas potential is harnessed only partially with considerable room for growth still remaining.

Graph no. 1: Share of particular sources in total production of renewable energy in 2015



Source: CSO (Chief Statistical Office), 2016, Renewable Energy in 2015. Department of Statistical Publishing, Warsaw.

Wind energy

In deciding to invest in wind farms, it is critical to define the kind of wind energy generation: will it be a small autonomous power plant with a capacity of up to dozens of kW (connected to isolated grids within households or manufacturing companies) a wind farm with a capacity of hundreds of kW to several MW (connected to the national grid). The project aim will determine the size of equipment whereas its technical specifications will affect further project factors which may be legal, environmental, economic and social.

The key variable determining the development of wind power in a given geographic area is wind speed patterns. The problem faced by prospective investors in selecting their sites is the lack of publically available information on wind characteristics in many parts of the country. The Institute for Meteorology and Water Management has assessed windiness in Poland. Measurements were taken in approximately 60 weather stations. Their results were used to make wind observation maps for Poland (Fig. 1.). Such maps show that roughly 60% of Poland's area offers favorable wind conditions that are sufficient for the use of wind as a renewable energy source. Particularly advantageous are areas in which the annual average wind velocity amounts to 5 m/s or more. These include the Baltic Sea coast and, in

particular, its northernmost part in Koszalin and Hel, as well as the Suwałki Region, central Wielkopolska, Mazovia and Bieszczady. Poland's existing wind farms are located mainly in the Pomeranian, West Pomeranian, Warmian-Mazurian and Wielkopolska Regions. According to the ERA [Energy Regulatory Authority, 2016], 1078,034 MW of wind energy was installed in Poland in 2016, whereas the total installed capacity as of June 30, 2016 was 5 660.070 MW.

In 2014, the rise of wind power plants in Poland slowed down considerably affected by a collapse of the "green certificate" market, which contributed a portion of revenues from the sale of certificates of origin. In the first half of 2016, a major increase was seen in installed wind power. This rise was driven by the enactment of the Wind Power Act of July 2016 [Act, 2016] which imposed restrictions on wind power facility locations in Poland, prompting investors to rush to complete ongoing projects.

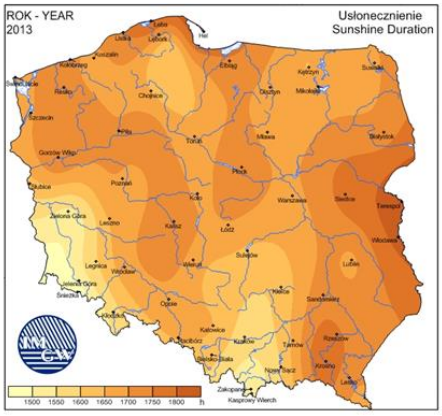


Figure no. 1: Sunshine duration zones in Poland

Source: *Lorenc, 2005*

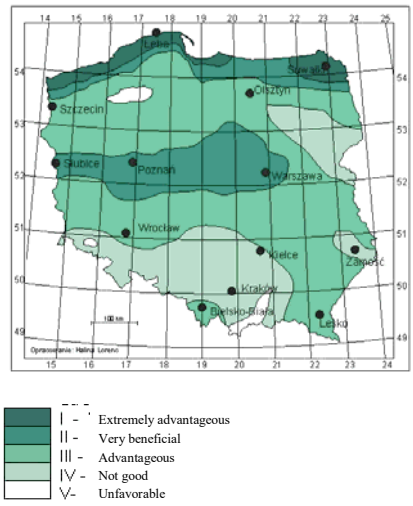


Figure no. 2: Wind power zones in Poland

Source: Lorenc, 1996

Photovoltaic energy

Compared to wind power, solar energy remains largely unutilized in Poland. Solar radiation varies widely throughout the year with 80% of total solar radiation being available between April and September. The average annual sunshine is 1600h/year. The most sunshine is available in the Wielkopolska and Lubuskie Regions (Fig.2.) whereas the operating conditions for equipment solar radiation in Poland range from 250 to 950 kWh/km^2.

By 2020, the Ministry of Energy plans to increase the number of installed solar energy capacity in Poland several times not only to comply with Directive 2009/28/EC but also to strengthen the country's energy security. The current capacity of solar power plants is 92.820 MW (as of June 30, 2016), compared to a mere 0.033 MW in 2010 [Energy Regulatory Authority, 2016]. After the adoption of power supply level 20 in the summer of

2015, Polskie Sieci Energetyczne (Polish Power Grids) published a "*report on threats to energy security and energy supplies"* which emphasized the significance of photovoltaic installations for such security. Furthermore, according to the Polish Photovoltaics Association, the number of prosumers in Poland is growing continually. Home photovoltaic facilities have more than 62 MW of installed capacity. Most of that capacity was added in the first half of 2016 [Polish Photovoltaics Association, 2016] before the President of Poland signed the amended Renewable Energy Sources Act. The current law adopts the term prosumer and defines rules for paying micro installations with a capacity of up to 40 kW [Act, 2016].

