

DIGITALES ARCHIV

Żuk, Piotr; Żuk, Paweł

Article

Prosumers in action : the analysis of social determinants of photovoltaic development and prosumer strategies in Poland

Provided in Cooperation with:

International Journal of Energy Economics and Policy (IJEPP)

Reference: Żuk, Piotr/Żuk, Paweł (2022). Prosumers in action : the analysis of social determinants of photovoltaic development and prosumer strategies in Poland. In: International Journal of Energy Economics and Policy 12 (4), S. 294 - 306.

<https://econjournals.com/index.php/ijeep/article/download/13124/6843/30785>.

doi:10.32479/ijeep.13124.

This Version is available at:

<http://hdl.handle.net/11159/12290>

Kontakt/Contact

ZBW – Leibniz-Informationszentrum Wirtschaft/Leibniz Information Centre for Economics

Düsternbrooker Weg 120

24105 Kiel (Germany)

E-Mail: [rights\[at\]zbw.eu](mailto:rights[at]zbw.eu)

<https://www.zbw.eu/econis-archiv/>

Standard-Nutzungsbedingungen:

Dieses Dokument darf zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden. Sie dürfen dieses Dokument nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, aufführen, vertreiben oder anderweitig nutzen. Sofern für das Dokument eine Open-Content-Lizenz verwendet wurde, so gelten abweichend von diesen Nutzungsbedingungen die in der Lizenz gewährten Nutzungsrechte.

<https://zbw.eu/econis-archiv/termsfuse>

Terms of use:

This document may be saved and copied for your personal and scholarly purposes. You are not to copy it for public or commercial purposes, to exhibit the document in public, to perform, distribute or otherwise use the document in public. If the document is made available under a Creative Commons Licence you may exercise further usage rights as specified in the licence.



Prosumers in Action: The Analysis of Social Determinants of Photovoltaic Development and Prosumer Strategies in Poland

Piotr Żuk^{1*}, Paweł Żuk²

¹The Centre for Civil Rights and Democracy Research, Wrocław, Poland, ²Department of Sociology and Social Policy, Wrocław University of Economics, Poland. *Email: piotr.zuk@protonmail.com

Received: 13 March 2022

Accepted: 17 June 2022

DOI: <https://doi.org/10.32479/ijeep.13124>

ABSTRACT

The aim of this article is to explain the mechanisms that have increased the grassroots development of photovoltaics (PV) in Poland and to explain the motives of prosumers. Micro-installations have become a driving force for PV in Poland, thanks to which the country, whose energy industry is mostly based on hard coal and lignite, became the fourth PV growth market in Europe in 2020. Based on focus group interviews, the authors explain the motives of prosumers, the impact of investing in PV on changing their lifestyle, their readiness to switch to off-grid systems and their potential to create a prosumer social movement in Poland. The decentralisation of the energy sector and the mass prosumer response to the increase in energy price led the government to change the regulations in force in Poland from April 2022, which defined the method of settling the surplus energy given by prosumers to the grid.

Keywords: Micro-installations, Prosumers, Solar Energy, Photovoltaics, Off-grid System, Energy Solidarity, Prosumer Movement

JEL Classifications: Q42, Q48, Q55, O35

1. INTRODUCTION

Since 2019, photovoltaics (PV) in Poland has been undergoing a development boom. The installed PV capacity is gradually increasing and this rate of increase has been recently extremely high. The vast majority of PV in Poland is based on micro-installations and individual investments by people who want to avoid high bills and are afraid of further increases caused by the outdated and mainly coal-based energy system in Poland. At the same time, individuals invest in PV installations as they search for new products and want to become independent from state-owned energy companies. Due to this grassroots activity of Polish society, Poland has moved to the fourth place in the European Union (EU) (after Germany, Spain and the Netherlands) for the development and amount of PV energy. The total power from PV in 2019 was 838 MW, while 1,850 MW was installed in 2020, increasing the total operating PV capacity to about 3,150 MW (SolarPower Europe, 2020, p. 55). Due to this rapid development

of PV, Poland was in the first place in Europe in terms of the growth rate calculated based on the compound annual growth rate (CAGR) over the last five years of development (Instytut Energetyki Odnawialnej, 2021b). Table 1 shows in detail the dynamics of the increase in the number of micro-installations and the total capacity of micro-installations in Poland from 2016 to 2022. During this time, the number of installations increased over a two hundred times.

