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SUSTAINABLE ENERGY AND DEVELOPMENT OF RENEWABLE ENERGY SOURCES IN ŻYWIEC DISTRICT (SILESIAN VOIVODESHIP)

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ABSTRACT

Climate change and human activity are the main threats to rural areas and surrounding cities. The effects of climate change are mainly an increasing temperature, but also the intensity and frequency of extreme events. Climate change and its consequences are a growing problem. One of the ways to mitigate climate change, improve the quality of the natural environment and meet international obligations is sustainable energy management and the use of renewable energy sources (the RES).
The aim of the study was to evaluate the energy economy, in particular the use of the RES in the Żywiec district in 2015–2020. In the rural areas of the Żywiec district, the preferred RES are solar energy (for all communities), energy from biomass and biogas from agricultural biogas plants. It has been assumed that the increase in the use of renewable energy (in this case PV installations) in the areas in question was mainly caused by the economic incentives. After the initial period (2015–2018) of lack of interest, there was a significant increase in the number of RES installations installed. PV installations prevailed. After the analysis, it seems that the increase in interest and installation of PV installations was mainly due to attractive, local subsidy programs, which significantly improved operational efficiency and shortened the payback time on investments in photovoltaic micro-installations. The adopted hypothesis was confirmed.

Keywords: Climate change, RES, sustainable energy management, rural areas

INTRODUCTION

The main threats to the rural areas surrounding cities are climate change and human activity. The effect of climate change is mainly increase in temperature, combined with the intensity and frequency of extreme weather events. They may be exacerbated by the inappropriate use of agricultural land, in particular changes to non-agricultural and non-forest use. In rural areas, especially in the areas directly adjacent to the city, uncontrolled urbanization (including urban sprawl) often takes place. Areas with scattered development generate the need to expand the technical infrastructure, in particular the power grid, water supply and sewage systems. Due to new legal regulations, imposing the necessity to use heating system in buildings that are less harmful to the environment and people (Introduction of restrictions on the operation of installations in which fuels are burned in the Silesian Voivodeship Resolution, 2017), the forecasts in which old, worn-out heating installations were indicated as the

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main source of pollution (Ministry of Agriculture and Rural Development, 2011) are no longer valid. Climate change and its consequences remain a growing problem.

Rational, sustainable energy management and the use of renewable energy sources (RES) is one of the ways to combat climate change. Reduction of CO_2 emissions, achieved, among others, by increasing use of renewable energy, has been included in many documents adopted by Poland, such as the Kyoto Protocol or the "Paris Agreements".

The article is a continuation of the issues related to sustainable energy management and the use and development of renewable energy sources in rural areas of the southern subregion of the Silesia voivodeship presented in (Halama, 2016).

The aim of the study was to evaluate the energy economy, in particular the use of renewable energy sources in the Żywiec district in 2015–2020. Selected comparative methods and in-depth case studies were used.

It has been assumed that the increase in the use of renewable energy (in this case PV installations) in the areas in question was mainly caused by the economic incentives. The "Sustainable Energy Action Plan" (SEAP, polish PGN) was adopted as the baseline, which should include detailed plans for the use of renewable energy sources and other planned activities aimed at reducing energy consumption, CO_2 emissions and increasing the use of renewable energy sources by 2020. Information obtained from Tauron Dystrybucja S.A. on the number of micro-installations in powiats was used. The article finishes with summary.

Rationale for the development of renewable energy sources

The first international actions towards climate protection took place in 1992 at the United Nations Framework Convention on Climate Change (UNFCCC). The key goal was to reduce the human impact on climate change by reducing greenhouse gas emissions. The provisions of the Convention were made more precise in the so-called 1998 "Kyoto Protocol".

Poland's accession to the European Union in 2004 was associated with the adoption of EU obligations, but also with the co-creation of the EU climate and energy policy. The next stage in climate policy was the "Paris Agreement', ratified by Poland in 2018. The milestone was the agreement concluded in 2020 on climate neutrality by 2050. This is to be achieved by reducing the emission of "European" greenhouse gases by 55%. Achieving this goal will require a number of actions in all sectors of the economy (European Commission, 2021), including:

1. Investments in environmental-friendly technologies;
2. Supporting industrial innovations;
3. Introducing cleaner private transport;
4. Decarbonization of the energy sector;
5. Making buildings more energy-efficient.

