ANNALS OF THE POLISH ASSOCIATION
OF AGRICULTURAL AND AGRIBUSINESS ECONOMISTS

received: 10.02.2019
acceptance: 05.03.2019
published: 11.03.2019

Annals PAAAE • 2019 • Vol. XXI • No. (1)

JEL codes: O13, Q20

DOI: 10.5604/01.3001.0013.0852

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SIGNIFICANCE OF RENEWABLE ENERGY SOURCES IN SUSTAINABLE DEVELOPMENT

Key words: sustainable development, renewable energy sources

ABSTRACT. Sustainable energy development implies an effective use of economic, human, technological, renewable and non-renewable natural resources. The gradual process of natural environment degradation and the inevitable exhaustion of natural fossil fuel deposits force the search for alternatives. A comparison of alternative opportunities to generate energy allows to identify their advantages and drawbacks. The article attempts a systematic review of factors 'in favour of' and 'against' the use of renewable energy sources (RES) in accordance with the principle of sustainable development. The study applies descriptive methods, including comparisons. CSO and ERO were the sources of data for 1988-2018. According to sustainable development principles, investments in RE need to be widely promoted and supported by the state, especially in rural areas. The attempt to systematise factors contributing to the use of renewable energy resulted in the identification of: the importance of economic circumstances and the traditional approach to the energy sector; the need to protect the natural environment by the reduction of pollution and mitigation of the greenhouse effect; the need for continuing the education of society on the implementation and fast development of technology and the desire to enhance self-reliance and independence in energy supply with a special consideration of rural areas.

INTRODUCTION

Over time and in the course of economic development, defining sustainable development is gaining broader significance. However, the common goal of scientific considerations and public sector decision-makers is to develop such mechanisms and methods of action that will allow the further development of civilization, simultaneously preserving nature and socio-economic aspirations of humanity [Skowroński 2006]. The general philosophy of sustainable development comes down to reconciling and joining together two concepts – 'growth' and 'development' [Skowroński 2006]. According to the theory of economic growth and the Solow model, the economy automatically achieves a state of sustainable growth [Czarny, Rapacki 2002]. Sustainable development requires maximizing the net benefits of economic growth in order to access services and the quality of natural resources over time [Turner 1988]. Such a model (the path) of socio-economic development of a given area, the assumptions of which result from natural conditions, does not affect the ecological balance [Kozłowski 1998], but protects the environment and strengthens social justice [Dunphy et al. 2000]. Therefore, both conditions typical

to a given area as well as time and continuity of transformation taking place become particularly important [Czyżewski, Kułyk 2016]. The effective use of energy, as well as human, economic and natural resources is a fundamental principle of Sustainable Energy Development (SED) [Graczyk 2011]. Sustainable development is a process of searching for, checking and implementing new forms of economic development, new forms of energy, social communication and new technologies [Poskrobko 1997]. Development only takes place in conditions of progressive changes resulting in new qualities [Klepacki 2000]. It is difficult to maintain a system's long-term sustainability without striving to achieve a balance between various objectives of socio-economic development [Runowski 2002]. As such, institutional economics points to a need of a value system which is consistent with sustainable development that establishes formal institutions within a market system [Graczyk 2018].

The economics of sustainable development is not a static theory. It indicates the need to discuss its cognitive interests [Rogall 2010]. The economics of sustainable development began to dominate the process of determining the desired direction of changes in agriculture [Parzonko 2016]. Numerous and strong linkages of agriculture with the macroeconomic environment and the natural environment make this sector significant, not only from the perspective of sustaining natural foundations of agricultural production, but also in shaping overall sustainability in socio-economic development [Majewski 2008].

Sustainable development has become a concept that many legal acts, policy documents and development strategies refer to at all levels of aggregation, from local to global [Stanny, Czarnecki 2011]. In economics, especially in macroeconomics, sustainable development is treated as a paradigm imposed from the outside (especially by international organizations, environmental organizations or legal regulations), not as a paradigm created by the economy itself [Borys 2011]. The concept continues to be surrounded by controversies resulting from its multidimensional character [Stanny, Czarnecki 2011], therefore this study focuses on a well defined aspect of sustainability, that is renewable energy.