According to Solar Power Europe, the installed PV capacity in Poland will increase from 8.3 GW to 13 GW by 2024 and will remain in fourth place in terms of the rate of increase in new PV capacity (SolarPower Europe, 2020, p. 55). However, according to the forecasts of the Institute for Renewable Energy, the total installed PV capacity at the end of 2024 will amount to 12.5 GW (an increase of 8.5 GW since 2021) (Instytut Energetyki Odnawialnej, 2021a). This quantitative increase in the potential of PV micro-installations may not only affect the energy market, but

Table 1: Annual increase in the number of micro-installations and their capacity

	Number of micro-installations connected by DSOs (pcs.)	Total power of micro-installations connected by DSOs (GW)	Percentage increase in the number of micro-installations y/y (%)	Percentage increase in micro-installation capacity y/y (%)
As of 1 January 2016	4,080	0.030	—	—
As of 1 January 2017	16,173	0.102	296.40	240.65
As of 1 January 2018	28,778	0.183	77.94	78.78
As of 1 January 2019	54,214	0.343	88.39	87.34
As of 1 January 2020	154,426	0.992	184.85	189.30
As of 1 January 2021	457,443	3.007	196.22	203.09
As of 1 January 2022	853,958	6.071	86.62	101.68

Source: PTPiREE, <http://www.ptpiree.pl/energetyka-w-polsce/energetyka-w-liczbach/mikroinstalacje-w-polsce> (Last accessed on 2022 February 15).

also, in the long run, influence cultural, social and environmental changes in the approach to energy (Brown et al., 2020).

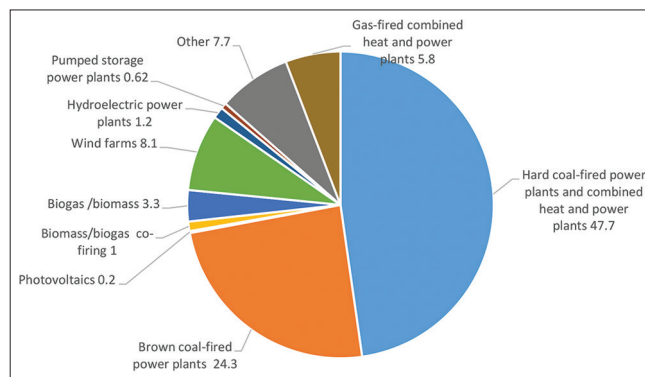
The aim of this article is to explain the mechanisms that drive this PV development in Poland and to explain the motives of prosumers. While there are known analyses of prosumer development paths in Western Europe (Inderberg et al., 2018; Stikvoort et al., 2020) and on a global scale (Keiner et al., 2019), there are no or very few analyses of prosumers in Eastern Europe. This article tries to fill this gap and answer the questions of whether this bottom-up shift towards PV can be the basis for developing a civic energy movement in Polish society and to what extent it can become a serious element of energy transition in Poland. The analyses are based on focus group interviews conducted with prosumers, data from reports showing the level of PV development, as well as information and data from the Polish Power Transmission and Distribution Association (PTPiREE).

2. POLAND’S SOCIAL AND ENERGY CONTEXT

Coal continues to be the dominant energy source in the Polish energy sector—in January 2021, as much as 72% of electricity production came from hard coal and lignite (Figure 1). Contrary to official statistics, however, major structural changes are taking place. Despite the dependence of the energy system on coal, the position of this energy source is beginning to falter. Its extraction in Poland is becoming more and more expensive and therefore it has to be imported—the amount of coal imported has been more than that exported since 2008, but this process has intensified in recent years (Czyżak et al., 2019). Due to the dependence on coal, the need to import it and the growing prices of the allowances of the EU Emission Trading System (EU ETS), energy prices in Poland are rising at a rapid pace. Additionally, in January 2021, the state introduced a hidden tax on energy, known as the “capacity fee.” This is officially called the energy security fee (constant electricity supply). In practice, it is a hidden form of surcharge, which is to cover the growing costs of maintaining coal-fired power units. Under these conditions, there is growing public support for environmentalists’ demands to abandon coal by 2030 (Żuk et al., 2021).

Although the myth of “black gold” and the “national treasure,” which had been in use in Poland since the communist times (Kuchler and Bridge, 2018), collapsed, official government media

Figure 1: Structure of electricity production (January, 2021)



still have a hostile attitude to the slogans of energy transition and the closure of coal mines, (Żuk and Szulecki, 2020) and environmentalists’ demands (Żuk, 2022). While this upholds the slogans of climate denialists even in certain business circles (Żuk and Żuk, 2021), there is also a bottom-up social shift towards tackling the rise in prices for “dirty energy.”