However, climate "neutrality" alone is insufficient. Simultaneously with the emission reduction goals, measures are taken to adapt to the, seemingly inevitable, climate change. In Poland, such a document is the "Strategic Adaptation Plan for sectors and areas sensitive to climate change until 2020 with a perspective until 2030" (hereinafter SPA) (Ministry of Environment, 2013).

The SPA indicates adaptation measures that should be taken to ensure sustainable development and effective operation of the economy and society. In the energy sector attention was paid to (Ministry of Environment, 2013):

1. Vulnerability of the overhead energy transmission networks predominant in Poland (exposed to extreme weather phenomena, e.g. hurricanes, storms and heavy snowfall);
2. Possible reduction in efficiency of conventional power plants that require significant amounts of water for cooling purposes;
3. Possible reduction in the amount of biomass;
4. Deterioration of wind conditions and increased unpredictability of energy generation from wind, which may cause increased risk of failure or destruction of the installation.

The only positive effect of climate change in the energy sector may be in the improvements in the solar energy sector, which should be more efficient

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Table 1. Selected directions for action 1.3 – adaptation of the energy sector to climate change

No.	Name of the adaptation activities provided for in the SPA	Main responsible institutions	Selected areas of development strategy containing adaptation activities
1.3.1	Developing alternative energy production opportunities at the local level, especially for heating and air conditioning in less densely populated areas	MG/ jst	1.3.5 Diversification of sources, efficient use of energy and responding to natural hazards 5.5. Increasing the use of renewable energy sources in rural areas 2.6. The growing importance of distributed renewable energy sector 4. Supporting the sustainable development of urban centers, including counteracting the negative effects of suburbanization
1.3.2	Provision of emergency energy sources and transmission in cases where the use of primary sources will not be possible	MG/ jst Energy distributors	2.4. Modernization of the commercial power sector, including preparations for the introduction of nuclear energy 1. Increasing the capacity of cities to create development, growth and employment
1.3.5	Supporting the development of RES, in particular micro-systems in agriculture	MG/ Energy distributors	1.3.5 Diversification of sources, efficient use of energy and responding to natural hazards 2.7. Energy development of suburban and rural areas

jst – local government units
MG – Ministry of Economy
Source: Ministry of Environment (2013).

with extended periods of sunny weather and shorter duration of winters. Adaptation measures in the energy sector are summarized in Table 1 (Ministry of Environment, 2013):

DETERMINANTS OF THE RES DEVELOPMENT

Specifics of RES and the possibilities of their application

Energy from fossil fuels (i.e. primary energy) is a non-renewable resource and, of course, it has been gradually depleted. Combustion of fossil fuels (especially as part of the so-called low and unorganized emissions) causes significant air pollution. In theory, renewable resources / energy sources are inexhaustible. Usually, micro-installations and small installations do not generate negative consequences in the environment[1], unlike, for example, large hydroelectric power plants and windmills. Large RES installations generate many negative impacts in the environment, and thus raise objections from environmental organizations.

The most important, renewable energy sources most often used in small and micro-installations include solar energy and biomass energy. The use of wind energy has been virtually completely halted by the so-called "Windmill Act" (Investments in wind farms Act, 2016).

The spatial distribution of renewable energy generation is not even in Poland. Renewable energy sources, such as wind or geothermal energy, are not evenly distributed in Poland. The solar energy (radiation) is distributed most evenly. The average amount of solar radiation for Poland is 1000 kW/m^2 and is equivalent to 100 l of fuel oil or 100 m^3 of natural gas (Szpryngiel, 2012). Solar energy can be converted into:

1. Heat, through solar collectors to heat domestic water or as support of basic heating (less frequently);
2. Electricity through photovoltaic panels (photovoltaic).

Renewable energy installations, especially photovoltaic ones, require the so-called smart metering, and increase in the number of photovoltaic installations

[1] Except disposal problems.

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installed requires the modernization of transmission networks, preferably to the standard of the so-called smart grids.

Formal and legal conditions for the use of renewable energy sources

Achieving the reduction goals and adaptation to climate change through the use of renewable energy sources, and in particular investments in photovoltaic micro-installations, is supported legally and economically in Poland. The most important act, which contains the basic principles of shaping the state energy policy, rules and conditions for the supply and use of fuels and energy, including heat, and the operation of energy providers, is (Energy Law Act, 1997). The purpose of the Act is, i.a., creating conditions for the sustainable development of the country, ensuring energy security, economic and rational use of fuels and energy (Energy Law Act, 1997). The above Act regulates, among others, the issues of energy transmission and connection of RES installations.

