JOURNAL OF SECURITY AND SUSTAINABILITY ISSUES
ISSN 2029-7017 print/ISSN 2029-7025 online
2023 Volume 13
https://doi.org/10.47459/jssi.2023.13.35

SUSTAINABLE DEVELOPMENT OF THE REGION – BIOMASS POTENTIAL ON EXAMPLE OF THE WEST POMERANIAN REGION

Marcin Rabe[1], Tomasz Norek[2], Katarzyna Widera[3], Andrzej Gawlik[4], Agnieszka Łopatka[5], Ewelina Gutowska[6]

[1]The Institute of Management, University of Szczecin, Poland
[2]The Institute of Spatial Management and Socio-Economic Geography, University of Szczecin, Poland
[3] Faculty of Economics and Management, Opole University of Technology, Poland
[4] Faculty of Environmental Management and Agriculture, West Pomeranian University of Technology in Szczecin, Poland
[5] Institute of Economics and Finance, University of Szczecin, Poland
[6] Faculty of Economics, The Jacob of Paradies University in Gorzów Wielkopolski, Poland;

E-mails: [1] marcin.rabe@usz.edu.pl; [2]tomasz.norek@usz.edu.pl; [3]k.widera@po.edu.pl; [4]andrzej.gawlik@zut.edu.pl; [5]agnieszka.lopatka@usz.edu.pl; [6]egutowska@ajp.edu.pl

Received 18 July 2023, accepted 14 Decemeber 2023, published December 30 2023

Abstract. This article attempts to identify and analyze the factors influencing the shaping of regional energy policy in the West Pomeranian Voivodeship, with particular emphasis on the potential for the development of renewable energy based on biomass. The aim of the publication is to determine the potential for the development of biomass resources, taking into account the criteria of sustainable development, i.e. economic, ecological and social aspects. So far, few researchers have dealt with this subject in a comprehensive way, and so far there has been a lack of detailed research on the potential of biomass in the West Pomeranian Region. The presented analyses are an important contribution to the development of knowledge about alternative energy sources in the energy sector. The research material used in the article comes from various sources, both domestic and foreign, including empirical data from scientific institutes of energy and fuels and regional institutions dealing with energy.

Keywords: Renewable Energy; Biomass; Region; Sustainable Development

Reference to this paper should be made as follows: Rabe, M., Norek, T., Widera, K., Gawlik, A., Łopatka, A., Gutowska, E. 2023. Sustainable development of the region – biomass potential on example of the west Pomeranian region. *Journal of Security and Sustainability Issues*, 13, 337-344. https://doi.org/10.47459/jssi.2023.13.35

JEL Classifications: O2, O38

1. Introduction

Polish's energy policy is an integral element of the management system of the country's development process, based on the Long-Term National Development Strategy, the Medium-Term National Development Strategy and nine Integrated Strategies. The main objective of this policy is to create the conditions conducive to steady and sustainable progress in the energy sector. This progress is expected to contribute to the growth of the national economy, ensure the country's energy security and meet the energy needs of enterprises and households. Three equivalent operational objectives have been defined in order to effectively achieve the main objective, including: ensuring the country's energy security, increasing the competitiveness and energy efficiency of the national economy within the EU's internal energy market, and reducing the negative impact of the energy sector on the environment (Ryghaug et al. 2018).

Poland, being an active member of the European Union, actively participates in shaping the Community energy policy and implements its main objectives in specific national conditions. The priorities of the Polish energy policy include improving energy efficiency, increasing the security of fuel and energy supplies, and diversifying the structure of electricity generation. These lines of energy policy are closely linked. Improving energy efficiency contributes to reducing the demand for fuels and energy, which in turn increases energy security by reducing dependence on imports. In addition, such efficiency works to the benefit of environmental protection by reducing emissions. Similar benefits are brought by the development of the use of renewable energy sources (Chilvers, Longhurst 2016).

In the implementation of activities in line with these directions, the energy policy aims to increase the country's energy security, while observing the principle of sustainable development of renewable energy sources. The aim of the publication is to determine the potential for the development of biomass resources, taking into account the criteria of sustainable development, i.e. economic, ecological and social aspects. So far, few researchers have dealt with this subject in a comprehensive way, and so far there has been a lack of detailed research on the potential of biomass in the West Pomeranian Voivodeship. The presented analyses are an important contribution to the development of knowledge about alternative energy sources in the energy sector. The research material used in the article comes from various sources, both domestic and foreign, including empirical data from scientific institutes of energy and fuels and regional institutions dealing with energy.