In general, the wave of right-wing populism, which has had a strong influence in Eastern European countries three decades after the collapse of the Eastern bloc (Żuk and Toporowski, 2020), has made the Visegrád countries (Czech Republic, Hungary, Poland and Slovakia) the main political and geographical blocks to the common climate and energy policy in the EU (Zapletalová and Komínková, 2020). Moreover, right-wing populism in both Poland and Hungary goes hand in hand with state centralism: in both countries, the governments defend the state’s full control over key entities in the energy sector and its infrastructure (Szabo and Fabok, 2020). Against the background of these dominant energy and political trends in Eastern Europe, the massive development of PV micro-installations in Poland should be considered a social phenomenon, and the decarbonisation process under these conditions is becoming not only a technological change, but also a real change in the social system (Żuk, 2017).

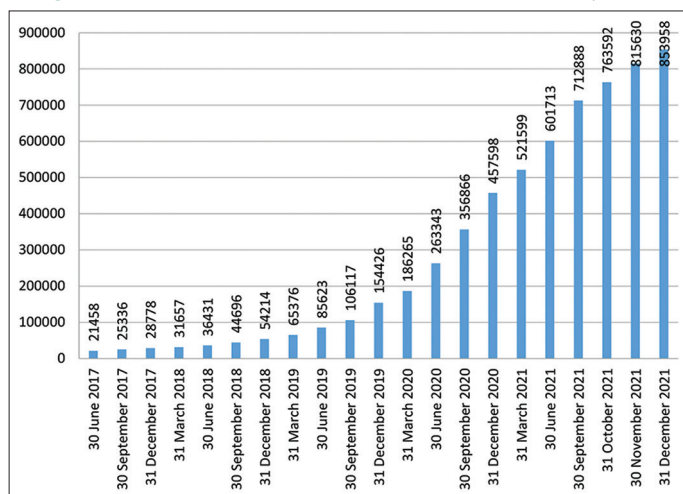
3. AN INCREASE IN THE PV POTENTIAL IN POLAND

2020 was a very good year for the development of PV in Poland. According to the PSE data, the installed PV capacity at the end of 2020 amounted to 3,935.74 MW, which was an increase of 2,463 MW year on year. This trend was driven by the activity of

prosumers. From the beginning of 2019, a dynamic increase in the number of micro-installations connected to the grid by distribution system operators (DSOs) has been observed. The year 2021 proved to be a record year for the development of PV in Poland. According to the PTPIREE’s data (Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej, 2021), from the beginning of 2019 to the end of 2021, the number of micro-installations increased nearly 16 times (by 1,475%) and their power capacity grew nearly 18 times. In 2021 alone, over 396,000 new micro-installations with a total capacity of over 3 GW were connected. By the end of 2021, the total number of all micro-installations connected to the DSO distribution network in Poland amounted to over 853,958 (Figure 2), and their power capacity exceeded 6 GW (Figure 3) (Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej, 2021).

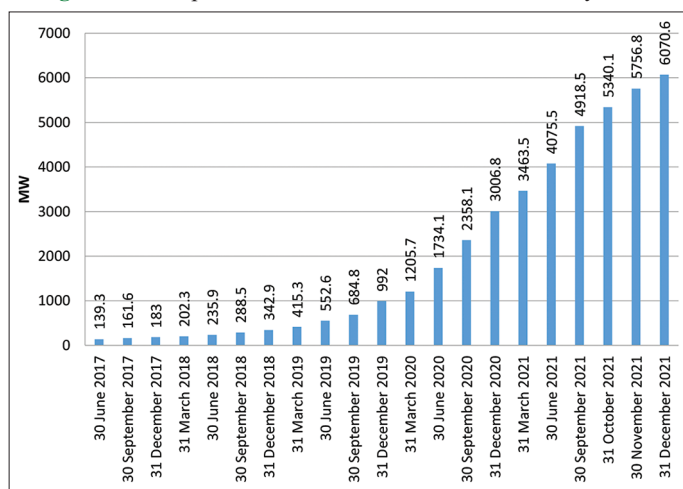
The structure of solar energy producers in the first quarter of 2021 clearly showed that the development of PV in Poland is based on

Figure 2: Total number of micro-installations connected by DSOs



Source: PTPIREE, <http://www.ptpiree.pl/energetyka-w-polsce/energetyka-w-liczbach/mikroinstalacje-w-polsce> (Last accessed on 2022 February 20).