Detailed conditions and rules for conducting activities in the field of electricity generation from renewable energy sources, together with mechanisms and instruments supporting the production of, among others, electricity from renewable energy sources, biogas and heat are included in the Act on RES (Renewable energy sources Act, 2015).

In Renewable energy sources Act (2015), among others, a micro-installation was highlighted, defined as a renewable energy source installation with a total installed electrical capacity of no more than 50 kW, connected to the power grid with a rated voltage lower than 110 kW, or with an maximum thermal power in combination of no more than 150 kW, of which the total installed electric power is not more than 50 kW (Renewable energy sources Act, 2015). If a RES installation achieves an installed electrical power between 50 and 500 kW or a thermal achievable power between 150 kW and 900 kW, it is referred to as a small installation (Renewable energy sources Act, 2015).

As a rule, starting and performing the economic activity in the field of generating electricity from any energy sources (including renewable energy) requires a license on the terms and conditions specified in the Energy Law. Excluded from this requirement is electricity produced:
– in micro-installations,
– in a small installation,
– from agricultural biogas.

Generation of electricity from the above-mentioned sources by a private person is not understood as economic activity (which allows to avoid additional costs and arduous requirements). In the case of small installations, an entry in the register of producers is required. The register is held by the Energy Regulatory Office (hereinafter ERO) – Art. 17 (Renewable energy sources Act, 2015). There are a number of additional obligations (mainly various types of notifications) that will not be discussed due to the limited size of this study.

The most important economic instruments supporting the development of renewable energy sources are non-returnable subsidies and loans with preferential interest rates. At the national level, these include:
1. The "My Electricity" program, dedicated to supporting the development of prosumer energy, in particular the segment of photovoltaic (PV) micro installations. The maximum amount of the subsidy is 5,000 PLN. The program started in August 2019. Currently, the third edition is planned (Ministry of Climate and Environment, 2021);
2. Tax relief, the so-called "Thermomodernization relief", addressed only to owners or co-owners of single-family homes, with ownership of the real estate. It is possible, among others, to deduct the costs of thermal modernization and installation of PV panels from tax.

Local instruments and programs to support the development of renewable energy are often available. They will be discussed in the chapter describing the studied area.

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CHARACTERISTICS OF THE STUDIED AREA

The subject of the research were activities in the Żywiec district in the field of sustainable energy planning and RES development, with particular focus on the use of photovoltaic micro-installations. The Żywiec district is part of the southern sub-region of the Silesian Voivodeship. The administrative structure of the district consists of: one municipality: Żywiec and fourteen rural communities. The district is bordered by the Bielsko and Wadowice districts to the north, the Sucha district to the east, Slovakia to the south and the Cieszyn district to the west. The district's area slightly exceeds 1000 km^2, which puts it in second place in terms of size. The population is 153 thousand people. The average population density is ca. 150 people per km^2. The largest density is in the Żywiec municipality and the lowest in the Ujsoły community. This area is presented in Fig. 1 and the most important data in Table 2.

The most important urban centers to which the inhabitants of the district commute are the cities of Bielsko-Biała and Żywiec. In most communities of the Żywiec district there are unfavorable phenomenon and development trends, including very poor transport accessibility and structurally weak agriculture (Marshal's Office of the Silesian Voivodeship, 2014). An important factor is the activity of the residents, thanks to which all rural communities in the Żywiec district belong to the group with good access to public services, generally participating in development processes (Marshal's Office of the Silesian Voivodeship, 2014).

The landscape and natural, recreational and touristic properties of the rural communities of the Żywiec district, located in the southern part of the voivodship, predestine them to fulfill tourist, recreational and service functions (Strategy, 2015).

The air quality in the Żywiec district is low. Table 2 shows the exceedings of selected compounds in the communes of the Żywiec district.

Table 2. Exceeding the concentrations of selected compounds in the municipalities of the Żywiec district in 2020

No.	Municipality	Particulate matter PM10	Particulate matter PM2,5	Benzo(a) pyrene
1	Żywiec	X	X	X
2	Czernichów			X
3	Gilowice	X	X	X
4	Jeleśnia	X		X
5	Koszarawa			X
6	Lipowa	X	X	X
7	Łękawica	X	X	X
8	Łodygowice	X	X	X
9	Milówka	X	X	X
10	Radziechowy-W	X	X	X
11	Rajcza			X
12	Ślemień			
13	Świnna	X		X
14	Ujsoły			X
15	Węgierska G.	X	X	X

X – Exceeding the concentrations

Source: own study based on Chief Inspectorate for Environmental Protection (2020).