2. Literature review

The reconstruction of the energy sector is necessary to achieve the goal of climate neutrality by 2050, as approved in December 2019 on the basis of the Paris Agreement by the Member States of the European Union. In all countries the transition to a low-carbon energy system can be challenging, requiring supporting policies and community involvement (Burningham et al., 2015; Naimoglu & Kavaz, 2023; Ntshangase et al., 2023; Zecca et al., 2023).

Until recently, society was seen in a regressive way: as passive consumers using centralized energy systems, powered mainly by nuclear, coal, gas, or hydroelectric power plants. Humans have often been seen as an obstacle to the development of new clean energy technologies due to a lack of awareness of the environmental, social, and economic benefits that can result from these new technologies (Perger et al., 2021). Efforts to implement renewable energy have been portrayed as a "NIMBY" situation (Burningham et al., 2015).

In the context of the European Union's current initiatives for clean energy for all citizens, different forms of energy citizenship can be considered to make the energy transition more inclusive, fair and democratic. This conceptualization builds on the theories of energy citizenship by Ryghaug et al. (2018) and Devine-Wright (2007), differentiating energy citizenship as performative and discursive. Energy citizenship in society can generally be understood as a spectrum of agencies ranging from limited power to full civic power, which translates into the role of energy consumer/user, environmental citizen, and critical citizen (Am, 2015; Neves et al., 2015; Melica et al,2018).

Directive 2001/77/EC defines biomass as "biodegradable product fractions, waste and residues of agricultural, forestry and related industries, as well as biodegradable fractions of industrial and urban waste" (Biomass 2012).

On the other hand, the Regulation of the Minister of Economy and Labour of 9 December 2004 defines biomass as "solid or liquid substances of plant or animal origin, biodegradable, derived from products, waste and residues from agricultural and forestry production, as well as the industry processing their products, as well as parts of other waste that are biodegradable" (Janowicz 2006).

The Energy Regulatory Office, on the other hand, classifies as biomass all organic substances of plant or animal origin, including those processed by humans, which can be used for energy production. Biomass is a store of solar energy accumulated in the process of photosynthesis, and its resources, under the influence of solar radiation and metabolic processes, have the ability to regenerate. Although biomass is not an inexhaustible source of energy, it is completely renewable (Pisarek 2006).

3. Biomass as a source of renewable energy

Biomass is the oldest and most widely used source of renewable energy. This resource includes both household waste and residues from pruning green areas. It consists of residues from agricultural production, forest residues, industrial and municipal rejects, constituting all organic matter present on Earth. When organic matter is burned, the CO2 emissions are equal to the amount of CO2 that the plant absorbed during growth, resulting in a zero CO2 balance. The potential of biomass is enormous, making it an economical and ecological source of energy (2018 Report).

Energy from biomass can be obtained by burning plant biomass, producing fuel oil from oilseeds, alcoholic fermentation of m.in potatoes, sugar cane or other fermentable materials to produce ethyl alcohol to power engines. For energy purposes, excluding organic matter from primary raw materials, plants from energy crops, wood and wood waste, sewage sludge, agricultural products and waste, as well as waste wood from the wood industry, such as wood chips, shavings, bark, wood briquettes, wood chips, sawdust or pellets, may be used. However, it is worth remembering that not all waste wood is suitable for energy purposes, due to the potential presence of unhealthy chemicals used in wood processing in a given plant, which may negatively affect the emission of gases into the atmosphere during combustion (Rabe 2017; Piccinetti et al., 2023).

Energy crops, rich in cellulosic compounds, are characterized by significant annual growth, high calorific value, resistance to diseases and parasites, low soil requirements, as well as the possibility of automation of agrotechnical works related to the establishment of plantations and harvesting the crop. Energy crops enable the effective management of inefficient or degraded agricultural areas. The useful life of energy crops is on average 15-20 years, and they can be used to produce briquettes or pellets or burn them whole. There are four main groups of energy crops:

(a) annual crops such as maize, cereals, hemp, oilseed rape, Sudanese sorghum, sunflower, reed;
(b) fast-rotation woody plants such as aspen, eucalyptus, poplar, willow;
(c) fast-growing perennial grasses, e.g. Miscanthus giganteus;
(d) slow-growing tree species (Nowak 2017).