Figure 3: Total power of micro-installations connected by DSOs



Source: PTPIREE, <http://www.ptpiree.pl/energetyka-w-polsce/energetyka-w-liczbach/mikroinstalacje-w-polsce> (Last accessed on 2022 February 20).

micro-installations purchased by prosumers. According to the Institute for Renewable Energy, the solar energy power structure was as follows (Instytut Energetyki Odnawialnej, 2021b):

- Micro-installations—installations with a total installed capacity not exceeding 50 kW; their total capacity amounted to 3,022 MW at the end of 2020 and 3,500 MW in the first quarter of 2021;
- Small installations—installations with a capacity of 50 kW to 500 kW; their installed capacity in Poland at the end of 2020 reached 65 MW and has recently exceeded 71 MW;
- PV installations with a capacity of more than 500 kW, which were created under the system of certificates of origin or outside the auction support scheme; their total installed capacity was estimated at 75 MW;
- PV installations built under the renewable energy sources (RES) auction; their total installed capacity was 750 MW at the end of 2020, and currently their capacity may be 820 MW; most often these are PV farms and solar power plants with a capacity of approximately 1 MW.

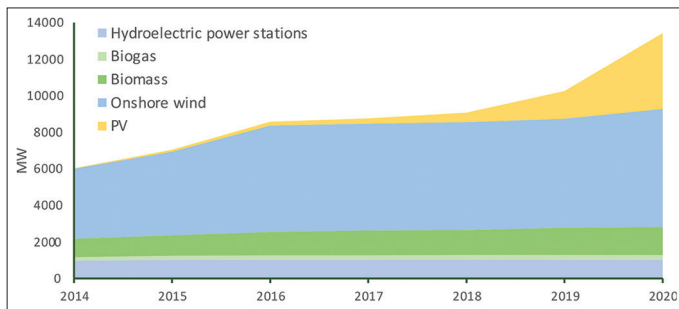
One of the main drivers of the growing number of prosumers was the subsidy system. EU funds from the Regional Operational Programmes offered a subsidy of up to 85% of the installation costs. In turn, the more extensive government programme “My Electricity” supported the installation of PV, regardless of its capacity, with a grant amounting to PLN 5,000 (approximately USD 1,300). Moreover, the money invested in PV could be deducted from income tax under the so-called “thermomodernisation relief.” The beneficiaries of the “My Electricity” programme could be individuals generating electricity for their own needs, and the installed electrical power of the PV micro-installations had to range from 2 kW to 10 kW. The first round of applications for the grant was from 30 August 2019 to 20 December 2019 and the second from 13 January 2020 to 6 December 2020 (Mój Prąd, 2021). The third round is due to start in the second half of 2021 and will be paid from EU funds. In the first round, a total of about 27,000 PV installations with a total capacity of 152 MW were co-financed. The total number of subsidies granted by May 2021 reached 199,000. According to all accepted applications, the total installed capacity reached 1.14 GW. Table 2 shows the number of micro-installations by province in the period until May 2021, and also indicates that the average power of PV installations in an individual household was about 5–6 kW (Instytut Energetyki Odnawialnej, 2021b). However, the “My Electricity” programme should be seen as action taken under pressure from the EU and a means to meet EU standards for renewable sources, rather than real support for civic energy. The success of the programme surprised government circles, who quickly decided to limit the development of prosumer energy, which is discussed in section 4.2.

The share of installed PV capacity in relation to the total installed RES capacity at the end of 2020 reached 30%, which is twice as high as in 2019. Thus, PV installations were ahead of biomass (11%), hydroelectric plants (8%) and biogas (2%). Onshore wind power continues to have the largest share, with 49% of installed capacity. However, these data indicate that PV has been the fastest growing RES in Poland for three years (Figure 4) (Instytut Energetyki Odnawialnej, 2021b).

Table 2: Implementation of the “my electricity” programme by provinces

Province	Amount of subsidies granted to PV installation projects	Total installation power [kW]	Average power [kW]	Percentage of households that received subsidies [%]
Śląskie	24,442	141,731	5.80	1.34
Wielkopolskie	23,463	133,882	5.71	1.91
Mazowieckie	22,271	126,761	5.69	1.07
Małopolskie	22,160	127,312	5.75	1.86
Podkarpackie	17,290	85,368	4.94	2.42
Dolnośląskie	13,293	82,393	6.20	1.15
Łódzkie	12,116	72,900	6.02	1.25
Pomorskie	11,471	65,626	5.72	1.32
Lubelskie	9,507	51,440	5.41	1.21
Kujawsko-pomorskie	9,190	55,653	6.06	1.17
Świętokrzyskie	7,433	39,200	5.27	1.63
Opolskie	5,906	37,549	6.36	1.58
Warmińsko-mazurskie	5,816	34,143	5.87	1.08
Zachodniopomorskie	5,575	32,864	5.89	0.82
Lubuskie	4,672	29,262	6.26	1.19
Podlaskie	4,142	22,962	5.54	0.92

Source: The Institute for Renewable Energy as of May 2021.