The key role of the sustainable development concept in planning and supporting rural local development in the European Union (EU), and in Poland results from international agreements [Rakowska 2019], starting from the Brundtland Report of 1987 [WCED 1987], Agenda 21 of 1992 [UN 1993] and the Cork Declaration of 1996 [EC 1996]. The concept of sustainable development was also given an adequate rank in national law, as it is included in the Constitution of the Republic of Poland (Art. 5) [Konstytucja RP 1997]. Moreover, providing all users with access to sources of stable, sustainable and modern energy at an affordable price was included in the 7th goal of the Agenda for Sustainable Development 2030, accepted by the Government of the Republic of Poland on February 14,2017 [OECD 2017]. Availability and stability of energy supply are particularly important in rural areas.

RESEARCH MATERIAL AND METHODOLOGY

The study aims at systematising factors ‘in favour of’ and ‘against’ the use of renewable energy sources in the context of sustainable development, with particular emphasis on the role and needs of rural areas. Descriptive and comparative methods were used to present

the research results. Economic studies, GUS (CSO – Central Statistical Office) and URE (ERO – Energy Regulatory Office) data for 1988-2018 were the source of research material.

RESULTS

The renewable energy market is changing due to economic (energy demand and production), social (health protection, energy security, employment), environmental (preventing environmental degradation, elimination of environmental threats) as well as institutional and legal conditions (frequent changes in Polish law on renewable energy sources – RES). Renewable sources used for energy production in Poland include: solar radiation converted into heat or electricity, wind, water, solid biomass, biogas and liquid biofuels, as well as geothermal resources [GUS 2018]. The use of RES reduces the negative impact on the natural environment by limiting the emission of harmful substances, especially greenhouse gases, resulting from coal burning, the main source of energy in rural areas. This is confirmed by a significant change in the structure of use of primary energy carriers (table 1).

Changes in the consumption of various sources of energy were quite dramatic between 1988 and 2016 (table 1). Firstly, the total use of energy decreased by almost 17% and the

Table 1. Total consumption of primary energy commodities in the national economy

Specification	Total use of primary energy feedstocks in the national economy [TJ]						Change 2016/1988 [%]
	1988	2000	2005	2010	2015	2016	
Total	5,353,466	3,847,603	3,970,444	4,386,883	4,383,052*	4,448,025	-16.9
Hard coal	3,628,603	1,940,687	1,907,363	2,007,947	1,703,736	1,772,100	-51.1
Lignite	592,337	507,526	532,820	484,708	514,280	490,125	-17.3
Crude oil	618,685	768,502	772,833	970,635	1,109,700	1,095,511	77.1
Natural gas	436,920	452,713	551,007	584,375	615,557	657,274	50.4
Peat and fuel wood	35,231	123,405	131,474	180,274	209,692*	213,888	507.1
Hydro, wind, solar, geothermal energy and heat pumps	6,455	7,723	8,894	17,664	49,266*	57,212	786.3
Solid waste fuels and other sources**	35,235	47,047	66,053	141,280	180,821	161,915	359.5

* Data have been re-calculated to allow comparison with the previously published data

** Refinery non-oil semi-products (alcohols, fuel additives, etc.), sewage gas (biogas), solid waste fuels and other biomass

Source: based on [GUS 2017]

decrease affected the use of hard coal (a decrease of -51.1%) and, much less, the use of lignite (-17.3%). From the standpoint of climate effects, the shift away from hard coal to oil and gas is desired, but does not assure sustainable development. However, the use of peat and duel wood increased more than six-fold between 1988 and 2016. Although the data do not distinguish between peat and flue wood, most of the growth was associated with increased fuel wood use. Peat use is not consistent with the sustainable development approach to the supply of energy, but fuel wood is a category of RE. The highest growth in energy generation was associated with RE, but although very impressive in relative terms, it is still very small in absolute numbers, even if compared to peat and fuel wood. In general, the tendency shows less dependence on hard coal and lignite, and a substantial growth in energy produced from renewable sources, which is desired in terms of sustainable development.