The introduction of plants, such as willow, on agricultural land makes it possible to obtain biomass for energy purposes, as well as to develop areas of low agricultural usefulness, currently not used for agriculture, obtaining heat energy from ecological sources and reducing unemployment in rural areas. In addition, these plants can be used for direct combustion or processed. Energy willow also contributes positively to environmental protection by reclaiming degraded land, regulating water relations and protecting against erosion (Płocharski 2017).

Pennsylvania mallow grows in all substrate classes except class V and VI. The areas intended for its cultivation must be free of weeds, and the woody and dried stems harvested each year can be harvested for a period of 15-20 years.

The tuberous sunflower is easy to grow, resistant to drought and frost. It can be grown in waterlogged soils, which contributes to soil drainage. The dried parts of the plant can be directly burned or processed and burned in the form of briquettes or pellets, and this plant can be grown for 15-20 years (Turnip 2018).

Miscanthus giganteus, as a grass species, is characterized by a high dry matter production of 8 to 25 t/ha. Despite its low soil requirements, it is sensitive to low temperatures, especially in the first year after planting, which requires crop protection.

ISSN 2029-7017 print/ISSN 2029-7025 online

Agricultural products and waste are also produced in agriculture, one of which is straw as one of the raw materials for heating purposes. Although it is commonly used as bedding, fodder or fertilizer, modern agricultural production methods, with limited livestock production, contribute to reducing the need for straw, which means that straw is often burned in the field. Nevertheless, there are significant opportunities to use straw as a biofuel (Jasiulewicz, Janiszewska 2018).

Thanks to innovative technologies of straw combustion and modification, its excess can be effectively used as a fuel for energy purposes in the combustion process. Straw is characterized by high productivity of about 24 t/ha and high calorific value. However, its high humidity, oscillating between 50 and 70%, is a challenge. The calorific value of straw depends on its species, moisture content and storage technology. It is preferable to use the so-called grey straw, which is characterized by better energy properties and lower emissions of sulphur and chlorine compounds compared to yellow straw, i.e. freshly cut straw. Straw intended for heating purposes should remain on the field for a certain period of time under natural conditions, which makes it possible to reduce the content of alkali metals and chlorine, as well as to increase the calorific value.

Straw as a fuel is characterized by low density, but at the same time it contains a large amount of volatile fractions, which can lead to some problems during combustion. Ash left after combustion can be a problem for the boiler room as a residue of non-flammable substances (Kawałko, Olek 2008).

4. Potential for the development of energy from biomass in the West Pomeranian Voivodeship

Important documents used to analyse the progress in the power sector in Poland are the applicable acts of the European Union law, national legal acts and government directives. The key document is the Polish Energy Policy until 2030 and the Act of 10 April 1997 on energy law (Journal of Laws of 2006, No. 69, item 625, as amended). The analysis of the biomass potential in the West Pomeranian Voivodeship also took into account the Draft Energy Policy Polish until 2040 of 23 November 2018 and the Draft Energy Policy Polish 2050 presented in August 2015.

In the context of the area of the West Pomeranian Voivodeship, regional and local documents are also taken into account, such as the Report on the Potential and Use of Renewable Energy Sources in the Production of Electricity and Heat in the West Pomeranian Voivodeship. This document was published by the Regional Office for Spatial Management of the West Pomeranian Voivodeship in November 2018, as well as the Energy Sector Development Programme in the West Pomeranian Voivodeship until 2015 with an outlook to 2030.

The analysis of the possibilities of obtaining energy from biomass in the West Pomeranian Voivodeship is a challenge, mainly due to the consideration of many variables. It is worth paying attention to potential conflicts, such as competition for agricultural space between agriculture and energy, or conflict between the natural functions of forests and their use for energy purposes. In addition, technical requirements, technological processes and complex financial aspects are important.