The main factor influencing the low quality of atmospheric air in the district is the so-called low emissions and transport. Hard coal is still the most popular fuel, due to the low coverage of the gas network and high gas prices. Air quality is an important factor influencing the residents' quality of life and the socio-economic development, and in this region also the tourist development. The use of renewable energy sources is one of the ways to fight air pollution.

There are conditions for the use of RES in the district. Preferred RES according to (Institute of Mineral Resources and Energy Management, 2005) in the area of the rural municipalities in question are: solar energy (for all municipalities), energy from biomass and biogas from agricultural biogas plants (Table 3).

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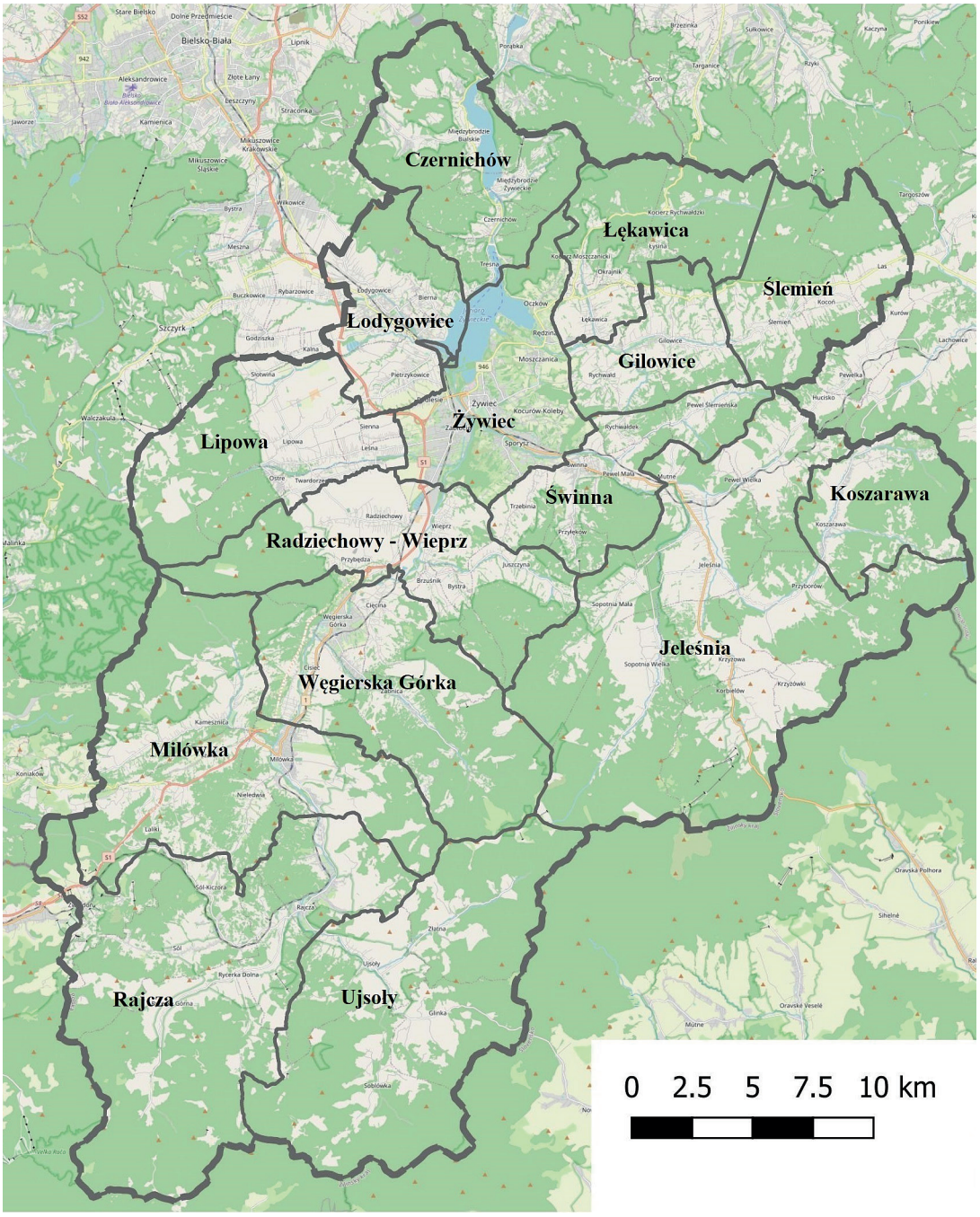

Fig. 1. Map of the Żywiec district
Source: own study based on OpenStreetMap.