Changes in the production of energy from renewable sources (table 2) show a slowdown of growth towards the end of the studied period, especially between 2015 and 2016. The slowdown coincides with the expiration of the first period when EU cohesion funds supported investment in RE and increased uncertainty associated with the period of changes in regulations guiding the RE sector. Among four types of RE, is energy generated by windmills. Its unprecedented growth results from a very low production level in 2000 and rapid growth between 2015 and 2016, which contrasted with the stagnation

Table 2. Changes in the production of energy from renewable sources

Year	Total production of energy	Total consumption of energy	Renewable energy production					Production share	
			total	of which				in total production of energy	in total consumption of energy
				geothermal	biomass	wind	hydro		
	Thous. toe**/%							%	
2000	80.1	89.6	3.8	3.0	3.6	0.46	181	4.75	4.24
2005	78,447/-2.0	93,014/3.8	4,549/19.7	11/266.7	4,166/15.7	120/25,987.0	189/4.4	5.80	4.89
2010	67,451/-14.0	101,725/9.4	6,864/50.9	13/18.2	5,866/40.8	143/19.7	251/32.8	10.18	6.75
2015	68,868/2.1	96,397/-5.2	8,679/26.4	22/69.2	6,597/12.5	934/553.1	158/-37.1	12.61	8.98
2016*	66,977/-2.7	100,695/4.5	9,069/4.5	22/0.0	6,415/-2.8	1,082/15.8	184/16.5	13.54	9.01
Change 2016/ 2000 [%]	-16.4	12.3	138.7	633.3	78.8	235,117.4	1.6	-	-

* Data have been re-calculated to allow comparison with the previously published data

** Toe – tone of oil equivalent – a unit of measure of energy used in international balances. It indicates the amount of energy that can be produced from combustion of one metric ton of crude oil. One ton of oil equivalent amounts to 41.868 GJ or 11.63 MWh

Source: based on [GUS 2017]

Table 3. Changes in the annual installed capacity

Renewable energy installation	Changes in the annual installed capacity [MW] (as of June 30, 2018)												
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Biogas plants	4.8	8.9	8.9	16.3	12.0	20.6	27.8	31.0	26.3	23.9	21.5	1.4	5.6
Installations using biomass	49.0	16.6	-23.4	20.5	103.2	53.5	411.0	166.2	21.4	114.4	158.4	81.0	1.6
Solar installations	-	-	-	-	0.032	1.1	0.2	0.6	19.1	50.0	28.1	4.8	22.1
Windmills	69.3	135.3	163.2	273.6	455.6	436.1	880.4	892.8	444.3	748.2	1,225.4	41.3	26.1
Hydro-energy installations	81.5	0.7	5.8	4.6	-8.2	14.3.0	14.7	4.0	6.9	4.8	12.2	-5.6	-9.2

Source: based on [URE 2019]

of growth in energy produced from other renewables. The most important source of RE is biomass and this source will likely to continue to be of most important in the future due to local availability of biomass, its relatively low cost, and availability regardless of season. It is likely that the generation of geothermal energy will accelerate because of its convenience despite a relatively high initial investment cost. The new period of funding from the EU, for the period 2014-2020, will contribute to the growth of production of energy from renewables, especially if the regulatory environment is more predictable. In general, the growth of RE production has been rapid and its importance increases in the implementation of the sustainable development concept in Poland.

The growing demand for energy increases possibilities of using renewable energy. The development of rural areas and agriculture can significantly contribute to an increase in investment in sources of renewable energy [ENRD 2016]. Agriculture already supplies substrates for the production of renewable energy, and rural households have become important investors in micro-installations using locally available renewable energy. The analysis (year-to-year) of installed power (in MW) generated by investment using renewable energy sources was based on Energy Regulatory Office data [URE 2019] (table 3). The results show a significant increase in all types of installations (except hydro) between 2006 and 2016. It is worth highlighting that between 2010 and 2015, there was a fiftyfold increase in installed capacity using solar energy. This significant increase results from investment in solar collectors made in rural area homes and commercial installations [Gradziuk 2017, Klepacka 2018]. The reported decrease in installed capacity between 2016 and 2018 may have been caused by the conversion of the green certificate system into an auction system [Klepacka, Pawlik 2018] and a new transfer of 2014-2020 cohesion funds from the EU.