Despite possible conflicts, there is potential to use biomass for energy production. However, it is important to strike a balance between the energy aspects and the original purpose of biomass production. In the case of energy crops such as Pennsylvania mallow, energy willow, rose or Miscanthus, their economic potential has a significant impact. In practice, in order to exploit the potential of biomass, farmers need to get the right price for the feedstock, taking into account the risks associated with new production.

In the West Pomeranian Voivodeship, where class I and II soils occupy about 10,000 ha, it is possible to establish energy crop plantations on soils of class IV (51.1%), class III (20.8%), class V (20.5%) and class VI (6.6%). These plants, due to their low environmental requirements, can be grown in areas of different quality, which makes them suitable for a region with over 300 thousand hectares of soils of V and VI class.

At the end of 2016, the West Pomeranian Voivodeship had an area of 954.2 thousand hectares intended for agricultural purposes. The report on "Potential and Use of Renewable Energy Sources in the Production of Electricity and Heat in the West Pomeranian Voivodeship" predicts that 15% of this area will be allocated to the production of energy from biomass, while the rest will be used for commodity production. The report assumes that an average of 50,000 kWh can be obtained from one hectare of energy crops.

143.13 thousand hectares × 50,000 kWh = 7,156,500,000 kWh.

It is estimated that the West Pomeranian Voivodeship has a relatively high biomass potential, in the form of 7156.5 GWh.

There are a number of key elements that shape the structure of agriculture in the West Pomeranian Voivodeship, ranging from a large area of farms, a favourable proportion of people working in the agricultural sector, and a focus on crop production, especially potatoes, cereals and sugar beets. At the end of 2018, the average size of agricultural area per farm was 30.67 hectares.

Due to the important role of organic fertilisers, such as slurry or manure, as substrates for the production of agricultural biogas, it is necessary to analyse the number of livestock in the region. The leading livestock are pigs, cattle, and poultry. According to the Central Statistical Office, the number of cattle and pigs is decreasing, while the number of poultry is increasing.

Investment in the construction and operation of agricultural biogas plants may contribute to reversing this downward trend. Nevertheless, it is worth noting that the location of a biogas plant in a specific area must be supported by the availability of suitable raw materials for biogas production. Therefore, animal husbandry in the immediate vicinity of the plant should be compacted or carried out on large farms (Report ROSM, 2018).

In addition to livestock production, there is great potential for biogas production in plants that process agricultural products, such as sugar factories, distilleries, breweries, slaughterhouses and fruit and vegetable processing plants.

In the West Pomeranian Voivodeship, the area of meadows and pastures is also decreasing – from 157.2 thousand hectares in 2016 to 143 thousand hectares in 2018 (Ryghaug, Skjolsvold, Heidenreich, 2018). Assuming that 10% of this area will be used for energy purposes, we forecast to obtain about 11.4 million m3·year-1 of biogas.

In the context of the operation of a biogas plant, cereals are also used, which are harvested at the appropriate stage to be used as an additional substrate in the form of silage. Maize silage is considered to be the optimal plant material for agricultural biogas plants (Rzepa, 2018).

The areas of maize cultivation in the West Pomeranian Voivodeship are gradually increasing. In 2016, the area under maize cultivation was 9.2 thousand hectares, while in 2017 it was almost 22 thousand hectares. At the same time, beet cultivation decreased slightly – in 2017 the area under cultivation amounted to 12.1 thousand hectares, compared to 11.4 thousand hectares in 2016. Despite the smaller cultivation area, the sugar beet harvest in 2017 was higher than in 2016.

Assuming that the area of 13.2 thousand hectares in the region can be used for the cultivation of maize for energy purposes, it is possible to achieve an annual biogas production of 56.4 million m3. In addition, by allocating sugar beet leaves to silage production, it is potentially possible to obtain around 39.6 million m3 of biogas per year.

It is estimated that the potential of the West Pomeranian Voivodeship, based on available resources such as waste from the agri-food industry, organic fertilisers, grasses from permanent grassland, sugar beet leaves and maize, creates the possibility of obtaining about 638.7 GWh of electricity from biogas plants.

Table 4. is presented below, illustrating the energy potential of the West Pomeranian Voivodeship.