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Table 3. Statement of population and income per 1 inhabitant in 2019 and directions of RES use in the Żywiec district
Note: Energy from solar radiation applies to the entire area of the Silesian Voivodeship

No.	Municipality	Population	Income per 1 inhabitant (PLN)	Directions of development preferred for implementation short-term investments	Directions of development of possible long-term investments
1	Żywiec	31,091	1,178.13	–	–
2	Czernichów	6,740	931.73	–	–
3	Gilowice	6,251	854.31	–	–
4	Jeleśnia	13,275	754.94	Surface Water Energy Wind Energy	Biogas energy from agricultural biogas plants Energy from biomass
5	Koszarawa	2,367	717.12	Wind Energy	–
6	Lipowa	10,846	946.53	–	Biogas energy from agricultural biogas plants
7	Łękawica	4,552	840.45	–	Biogas energy from agricultural biogas plants Energy from biomass
8	Łodygowice	14,567	1,018.35	Biogas energy from agricultural biogas plants	–
9	Milówka	10,067	700.58	Surface water energy	Biogas energy from agricultural biogas plants
10	Radziechowy-W	13,079	769.87		Biogas energy from agricultural biogas plants
11	Rajcza	8,810	750.21	–	–
12	Ślemień	3,531	875.68	–	–
13	Świnna	8,070	893.47	–	Biogas energy from agricultural biogas plants Energy from biomass
14	Ujsoły	4,430	572.93	–	–
15	Węgierska G.	15,080	852.46	–	Biogas energy from agricultural biogas plants Surface water energy

Source: own study based on Halama (2016), www.stat.gov.pl, Institute of Mineral Resources and Energy Management (2005).

Table 4. Register of energy generators in a small installation

No.	Entry date	Manufacturer	Place of business	Type of RES	Scope and type of activity performed
1	07.05.2015	„MEW" s.c. Mała Elektrownia Wodna Paweł Wiewióra, Agata Wiewióra	Żywiec	WO – Hydropower installation generating electricity	35.11.Z Generation of electricity from renewable sources
2	17.07.2018	Miejskie Przedsiębiorstwo Wodociągów i Kanalizacji Spółka z o.o.	Żywiec	BG electricity and biogas in cogeneration	BG electricity and biogas in cogeneration

Source: own study based on Register of energy producers in a small installation (2021).

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ENERGY MANAGEMENT AND RES DEVELOPMENT IN THE ŻYWIEC DISTRICT

Data and plans for the use of renewable energy sources, most often for the years 2015–2020, contained in the documents prepared in 2014–2015 (called SEAP), were adopted as a reference level. Adoption and passing by the community of a low-emission economy plan was not obligatory, however it was argued, as a kind of incentive, that only the investments included in the plan could be subsidized, both from EU and national sources. Therefore, it was an important document, the adoption and passing of which was in the interest of the community. The preparation of SEAP was based on information obtained from stakeholders (residents of communities), and the passing had to be preceded by public consultations. For this purpose, the study (Halama, 2016) was used, in which the SEAPs, presented by rural communities located in the Żywiec district, were analyzed. When analyzing the plans, the main difficulty was the differences in the way of presenting data and estimating the effects of activities planned at SEAP. Often, short-term and long-term goals have been mixed up. Data were not presented consistently. The key ecological effect was the reduction of CO_2 reduction, obvious energy savings were ignored. Some of the missing data were supplemented on the basis of the given CO_2 reduction, assuming that the dominant and most frequently used energy carrier is still hard coal (due to the district's properties). For this purpose, CO_2 emission factors for 2014 were used (The National Centre for Emissions Management, 2014).

Planned investments

When analyzing the plans of the residents of the Żywiec district to invest in renewable energy in 2014–2015 (included in SEAP), it is not difficult to notice their low activity. In total, in the light of the declarations included in SEAP, the residents of the district planned to install a total of only 47 PV installations in the years 2015–2020 (Chart 1).