Figure 4: Installed capacity of RES installations for generating electricity (as of the end of 2020)


Source: Institute for Renewable Energy.

4. LEGAL CONDITIONS, TECHNICAL BARRIERS AND POLITICAL THREATS TO THE DEVELOPMENT OF PV IN POLAND

The massive grassroots actions of citizens investing in PV were a surprise to the authorities, energy companies and operators managing the distribution and infrastructure of electric networks. It turned out that this uncontrolled and spontaneous movement of prosumers might soon encounter various types of barriers and obstacles to the further development of PV micro-installations in Poland.

4.1. Technical and Infrastructure Barriers

According to PTPiREE (Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej, 2021), in most cases, micro-installations cooperate with the low voltage (LV) grid without interference and a negative impact on its parameters. However, a further increase in the number of micro-installations may lead to problems resulting from the presence of distributed generation in the LV grid. According to PTPiREE, the risk of problems with the cooperation of micro-installations with the power grid increases in the case of the single or combined occurrence of the following conditions:

- Power of a large number of micro-installations in an area supplying one transformer station converting medium voltage into low voltage (MV/LV);
- Large distance of micro-installations from a MV/LV power station;
- High line resistance and reactance (small wire cross-sections, uninsulated network);
- Low demand for energy during the periods of highest production capacity (hours of the highest insolation);
- Expansion of an existing micro-installation without the owner informing the DSO (Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej, 2021).

From the point of view of the electricity distribution networks, the main negative phenomenon is the risk of the failure to meet the power quality parameters at a specific point in the grid or in the entire LV circuit, resulting from an increase in voltages caused by the operation of PV micro-installations. Unstable operation of PV inverters sometimes causes an excessive increase in the long-term flicker index. It cannot be ruled out that with a further increase in the number and capacity of installed micro-installations, the LV grids will not also be overloaded.

DSOs face the challenge of implementing technical solutions aimed at eliminating or minimising the negative phenomena related to connecting a large number of micro-installations to the distribution networks. These activities include, but are not limited to (Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej, 2021):

- Assembling transformers with a capacity increased in relation to the customers' needs;
- Installing/replacing cables with ones with increased cross-sections;
- Shortening (if possible) 0.4 kV circuits;
- Constructing energy storage;
- Ensuring the possibility of controlling the operation of PV installations;
- Installing compensation devices.

Due to the early stage of the development of individual micro-installations, there are still no developed models that would ensure the reliable functioning of community micro-grids (Mashlakov et al., 2021) in Poland.

4.2. Legal Conditions and Changes to the Rules for Prosumers' Functioning in Poland

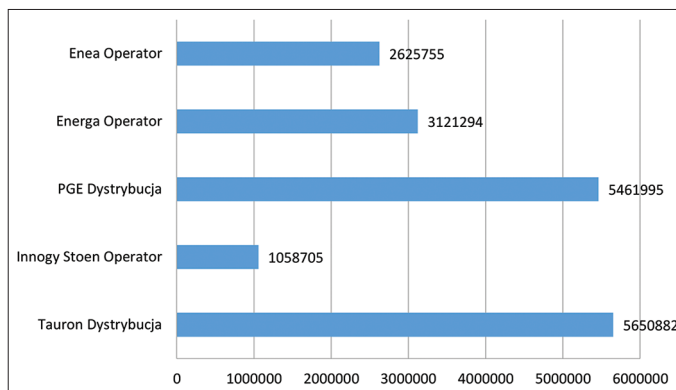
The grassroots activity of prosumers is regulated differently in individual European countries. The most favourable solutions for collective prosumers are found in France, Germany, the Netherlands and United Kingdom (Inês et al., 2020).

In accordance with the Energy Law Act, which has been in force so far and will be valid until the end of the first quarter of 2022, a recipient of energy from a PV installation may agree barter payments with the energy supplier. In exchange for electricity supplied to the grid (during the day and especially in summer), they can use for free, at other times (for example, in the evenings or in winter, when the PV installation does not work or has lower efficiency), 80% of the previously supplied energy. From the perspective of prosumers, the current solution acts as electricity storage which has an efficiency of 0.8 and does not need to be purchased. The prosumer only pays the distribution fee charged by the energy companies. Generally, regardless of whether it concerns traditional energy consumers or prosumers, energy companies transfer the costs of energy transmission to them. The system operating in Poland does not allow, for the time being, the exchange of energy between autonomous micro-grid prosumers as part of the peer-to-peer (P2P) energy transaction (Wang et al., 2020; Wilkinson et al., 2020).

