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ROCZNIKI NAUKOWE STOWARZYSZENIA EKONOMISTÓW ROLNICTWA i AGROBIZNESU

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IMPACT OF THE RES MICROINSTALLATIONS IN SINGLE-FAMILY HOUSES ON CARBON DIOXIDE EMISSION REDUCTION

WPŁYW WYKORZYSTANIA MIKROINSTALACJI OZE NA REDUKCJĘ EMISJI CO_2 W BUDYNKACH JEDNORODZINNYCH NA OBSZARACH WIEJSKICH

Key words: OZE, microinstallations, carbon dioxide reduction, prosumer

Słowa kluczowe: OZE, mikroinstalacje, redukcja emisji $CO_{2,}$ prosument

JEL codes: O13, O18, Q42, Q54, R11

Abstract. The article is an attempt to estimate the potential of reduction carbon dioxide emissions using microinstallation of renewable energy sources (RES) in single-family housing. Based on the energy demand of the building, statistical data including the average number of single-family buildings built per year and the average area of a single-family building, the forecasted national annual reduction of carbon dioxide emissions resulting from the implementation of microinstallations in single-family buildings was calculated. The research results indicated an annual reduction of carbon dioxide emissions resulting from the use of selected RES microinstallations only in the single-family housing sector at the level of 230,000 t/year.

Introduction

Between Poland and European Union (EU) countries in the field of the use of renewable energy sources (RES), there are differences both in the field of RE use in total energy consumption as well as in inefficient national energy generation structure [Graczyk et al. 2017]. There has been a significant increase in energy from renewable sources in the EU. Specifically, the share of energy from renewable sources in final gross energy consumption has almost doubled in recent years, from around 8.5% in 2004 to 17.0% in 2016 [Eurostat 2018]. The changes between 2004 and 2016 in the share of energy in the EU countries presented in table 1. Already 11 EU countries use more energy from renewable sources than they anticipated for 2020 year. These countries include Croatia, the Czech Republic, Estonia, Bulgaria, Lithuania, Hungary, Sweden, Finland, Romania, Italy and Denmark. Most of them are comparatively or less affluent countries than Poland [Derski 2017]. In Poland, the use of energy obtained from renewable sources is less than one half of that in EU countries. Dynamics of the amount of energy obtained from renewable sources in Poland compared to the EU countries indicate that in our country there is a lag behind the trend of increasing the use of these sources [Gotowska, Jakubczyk 2014].

According to Lidia Grzegorczyk [2014], there is still no place for small innovative enterprises, independent energy suppliers and dispersed power generation structure. Without urgent adaptation of the national energy strategy to the EU policy, further functioning of Poland as an equal, competitive and energy safe partner may be problematic. In October 2014, EU representatives defined the framework of climate and energy policy until 2030. One of its goals (apart from the new aim of increasing the renewable energy production up to 32%) is to reduce the emission of greenhouse gases by at least 40% in relation to the goal from 1990 [Pach-Gurgul 2014].

One of the possibilities of increasing the level of renewable energy is transformation of the owners of detached houses into prosumers and buildings into micro-power plants used for generating energy. The largest number of beneficiaries of new technological solutions may be households situated in rural areas, which offer possibilities of installing the equipment for manufacturing clean energy [Kacejko et al. 2014]. The amendment of the Act on Renewable Energy Sources [JL 2015 poz. 478] offers such opportunity.

Table 1. Changes in the share of energy from renewable sources in the final gross energy consumption in 2004 and 2016 in the EU countries

No.	Country	Share of energy [%] in years	
		2004	2016
1.	Sweden	38.7	53.9
2.	Finland	29.2	39.3
3.	Latvia	32.8	37.6
4.	Austria	22.5	33.0
5.	Denmark	14.9	30.8
6.	Croatia	23.5	29.0
7.	Estonia	18.4	28.6
8.	Portugal	19.2	28.0
9.	Lithuania	17.2	25.8
10.	Romania	16.3	24.8
11.	Slovenia	16.1	22.0
12.	Bulgaria	9.4	18.2
13.	Italy	6.3	17.5
14.	Spain	8.4	16.2
15.	Greece	6.9	15.4
16.	France	9.5	15.2
17.	Czech Republic	6.8	15.1
18.	Germany	5.8	14.6
19.	Hungary	4.4	14.5
20.	Slovakia	6.4	12.9
21.	Poland	6.9	11.8
22.	Cyprus	3.1	9.4
23.	Irleand	2.4	9.2
24.	UK	1.1	8.2
25.	Belgium	1.9	7.9
26.	Holand	2.1	5.8
27.	Luxemburg	0.9	5.4
28.	Malta	0.1	5.0