It is difficult to see any relationship between the population and income, and the number of planned investments in renewable energy. The reason could be the low ecological awareness of the residents, the "fledgling" market of PV panels and the lack of economic support. No investments in biogas plants were planned, which should be the preferred investments in rural areas. It could have been caused by the dominant tourist and recreational function of the surveyed communities.

Implementation of plans in 2015–2020

In the analyzed period, the investment conditions changed, new economic support instruments were introduced, both for renewable energy sources and selected pro-ecological activities. Apart from the generally available economic instruments used throughout the country, which could be used by all residents of the district, selected communities of the Żywiec district introduced additional support programs. The most important of them are:

1. Low Emission Reduction Program (hereinafter referred to as PONE), implemented in the city of Żywiec since 2007, subsidised by the Wojewódzki Fundusz Ochrony Środowiska i Gospodarki Wodnej (Provincial Fund for Environmental Protection and Water Management), addressed to individuals who modernize heat sources in their homes. The main focus is placed on the replacement of heat sources. Coal-fired boilers were still allowed. The maximum amount of subsidies is up to PLN 6000 (https://www.ekoterm.ig.pl/index.php/pone; Resolution, 2021).
2. „Słoneczna Żywiecczyzna". It enables co-financing of the implementation of, i.a, 2,228 photovoltaic installations in 10 communities of the Inter-Communal Union for Ecology of the Żywiec district (i.e. Gilowice, Jeleśnia, Koszarawa, Lipowa, Łodygowice, Milówka, Radziechowy Wieprz, Rajcza, Ujsoły, Żywiec) (http: //zywiec.ascalor.pl/). The maximum amount of the subsidy is PLN 4,200 excl. VAT/kWp, in total not more than PLN 42,000 excl. VAT (Resolution, 2019).

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3. Reduction of low emissions in the area of the activities of the Inter-Communal Union for Ecology in Żywiec Stop Smog. Subsidies for the replacement of boilers and for renewable energy sources from 2018. Currently, subsidies only for 144 photovoltaic installations can be obtained. Co-financing maximum PLN 42,105.26 incl. VAT (Intercommunal Union for Ecology in Żywiec, 2021).

When analyzing period 2015–2020 on the number of connected micro-installations (mainly PV), a significant increase in their number could be noticed, especially from 2019. The number of new micro-installations in 2019 is 247, while in 2020 it is already 1,754 (Chart 2). The terminology "new micro-installations" should be understood as the installation of a new RES source on a new or existing building. The share of micro-installations in the total number of meters is summarized in Chart 3. It shows that PV installations are also installed on existing buildings, as evidenced by an increase in their share from less than 0.7% (2019) to over 3% a year later.

In the Żywiec district, in accordance with statutory declarations and restrictions, no wind installations were established (data based on map analysis at https://mapy.geoportal.gov.pl). The closest location is in the vicinity of Lachowice. There is one biogas plant listed in 2018 to the register of energy producers in small installations (Table 3), item 2.