Under Polish conditions, the largest electricity sellers lose the most from the increase in the number of prosumers—these are state-owned companies directly dependent on the government. For them, the mass development of prosumers has become their greatest threat. The market of energy distributors in Poland is divided by monopolists—Tauron and Polska Grupa Energetyczna (PGE) are the two largest in terms of both the number of customers (Figure 5) and the amount of distributed energy (Figure 6). Hence, in early June 2021, a draft act was published to amend the Energy Law Act and the Renewable Energy Sources Act (Minister Klimatu i Środowiska, 2021), according to which the current solutions for prosumers will only be in force until the end of March 2022. Anyone whose micro-installation starts electricity production from 1 April 2022 will only be able to sell surplus energy (until now this was not possible in Poland)—prosumers will be billed in the net-billing system. They will sell their surplus energy supplied to the grid, and in the case of consumption from the grid, they will pay the same as all consumers and bear the full cost together with the distribution fee, which will be a less advantageous solution than the current one. The price at which prosumers will sell energy to the operator will be calculated based on the average wholesale energy price in a given month. On the other hand, the retail price resulting from the tariff will remain the price of energy purchased from the operator. This means that the owners of the installations will sell the energy they produce at a lower price and buy it at a higher price.

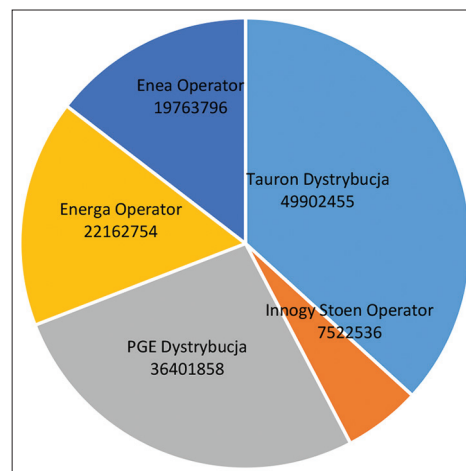
There have been concerns that the new regulations may slow down the growth in the number of micro-installations. Who will

Figure 5: Number of clients connected to the grid (data as of the end of 2019)



Source: PTPiREE, <http://www.ptpiree.pl/energetyka-w-polsce/energetyka-w-liczbach/dane-liczbowe> (Last accessed on 2021 July 03).

Figure 6: Volume of distributed energy in 2019 (MWh) by energy companies



Source: PTPiREE, <http://www.ptpiree.pl/energetyka-w-polsce/energetyka-w-liczbach/dane-liczbowe> (Last accessed on 2021 July 03).

benefit? State-owned energy companies and the coal industry, which supplies coal as the main fuel for power plants belonging to energy companies. This state framework defining the principles of how prosumers' function will hinder the development of social and civic energy and also block bottom-up ways to improve the reliability of energy services (Chen et al., 2021). There are also opinions that the technical barriers in the transmission networks were one of the reasons for the creation of the draft act that will delay the development of PV in Poland.

4.3. Political Barriers to the Development of PV

However, the draft amending the energy law should be associated primarily with political conditions and the lack of a stable energy policy in Poland. The vision of energy transition shared by the right-wing populist Law and Justice (PiS) government, which has been in power in Poland since 2015 (Żuk and Toporowski, 2020), differs strongly from the postulates of just transition, the constant elements of which are the decentralisation of energy systems (Forman, 2017), civic involvement (Soutar and Mitchell, 2018) and the idea of energy democracy (van Veelen and van der Horst,

2018). It can be said perversely that the populist authorities in Poland have noticed very quickly that PV, being so dynamically installed by citizens, has dangerous political potential for social self-organisation and offers an opportunity—arising from energy transition—for democratisation and the empowerment of citizens (Coy et al., 2021). They are afraid that state-owned energy companies will lose profits and that the prosumer movement will become politicised. Energy transition in Poland generally heralds the destabilisation of the existing energy and political order as was also the case in many other countries, where the coal industry played a significant role (Turnheim and Geels, 2013).

The grassroots civic energy transition variant is generally at odds with the vision of state policy. Firstly, the government wants to keep coal-based power plants and mines that supply coal fuel for as long as possible. According to government policy and an agreement signed with the mining trade unions, coal mining in Poland is to be guaranteed until 2049 (Furtak and Czoik, 2021). Secondly, it is not the development of dispersed renewable energy, but the development of nuclear energy that is the main element of energy transition and the way to reduce the role of coal. The government's forecasts predict that in 2035, nuclear capacity can generate even more than 20 TWh: "This is nearly twice as much energy as will be obtained in the same period from PV, with nearly 4.5 times less installed nuclear capacity" (Ministerstwo Klimatu i Środowiska, 2021). This trend is clearly expressed and confirmed in the planned investments presented in the government programme document entitled "The Energy Policy of Poland until 2040." Most state-owned investments in the energy sector by 2040 are to be allocated to nuclear energy (PLN 104.8 billion/USD 26.8 billion) and offshore wind farms (PLN 125.8 billion/USD 32.25 billion). In comparison, solar energy can count on PLN 27.6 billion (USD 7 billion) by 2040 (Horstink et al., 2021).