Source: own elaboration based on [Eurostat 2018]

Implementation of the RE micro installations development scenario is not only a fulfilment of duties towards EU but an opportunity to obtain increased social, economic and environmental benefits. At the local level, special heat generating installations may also serve the purpose of reducing CO_2 emission, whose level in Poland is problematic [Wiśniewki, Oniszk-Popławska 2015]. According to the latest available data that refer to 2016, the national carbon dioxide emissions amounted to 209.4 million t [GUS 2016].

Research material and methods

The aim of the article is an attempt to estimate the potential of reduction of carbon dioxide emissions using microinstallation of selected renewable energy sources (RES) in single-family housing in rural areas. The existing regulations [JL 2015, item 376] were applied to assess the nation-wide CO_2 emission reduction by considering the average annual number of newly-constructed single-family houses in the country, the average area of a single-family house [GUS 2016], and the energy demand of a single-family building. Projected reduction of CO_2 emission resulting from the adoption to the Directive 2010/31/UE is estimated. The Directive refers to the reduction of energy consumption of buildings through the use of RE sources. Article 9 of the Directive states that from 2021 all newly constructed buildings should meet zero--emission requirement, which is expected to result from RE microinstallations. To determine the average annual reduction of CO_2 emissions in newly built single-family houses Poland, this study uses the statistical data provided by the Central Statistical Office for the years 2014-2016. According to the available figures, approximately 80,000 residential single-family buildings (B) with an average area of 145 m^2 (P) are constructed annually [GUS 2014, 2015, 2016]. This study assumes that such number of new single-family houses will be built in the foreseeable future. The descriptive and comparative method was used in the implementation of the stated objective.

Prosumer microinstallations in light of amended Act on renewable energy sources of 29 June, 2018

An significant change regarding the potential of reduction of CO_2 emissions in single-family houses is the amendment to the National Renewable Energy Act, introduced in June 2018,focusing on promotion of microinstallation and development of prosumer energy generation. Among other things it introduces flexible and clear rules of green energy generation based on microinstallations. Article 41, sections 10-20 of the amended Act contains regulations concerning the so-called "prosumer amendment", which introduces a system of tariffs guaranteed for the owners of smallest RE microinstallations. The amendment offers consumers an option to choose between buying the energy from the supplier network, selling their own energy generated in the household microinstallations to the network or generating power for own purposes [JL 2015, item 478]. The RE Act amended in June introduced modified microinstallation definitions extending its scope of application to increased admissible power. It also introduced enhancements and more attractive conditions of use of microinstallations for prosumers.

A prosumer is perceived on the energy market as energy recipient who consumers and generates electricity at the same time. In the Polish legal system (as a result of amended RE Act of June 2018), the notion of microinstallations concerns solely the installation consisting of renewable energy sources with the total installed capacity not exceeding 50 kW and connected to power grid with the voltage rating lower than 120 kV or with achievable heating power from cogeneration not exceeding 150 kW [JL 2015, item 478].

Condition and technical potential of microinstallations in Poland

The beginning of the Polish market for microinstallations generating electricity may be traced back to the middle of 2013 when for the first time the Energy Law was introduced to facilitate the connection of such devices to the power grid and granted them a dedicated system of settlement of surplus energy entering the network. Households installing their own microinstallation were then relieved from among other things necessity to obtain a licence or permit for the construction and the connection procedure was simplified [Cieślik 2015].

In 2014, the number of all microinstallations generating electricity in Poland amounted to 3.7 thousand with an annual growth rate of several hundred. The share of this segment in the RE market amounted to modest 15%. According to the Energy Regulatory Office (URE) data, in 2015 the total number of on-grid microinstallations amounted to 4,738, while in 2016 this number nearly tripled totalling 12,860, which constituted 75% all connected microinstallations in general [Żabińska 2017]. At the end of December 2016, the total installed RE capacity in Poland exceeded 8.4 MW [URE 2017].