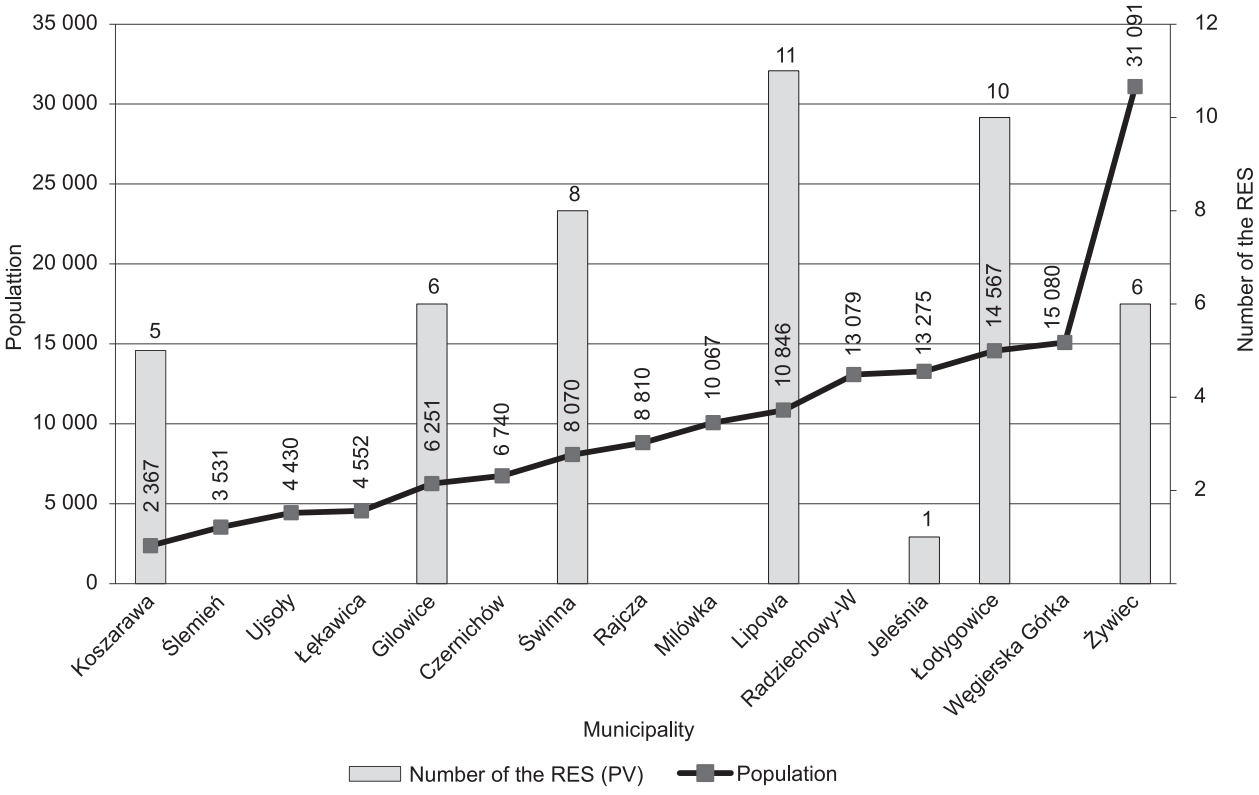

Chart 1. List of investments in renewable energy planned by the residents of the Żywiec district in 2015–2020. Communities ranked in ascending order in terms of population

Source: own study.

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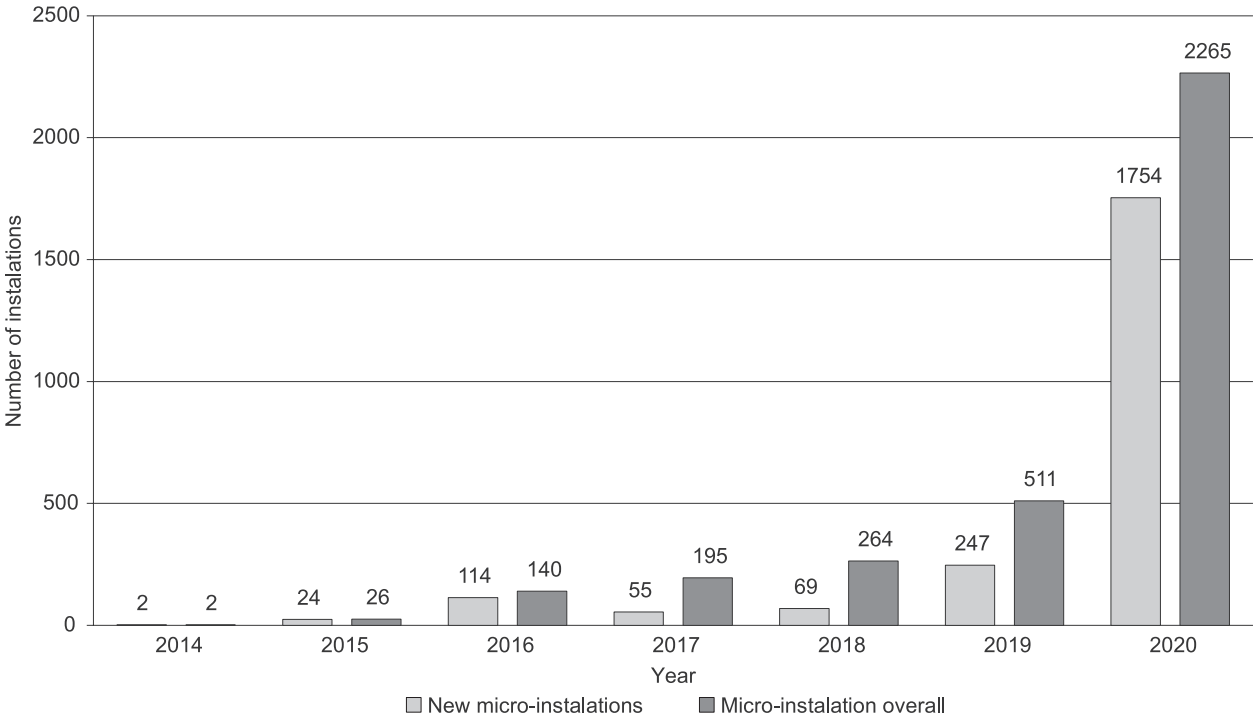

Chart 2. A summary of the number of micro-installations in the Żywiec district
Source: own study based on data from TAURON Dystrybucja S.A.