For these reasons, the grassroots energy activity of citizens cannot gain the support of the authorities, but the attempt to discourage the development of PV micro-installations has come as a surprise for society. The plans of the Polish government are once again going in the opposite direction to EU energy policy, which envisages a transformative shift from centralised, fossil-fuel based systems to decentralised systems based on RES (Horstink et al., 2021). The question that looms on the horizon is whether the systemic barriers encountered by individual prosumers will hinder the development of micro-installations in Poland or instead will encourage them to establish prosumer organisations which will act collectively. This issue is particularly important in the context of the energy crisis caused by the war in Ukraine – as access to cheap energy is threatened, prosumer energy may receive a new stimulus for development (Żuk and Żuk, 2022b).

5. RESEARCH METHODS

The research was carried out in June 2021 using the focus group interview method. There were four groups and each consisted of eight participants who were guaranteed anonymity and free speech. The interviews were recorded and then transcribed. The transcribed material was the raw material for the qualitative analysis. Each interview lasted approximately 1.5 hours and was moderated by one of the authors of this article. The participants selected for the

interviews were prosumers who had invested in solar panels for their own needs during the past two years. The interviews were conducted according to a previously prepared scenario. We were interested in five main issues: a) the reasons why the participants decided to install PV panels; b) the impact of the decision to invest in PV on changes in lifestyle; c) assessment of the settlement system with energy companies; d) views on the transition to an off-grid system; and e) analysis of the readiness for collective prosumer action and the potential to create collective energy entities.

The installations in each household of the surveyed prosumers had a power production capacity ranging from 3 to 10 kW and most often were 5–6 kW.

The material obtained from qualitative research is never a representative sample, but it allows for an in-depth understanding of the motives of a given environment and identification of additional issues that require further research, and also using quantitative methods.

6. RESULTS

6.1. Being a Prosumer: The Reasons for Installing Solar Panels

In macrosocial terms, prosumers are described as a manifestation of ecological citizenship (Islar and Busch, 2016), an element of broad energy-transition coalitions (Hess, 2018) or a new form of social movement (Campos and Marín-González, 2020) that democratise energy policy and change the ownership structure of energy suppliers. At the individual level, however, the reasons for becoming a prosumer are often more trivial: individuals want to avoid high bills and financial pressure from energy companies. This attitude is illustrated by the following two statements:

- *Savings, but it is also about ecology. When we have savings, we are not dependent on the supplier and price increases. I guess that was the basic element of my decision.*
- *First of all, economy, because we paid large bills for electricity. Even when you take credit for this installation, the loan instalment is PLN 100 less than the bill I received before.*

The reasons for becoming a prosumer are obviously more diverse and, in order to learn about them in Polish conditions, we wanted to assess the potential for transforming prosumer behaviour from the level of individual action to that of collective action. Sometimes people came into contact with PV by coincidence. As one of the participants stated:

- *My case was funny, because we were doing thermal modernisation of the house. We replaced the windows and insulated the building. The company that did this also installed solar panels. They said they were entering the market and wanted to build a show house. And they asked us if we would agree to it. Sure we would, just give us a nice discount, please. They did it with a good discount and that's it.*

When explaining their motives for action, a number of participants indicated both ecological and economic reasons:

- *I am aware that electricity in Poland is obtained from dirty sources. If you can combine environmental care with economy,*

why not? Of course, not only ecology, lest it sound idealistic, but it was one of the elements. Plus saving. We wanted to save funds.

Additionally, the theme of new consumption possibilities was repeated by prosumers:

- *A vision of an electric car in the future and a sauna, but also savings in order to generate electricity alone and not be so dependent on the companies that sell energy.*

The plans to purchase an electric car were repeated in several statements. However, unlike prosumers in Norway (Winther et al., 2018), prosumers in Poland, who treated PV as an element of an ecological lifestyle and a manifestation of a more environmentally friendly attitude, focused on PV firstly, and only planned the purchase of an electric car.