The majority of electricity generated in detached houses was produced based on photovoltaic sources. In 2017, 12,500 new photovoltaic microinstallations were connected to the grid. In total, 27,310 photovoltaic microinstallations are part of the polish energy system. In 2017, total capacity installed in photovoltaic installations reached the level of 172.5 MWp. Photovoltaic microinstallation account for 62% of the installed capacity available generated by photovoltaic installations in Poland [SBF Poland PV 2017].

Heat generating microinstallations include mainly biomass boilers, heat pumps and solar collectors. At the end of 2017, 10,145 thousand m^2 of solar collectors were installed and used, which is an equivalent of 637 MW heat capacity [Starościk 2015].

Another RE microinstallation solution often used by prosumers are heat pumps. In 2016, the market for all heat pump types related to central heating increased by 30% [CIRE 2018]. Also increased considerably was the share of ground heat pumps in new detached houses which amounted to 12.5% (every eighth newly built house). According to the data of Polish Power Transmission and Distribution Association (Polskie Towarzystwo Przemsyłu i Rozdziału Energii Elektrycznej – PTPiREE) [PTPiREE 2018], at the end of the first quarter of 2018, the total capacity of microinstallations operating in Poland increased up to 202.3 MW and was generated by 31,657 systems.

Despite the fact that the household share of energy obtained from the solar radiation (solar collectors, photovoltaic cells) was only 1.77% in 2016, and the share of energy obtained from heat pumps was 0.08% [CSO 2017], microinstallations in single-family housing significantly reduced CO_2 emissions. According to IEO, the share of microinstallations in households is expected to increase from around 1% in 2017 to 50% in 2030 [IEO 2015]. This will be the result of legislative action, including the Directive 2010/31/EU (art. 9) according to which "until December 31, 2020, all new buildings are almost zero-energy buildings" which refers, to a large extent, to the use of energy from renewable sources. It should therefore be concluded that single investments in micro-energy in single-family housing are possible, or even desirable, and create opportunities for a significant increase in the share of green energy production in the overall energy production for the country [CIRE 2018].

For example, based on a study by Anna Maria Klepacka [2018], the largest number of microinstallations included investments in photovoltaic panels (2,933), followed by microinstal-

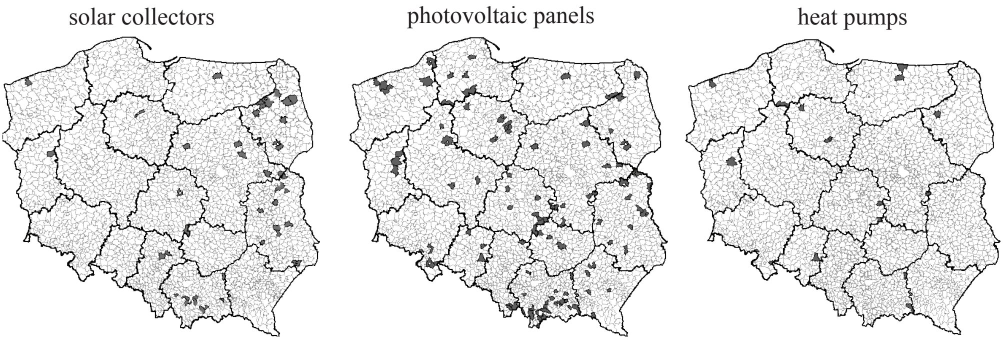

Figure 1. Concentration of microinstallations in solar collectors, photovoltaic panels and heat pumps
Source: own study based on MRiRW data

lations in solar collectors (2,876) and heat pumps (323), while the highest level of total power was generated by microinstallations in solar collectors (12,403 kW) and photovoltaic panels (11,896 kW), lower in heat pumps (1,697 kW). Such location of microinstallations offers a wide range of opportunities to reduce CO_2 emissions at the local scale (fig. 1).

Technical potential for the RE microinstallation application in Poland was determined on the basis of correctly estimated demand for installations reported by prosumers who could use them in their detached houses [IEO 2015]. According to GUS data [2013] and National Population and Flat Census, the number of detached houses amounted to 5.5 million, 3 million of which are situated in rural areas which constitutes the majority (61%) of potential prosumers. Looking ahead to the EU Directive, its requirements could be satisfied by 2030 due to microinstallations installed in detached houses in buildings in rural areas thus considerably increasing the renewable energy generation and at the same time limiting the emission of greenhouse gases.