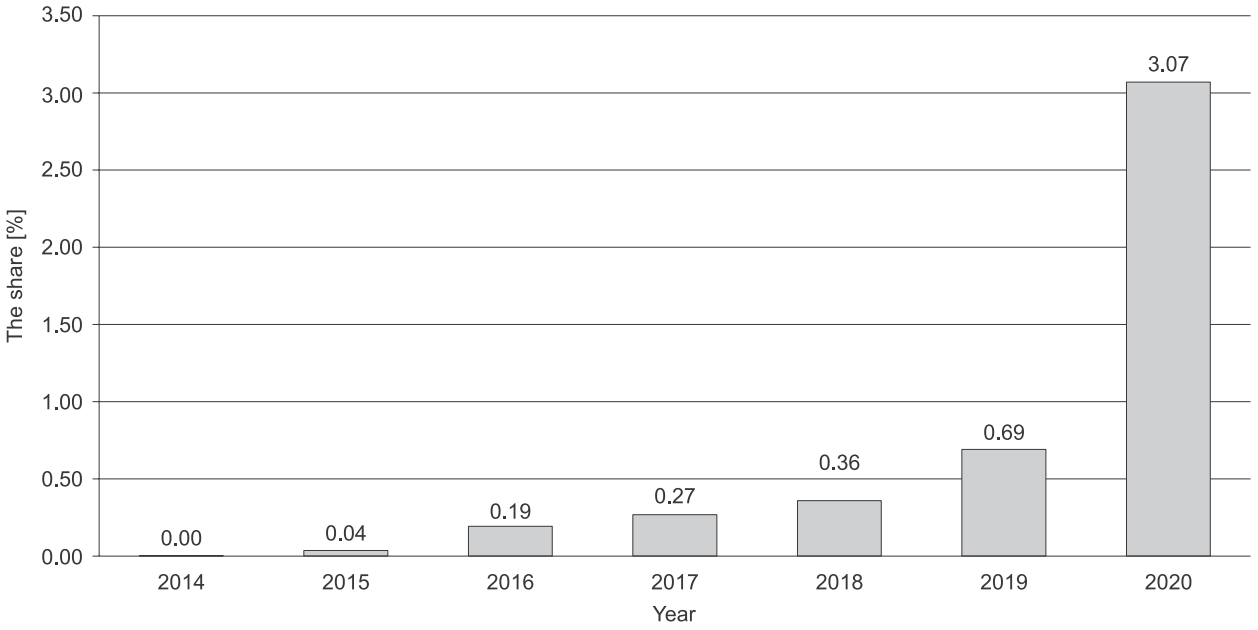

Chart 3. The share of micro-installations in the total number of meters in the Żywiec district
Source: own study based on data from TAURON Dystrybucja S.A.

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CONCLUSIONS

The most popular and used renewable energy in the Żywiec district is solar energy. After the initial period (2014–2016) of lack of interest (plans to implement only 47 investments in photovoltaic micro-installations were declared), there was a significant increase in the number of micro-installations installed. After the analysis, it seems that the increase in interest and commissioning of PV installations was mainly due to attractive, local subsidy programs, which significantly improved operational efficiency and shortened the payback time on investment in photovoltaic micro-installations. This confirms the adopted hypothesis. Attractive financing of investments with a long payback period is of particular importance in the case of low income of the population living in the area in question.

The expected increase in electricity prices and low bank interest rates in Poland may encourage more affluent people with financial resources to invest in RES.

Despite the creation of a seemingly attractive legal framework for investments in renewable energy sources, attention should also be paid to the high risk associated with planning investments in renewable energy sources. There is a lack of long-term, stable planning, especially in legal and financial matters. The rules of billing and purchasing energy from RES are changed relatively often.

Lack of interest in the use of biogas may be caused by the tourist and recreational function of rural communities dominating in the district, and the disappearance of large farms.

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