It is very important to continuously observe the dynamically developing market environment, to recognise factors 'in favour of' and 'against' the use of renewable energy sources in the context of sustainable development. For that purpose, an attempt was

made to systematise economic, environmental, social, institutional, legal and technological factors, which encourage or discourage potential beneficiaries to use renewable energy sources (table 4).

Rural households appear to be driven by utilitarian aspects of RE including a greater degree of independence in energy supply and a reduction of costs of monthly energy bills. The motive of lowering the energy cost was identified among solar panel investors [Klepacka et al. 2018]. However, due to the seasonality of solar radiation, rural households cannot fully depend on solar energy and will likely continue the use of coal in the foreseeable future. Over time (table 4, Supply), rural households that own forested land could become suppliers of wood biomass for use in heating homes or for the production of wood pellets. Burning wood biomass is less polluting than burning coal, and in line with the sustainable development path. Afforestation of low quality land also contributes to carbon sequestration and effects the local microclimate – factors listed among the environmental/ecological factors, while the life cycle of solar panels leads to a need to recycle them. Solar panel recycling will increase in the future since most currently operated panels have recently been installed. Rural resident acceptance varies by RE source

Table 4. Factors 'in favour of' and 'against' using renewable energy

FACTORS 'IN FAVOUR'	FACTORS 'AGAINST'
ECONOMIC	
Demand	
RES play an important role in reducing the use of fossil fuels; energy availability improves the quality of life and stimulates local economic development	Dependence on coal as one of the main heating energy source for farms located in rural areas
Reduction of the risk of disruptions in energy supply in rural areas	Domination of energy grids dependent on fossil fuels
Reduction of monthly energy bills	The price of energy per unit depends on the location and infrastructure; prices vary considerably for each renewable energy source
Subsidies under national and the EU programmes	The subsidy level limits the decision-making of potential beneficiaries
Reductions of personal income taxes	Required contribution of own resources
Supply	
Enabling rural households to become energy suppliers	The lack of financial benefits from the sale of electricity
Availability of raw materials at the local level (e.g., wood biomass)	The cost of RE production is related to the regulations and availability of raw materials
Free and unlimited access to some locally available renewable energy sources (sun, wind, water)	It takes long time to recuperate the installation costs (high initial capital and modernization costs)
Use of low-quality arable land (class V and VI) for installation purposes (PV farms, windmills, wood biomass)	High initial costs of RES installations
Afforestation as a long-term investment	Limited availability of land for afforestation and funds for subsidies to afforest land
Production of biogas possible throughout the year due to the availability of raw materials (especially from animal production and waste from crop production)	Lack of continuity of supplies, not always available and difficult to predict in the case of some renewable energy sources (sun, wind)

Table 4. CONT.

ECOLOGICAL/ENVIRONMENTAL	
Unlimited resources of sources	Production of energy (water, wind, sun) depending on atmospheric conditions
Reduction of pollution of air, soil, surface water and the mitigation of the greenhouse effect and climate change	Interference with the rural landscape, adverse impact on the landscape and ecosystem
Carbon sequestration is an important benefit resulting from the afforestation of poor quality agricultural land	-
Forests produce local cooling effect by shading	-
-	Problematic recycling of installations, i.e. solar collectors, PV panels, windmills
SOCIAL	
Common public acceptance of solar energy	Protests against some of the RE sources (windmills, biogas plants), because of their allegedly negative impact on the health of residents, noise
Creating local jobs mostly in installation and service companies (e.g. solar energy)	Awareness of potential beneficiaries about the possibilities of using renewable energy (educational training and advisory services are recommended)
Ecological awareness, care for future generations, promoting the eco trend	-
Energy independence contributes to the improvement of living standards by reducing the consumption of conventional energy	-
INSTITUTIONAL AND LEGAL	
A significant role of commune self-governments in implementing investment projects	Bureaucracy and the lack of transparency of the mechanism for obtaining assistance funds discourage beneficiaries
-	Legal difficulties in case of potential renewable energy water installations
TECHNICAL/TECHNOLOGICAL	
Diversity of renewable energy installations, new technologies	Difficulties in adapting most of the old residential buildings to the installation of renewable energy sources
The ability to sell energy	Possible technological barriers (underdeveloped transmission network)
Provision of energy to areas not connected to the network	Formal and legal restrictions