Type of renewable energy	Energy potential of the West Pomeranian Voivodeship GWh
wind turbines	26600,0
installations generating energy from biogas	638,7
biomass energy installations	7 156,5
solar power generation installations	393,2
run-of-river hydroelectric power plants	14,3

Source: In-house analysis based on the model.

5. Summary

The assessment of the possibility of obtaining energy from biomass in the West Pomeranian Voivodeship is a difficult issue, mainly due to the need to take into account numerous variables. Among other things, you should pay attention to:

- a potential conflict between the agricultural and energy uses of agricultural space;
- potential conflict between the natural functions of forests and their exploitation for energy purposes;
- specific technical requirements and technological processes;
- complex financial considerations.

Despite potential conflicts between the energy use of biomass and the agricultural or forestry function, it is possible to use the resulting biomass for energy purposes. It is extremely important to maintain the right balance between the energy and the primary purpose of its production. In the case of strictly energy crop plantations, the economic potential of biomass has a great impact. In practice, the theoretical potential is conditioned only by the presence of appropriate soil quality and other similar factors. In order for this potential to be realised, farmers need to obtain the same price for biomass as they receive for their current food production and, in addition, a premium for the risks associated with new production. For this reason, biomass is the most expensive source of renewable energy. In addition to investment costs, energy installations using biomass as fuel are accompanied by constant, high operating costs (costs of production and delivery of biomass). The technical and economic potential is of great importance for biomass from forests, urban green areas, orchards, etc. The main problem, both for customers involved in both direct combustion of biomass and its processing, is to ensure the continuity of supply of the raw material.

References

Am H. (2015) The sun also rises in Norway: Solar scientists as transition actors. Environmental innovation and social change 16, 142-153.

Biomass in terms of energy (2012). ERO Newsletter 6, p. 54-60.

Burningham, K., Barnett, J., & Walker, G. (2015). A series of deficits: unpacking NIMBY discourses in conceptualizing wind energy developers to their local opponents. Society & Natural Resources, 28(3), 246-260.

Burningham, K., Barnett, J., & Walker, G. (2015). A series of deficits: unpacking NIMBY discourses in conceptualizing wind energy developers to their local opponents. Society & Natural Resources, 28(3), 246-260.

Chilvers, J, Longhurst, N. (2016) Participation in transformation(s): Reconceiving public commitments in the energy transition as co-producing, emerging, and diverse. Journal of Environmental Policy & Planning 18(5), 1-23.

Chehabeddine, M. R., Grabowska, S., & Adekola, A. F. (2022). Building a model for securing regional development from ecological threats, Insights into Regional Development, 4(2), 22-40. https://doi.org/10.9770/IRD.2022.4.2(2)

Janowicz, L. (2006). Biomass in Poland, in Energy and Ecology, August 2006, p. 601-604.

Jasiulewicz, M., & Janiszewska, D. A. (2018). Potential possibilities for the development of biogas plants on the example of the West Pomeranian Voivodeship, Agricultural Engineering, Koszalin, p. 91-102.

Kawałko, S., & Olek, M., (2008). Biomass combustion, Institute of Thermal Engineering and Air Protection, Cracow University of Technology, p. 44-45.

Melica, G., Bertoldi, P., Kona, A., Iancu, A., Rivas, S., & Zancanella, P. (2018). Multi-level sustainable energy policy management: Role of regions and provinces in supporting the participation of small local authorities in the Covenant of Mayors, Sustainable Cities and Society, 39, 729-739, https://doi.org/10.1016/j.scs.2018.01.013

Naimoglu, M., & Kavaz, I. (2023). Energy use tendencies in a resource-abundant country: the case of Canada. Insights into Regional Development, 5(4), 65-79. http://doi.org/10.9770/IRD.2023.5.4(5)

Neves, A. R., Leal, V., & Lourenço, J.C. (2015). Methodology for sustainable and inclusive local energy planning, sustainable cities and society, 17 110-121, https://doi.org/10.1016/j.scs.2015.04.005.

Nowak, J. (2017). Analiza projektu Studium potencjału i rozwoju odnawialnych źródeł energii w województwie zachodniopomorskim, Regionalne Biuro Gospodarki Przestrzennej Województwa Zachodniopomorskiego, Szczecin 2017, s.15-28.