Shale gas

Well extraction of non-conventional hydrocarbon deposits is a sector of the extraction industry that exerts a substantial impact on the environment. It is therefore only logical to search for alternative solutions and technologies that will be less environmentally harmful. Natural gas is the only fossil fuel viewed as a viable "bridge" in the transition towards a future RES-based energy industry. This is because of the emissions released in burning gas to generate energy are considerably below those for other fossil fuels [Bocianowski, 2016]. Another argument are synergies with RES-based energy generation systems allowing to use gas-fuelled power generators to rapidly stabilize grids (compared to other electricity generation systems such as coal-fired) during times in which wind or photovoltaic energy proves insufficient to meet current demand. The 21st century was proclaimed to be "the Golden Age of gas". Poland's natural gas deposits are relatively meager forcing it to import substantial volumes of this fossil fuel. The discovery and extraction of shale gas in the United States made the country independent of imports. Next to another non-conventional fuel, i.e. methane from coal deposits, shale gas forms a part of the governmental project of Strategy for Responsible Growth. Poland is only starting to prospect for shale gas deposits. According to the Polish Geological Survey, a much valued and searched for type of Polish shale is Ordovican and Silurian, which occur in the north, east and south-east of the country [Kiersnowski and Dyrka, 2013]. In the timeline of events associated with releases of information on Poland's local shale gas deposits, the first approximate calculation was provided by the Energy Information Agency (EIA) at the US Department of Energy, which put the total at 5.3 billion cubic meters [EIA, 2011]. Correlated with estimates of national consumption, as quoted at the time by the Ministry of Energy (15.0 billion cubic meters in 2014), such an amount of natural gas would satisfy domestic demand for approximately 300 years [Ministry of Energy, 2015] . However, Polish experts have pointed out certain flaws in the precepts adopted for the EIA Report. Scientists from the State Geological Survey estimated the possible shale gas resources at 346-768 billion cubic meters [Kiersnowski and Dyrka, 2013]. Such an amount would render Poland independent of gas imports for approximately 20-50 years. Unfortunately, prospecting work and production tests designed to estimate Poland's actual shale gas deposits, especially those that hold the biggest promise of being utilizable in real life, have since ground to a halt.

Conclusions

1. If the current long-term global rising trends in medium-term energy demand remain unchanged, global deposits of non-conventional fossil fuels are bound to be depleted.
2. The extraction and use of fossil fuels has an adverse environmental impact.
3. RES are the future for the people, the economy and the environment.

4. Poland's geography makes the country well suited for harnessing wind, solar, hydro and biomass energy.
5. Despite many challenges, power co-generation from biogas is becoming increasingly more significant in Poland. Recent years saw the biggest increases in the number of agricultural biogas power plans.
6. The Wind Energy Act of 2016 imposed restrictions on the location of facilities that rely on such technologies in Poland, hampering the development of the RES subsector.
7. Further growth of photovoltaics requires an increased environmental awareness among Poland's population, the development of energy storage technology and increases in the efficiency of photovoltaic installations.
8. If the current long-term global rising trends in medium-term energy demand remain unchanged, global deposits of non-conventional fossil fuels are bound to be depleted.
9. The extraction and use of fossil fuels has an adverse environmental impact.
10. RES are the future for the people, the economy and the environment.
11. Poland's geography makes the country well suited for harnessing wind, solar, hydro and biomass energy.
12. Despite many challenges, power co-generation from biogas is becoming increasingly more significant in Poland. Recent years saw the biggest increases in the number of agricultural biogas power plans.
13. The Wind Energy Act of 2016 imposed restrictions on the location of facilities that rely on such technologies in Poland, hampering the development of the RES subsector.
14. Further growth of photovoltaics requires an increased environmental awareness among Poland's population, the development of energy storage technology and increases in the efficiency of photovoltaic installations.
15. Own non-conventional gas resources are mainly significant for energy independence. Domestically-generated energy designed to stimulate the growth of industry is expected to trigger the growth of the entire country.
16. Given the extraction technologies suited to Poland's geology and solutions that reduce environmental impacts, shale gas appears to be a significant energy resource that can be viably utilized in the future.

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