CO_2 emission reduction – environmental benefits

According to International Energy Agency, in the years 2013-2016, for the first time in 40 years, due to increase of energy efficiency and inclusion of renewable energy sources it was possible to stop and stabilize global annual increase of CO_2 emission at the level of 32.2 mln t [IEA 2015].

RE microinstallations, as devices producing green energy have major effect on reduction of pollution due to the use of fossil fuels. It is particularly important for domestic energy generation where 87.5% of the generated power is a result of processing fossil fuels [Gawlik, Mokrzyczki 2017]. According to the scenario proposed within the scope of the National RE Micro Installation Development Plan drafted by IEO, the accumulated reduction of CO_2 emission may exceed 100 mln t by 2030. The largest contribution into the process will be due to the use of photovoltaic panels (56%), heat pumps (28%) and solar collectors (20%) [Sarniak 2008].

By increasing the share of microinstallations using renewable energy in single-family houses, Poland will be able to fulfil its duties imposed by the EU with respect to reduced greenhouse gases emission into the atmosphere and satisfy the RE application growth as laid down in Directive 2009/28/EC.

Research results

Based on own research carried out for a single-family residential building located in a rural area, the reduction of CO_2 (*E*) obtained as a result of the use of microinstallations represented by the solar collectors and a ground heat pump equals 20 kg CO_2/m^2/year (*E*). In the case of using only one renewable energy source (heat pump), the reduction was 10 kg CO_2/m^2/year.

Assuming all new homes are equipped with RES microinstallations and considering the annual number of houses built in Poland, their average area and the level of CO_2 reduction, we can calculate the average estimated volume of national annual reduction of CO_2 emissions (*R*) in single-family home obtained as a result of utilization of RES as an additional source of energy.

$$R = B * P * E$$

where: *R* is an average level of national annual CO_2 emission reduction: *B* – average annual number of detached houses, *P* – average size of a detached house, *E* – CO_2 emission reduction obtained in connection with the use of microinstallations in the form of solar collectors and heat pumps.

In the case of using two microinstallations in the building (e.g. heat pump and collectors) in Poland, the national emission reduction would be *R* = 232,000 t/year. If a single installation, e.g. a heat pump, is used in all single-family houses, the reduction of CO_2 emissions would be limited by 116,000 t/year.

Research results show that due to the use of RE microinstallation and elimination of emission due to conventional fuel transportation (e.g. hard coal) in connection with the local power generation by the microinstallations, a high environmental effect may be obtained reducing the CO_2 emission by 232,000 t/year in comparison with the energy generation for detached house purposes based on conventional sources.

Conclusions

Agricultural households have many RE options to choose from. Rational application of these sources in rural areas not only allows to reduce the household maintenance expenses but it may also become a source of additional income for prosumers. Intensified application of microinstallations in single-family buildings and the development of nationwide prosumer energy will also improve the quality of the natural environment and will help to reduce the greenhouse gas (GHG) effect. The use of renewable energy sources for production purposes and in households would result in observable reduction of greenhouse gases in particular carbon dioxide into, the atmosphere.

The inclusion of Poland in the implementation of the objectives of European climate policy by 2030 should be an element of low-carbon transformation. Proper shaping of the climate and energy policy ensures, among other things, increased application of renewable energy and efficient use of energy. This approach looks ahead to the challenges linked with the EU membership as well as the way to achieve the country's energy independence and reduce carbon dioxide emissions.

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Streszczenie

Podjęto próbę oszacowania potencjału redukcji emisji dwutlenku węgla przy zastosowaniu mikroinstalacji odnawialnych źródeł energii (OZE) w budownictwie jednorodzinnym. Na podstawie zapotrzebowania energetycznego budynku jednorodzinnego o określonej średniej powierzchni oraz danych statystycznych obejmujących średnią liczbę budynków jednorodzinnych budowanych rocznie w Polsce obliczono prognozowaną krajową roczną redukcję emisji dwutlenku węgla, wynikającą z wdrażania mikroinstalacji w budownictwie jednorodzinnym. Wyniki badań wskazały na roczną redukcję emisji dwutlenku węgla wynikającą z zastosowania wybranych mikroinstalacji OZE wyłącznie w sektorze budownictwa jednorodzinnego na poziomie 230 tys. t/rok.

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