Source: own study

and windmills have encountered particularly frequent opposition [Klepacka et al. 2016]. Solar energy has been well accepted and available subsidies for the household purchase of such installations encouraged investment in rural areas. Subsidies have been provided under local projects stressing the key role of commune governments, a factor listed in the institutional/legal category. A clear negative factor is the frequent changes in regulations of the RE sector.

CONCLUSIONS

According to the assumptions of the sustainable development concept, all investments in renewable energy sources, especially those implemented in rural areas, should be widely promoted and supported by the state. Based on the classification of factors 'in favour of' and 'against' the use of renewable energy sources, the following conclusions can be drawn:

1. Renewable energy sources investments are consistent with the principles of sustainable development.
2. Economic conditions and the traditional approach to energy generation can prevent the fast development of renewable energy sources.
3. Renewable energy sources investments coincide with the assumptions of environmental protection as they reduce air, soil and surface water pollution, as well as reduce the greenhouse effect.
4. There is a need to further educate society on local advantages resulting from the use of RESs and implementing new, fast developing technologies used in RES installations.
5. Investments using RESs contribute to an increase in energy self-sufficiency and independence, especially in rural areas vulnerable to disruptions in energy supply.

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ZNACZENIE ODNAWIALNYCH ŹRÓDEŁ ENERGII W ZRÓWNOWAŻONYM ROZWOJU

Słowa kluczowe: zrównoważony rozwój, odnawialne źródła energii

ABSTRAKT

Fundamentalną zasadą zrównoważonego rozwoju energetycznego jest efektywne wykorzystanie zasobów odnawialnych i nieodnawialnych, ekonomicznych, ludzkich i technologicznych. Postępujący proces degradacji środowiska naturalnego i nieuchronne wyczerpywanie się surowców kopalnych wymuszają poszukiwanie alternatywnych rozwiązań energetycznych. Konieczność porównania różnych możliwości wytwarzania energii, pozwala wyłonić ich zalety i wady. Celem artykułu była próba dokonania systematyki czynników przemawiających „za" i „przeciw" wykorzystaniu źródeł energii odnawialnej w aspekcie zrównoważonego rozwoju. Do prezentacji wyników badań zastosowano metodę opisową i porównawczą. Źródło materiału stanowiła literatura przedmiotu oraz dane Głównego Urzędu Statystycznego (GUS) i Urzędu Regulacji Energetyki (URE) za lata 1988-2018. Zgodnie z założeniami zrównoważonego rozwoju inwestycje w odnawialne źródła energii (OZE), szczególnie realizowane na obszarach wiejskich, powinny być szeroko promowane i wspierane przez państwo. Na podstawie dokonanej próby systematyki czynników przyczyniających się do wykorzystania OZE wskazano na istotę znaczenia uwarunkowań ekonomicznych i tradycyjnego podejścia do energetyki; zbieżnego z założeniami zrównoważonego rozwoju ochrony środowiska, przez zmniejszenie zanieczyszczenia i ograniczenie efektu cieplarnianego. Podkreślono także potrzeby dalszej edukacji społeczeństwa i wdrażania nowych, szybko rozwijających się technologii oraz dążenia do zwiększenia samowystarczalności i niezależności energetycznej ze szczególnym uwzględnieniem obszarów wiejskich.

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