Ntshangase, B.A., Makole, K.R., & Msosa, S.K. (2023). Governance of state-owned companies in the energy sector of South Africa: peculiarities and challenges. Insights into Regional Development, 5(4), 135-144. http://doi.org/10.9770/IRD.2023.5.4(9)

Perger, T., Wachter, L., Fleischhacker, A., & Auer, H. (2021). PV participation in local communities: Peer-to-peer trade-in prosuche readiness to pay, Sustainable cities and society, 66.102634, https://doi.org/10.1016/j.scs.2020.102634

Piccinetti, L., Rezk, M.R.A., Kapiel, T.Y.S., Salem, N., Khasawneh, A., Santoro, D., & Sakr, M.M. (2023). Circular bioeconomy in Egypt: the current state, challenges, and future directions. Insights into Regional Development*,* 5(1), 97-112. http://doi.org/10.9770/IRD.2023.5.1(7)

Pisarek, M. (2006). Energia roślin, Serwis informacyjny Gminy Dukła, PWSZ Krosno.

Płocharski, M., (2017). Use of renewable energy sources in district heating - report on the state, legal and economic conditions and prospects for the development of renewable energy sources in the West Pomeranian Voivodeship, Regional Office of Spatial Management of the West Pomeranian Voivodeship, Szczecin, p. 24-35.

Polish Energy Policy until 2040 (PEP2040), 2018, Warsaw, p. 27-38.

Rabe, M. (2017). Analysis of the current formal, legal, and market situation, as well as technical conditions for the use and development of renewable energy sources in the West Pomeranian Voivodeship, The Regional Office of Spatial Management of the West Pomeranian Voivodeship, Szczecin, p. 33-37.

Report. The potential and use of renewable energy sources in the production of electricity and heat in the West Pomeranian Voivodeship. Regional Office of Spatial Management of the West Pomeranian Voivodeship, Szczecin 2018, p. 36-60.

Ryghaug M., Moe Skjolsvold, T., & Heidenreich S. (2018). Creation of energy citizenship through material participation. Science, 48(3), 283-303.

Rzepa J. (2018). Potencjalne zasoby i możliwości wykorzystania energetycznego biomasy do produkcji biogazu w województwie zachodniopomorskim, w: Regionalny i lokalny potencjał biomasy energetycznej, M. Jasiulewicz (red.). Wydawnictwo Uczelniane Politechniki Koszalińskiej, Koszalin, p.59.

Zecca, E., Pronti, A., & Chioatto, E. (2023). Environmental policies, waste and circular convergence in the European context. Insights into Regional Development, 5(3), 95-121. http://doi.org/10.9770/IRD.2023.5.3(6)

Funding: The project is financed within the framework of the program of the Minister of Science and Higher Education under the name "Regional Excellence Initiative" in the years 2019 – 2022; project number 001/RID/2018/19; the amount of financing PLN 10,684,000.00.

Author contributions: Writing – original draft preparation, M.R.; writing – review and editing, M.R., T.N., K.W., A.G., A. Ł and E.G. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

Robert RABE - The Institute of Management, University of Szczecin**,** PL. Research interests: energy, management, security.
ORCID ID: 0000-0002-4817-1971

Tomasz NOREK - The Institute of Spatial Management and Socio-Economic Geography, University of Szczecin, PL. Research interests: data analysis, computer science, spatial economics, security.
ORCID ID: 0000-0001-9651-6295

Katarzyna WIDERA - Faculty of Economics and Management, Opole University of Technology, PL. Research interests: national security, internal security.
ORCID ID: 0000-0003-0651-8049

Andrzej GAWLIK – Faculty of Environmental Management and Agriculture, West Pomeranian University of Technology in Szczecin, PL. Research interests: national security, internal security.
ORCID ID: 0000-0002-2852-0986

Agnieszka ŁOPATKA – Institute of Economics and Finance, University of Szczecin, PL. Research interests: national security, internal security.
ORCID ID: 0000-0001-9775-640X

Ewelina GUTOWSKA – Faculty of Economics, The Jacob of Paradies University in Gorzów Wielkopolski, PL. Research interests: logistics economics management.
ORCID ID: 0000-0002-0914-1948