The pursuit of modernisation and new technologies does not necessarily entail the pursuit of deeper social changes (such as eradication of energy poverty and reduction of structural inequalities in the wider social context). Prosumers may only support technological modernisation in the energy sector, and not necessarily changes in other fields (Hess, 2018). On the other hand, engaging in renewable energy as a technological alternative to coal may lead to a further re-evaluation of personal preferences in other areas of public life. The following statements by two prosumers can illustrate this attitude:

- *I was curious about how this new technology really works. It is advertised a lot; a lot has been said about it. I wanted to check if it was effective and how it worked. I can say after these years of use that it works. Only now do I see what opportunities it offers and how it can change our lives.*
- *As I deal professionally with renewable energy sources, the eco-approach was dominant in my case. Economic issues are only in secondary. Firstly, I already use collectors to warm my water. I have a tank with heaters, so I can also heat them up with excess electricity. Besides, I also planned to use an electric car. So, it was an investment a bit ahead. For now, it is a bit oversized, because we do not have such power consumption yet. But we'll see what happens next.*

A completely different reason for investing in PV can be the pursuit of social security: investing in a peaceful and financially secure old age. In Poland, where the pension system is inefficient and the pensions expected in 20 or 30 years will be much lower than the current ones (Żuk and Żuk, 2017), many middle-aged people think of PV panels as an investment that will reduce the cost of living in the future. As one of the participants stated:

- *PV is an investment to get something for free. I think to myself, now I still have money, I work, I earn, I can afford it. I prefer to install it, because when I retire, I don't know what it will be like. I would like to live in this house almost free of charge. We also want to install recuperation. To become as independent as possible from fixed fees, to be financially secure in old age.*

Motivations related to investing in a peaceful old age and reducing home heating costs were repeated in several other statements by people of pre-retirement age. The problem of energy poverty

among elderly people seems to be a common challenge in contemporary societies (Chard and Walker, 2016). Hence, analyses of civic forms of renewable energy as a preventive measure of energy ageism should be a separate subject of research. These challenges can be illustrated by the following two statements:

- *We paid quite large electricity bills, over PLN 300. Moreover, we were a bit bothered by the fact that we only have heating in part of the house, downstairs, and not yet upstairs. Because we have not finished construction, but we already live downstairs, and it was cold upstairs. So, we just used infrared heating. We didn't want to be overwhelmed with bills. I took out a loan for seven years and I am actually repaying an instalment of PLN 120 more than normal bills. I have found that I am preparing for retirement in this way.*
- *Energy alone, plus expenses for fuel, regardless of whether it is coal or pellets, for a house like I have, that is at least PLN 10,000 per year. Well, having it in your pocket or spending it, that's the difference. In my case, it is also an investment for the future.*

6.2. Energy Efficiency and Changing Lifestyle

Some researchers emphasise that the decision to install PV for many prosumers is an element of a certain lifestyle (Thronsdén et al., 2017). Continuing this thought, PV can be a lifestyle-changing factor. In the first phase, after the panels were installed, the prosumers felt a certain enthusiasm and a sense of freedom and relief after the reduction of energy costs. As one of the participants stated:

- *I used to have this weekend rate with a split between peak and off-peak hours. When I turned on the dishwasher, washing machine or whatever, I took care to do this in those hours, because why should I pay more when the electricity meter was counting? Now it's over, we just turn them on when we need it. We no longer wait until 10 pm to turn them on. No need to wait.*

When the financial pressure related to electricity bills disappears, people tend to buy new utility items leading to an increase in energy consumption. This is evidenced by the following statements:

- *I have installed outdoor lighting at the house and in the garden. At the moment, I don't have to worry about the costs. I have invested in outdoor lights...*
- *We have air conditioning, so we'll probably be more likely to use it, but I'm frugal. However, it is perfectly correct that you can invest in additional lighting and stop limiting yourself.*
- *As soon as panels appear, new things appear. I also have it at the back of my head to buy an electric car. Now I drive a hybrid. I think I will change it, because the city of Wrocław promotes all these bus lanes, and then you can easily drive an electric car. I drive ninety percent of the time around the city, so it would be great for me.*

Similar behaviour was observed among prosumers in Sweden, who increased consumption when they installed PV and felt open access to “free energy” in their households (Palm et al., 2018). However, prosumers, more often than traditional consumers, express the intention to engage in environmentally friendly behaviour, attach more importance to it and more often recognise that such behaviour will improve their quality and comfort of life.

They also have more electricity awareness (Stikvoort et al., 2020). However, it is only in the second phase after PV assembly that a deeper reflection appears related to the interest in energy policy. According to one of the prosumers:

- *I was looking at what these PV look like and I started to be interested in them. That huge boom that was for heat pumps is now even bigger for PV. They look nice, because they are probably the size of the production from the Belchatów power plant (the largest power plant in Poland based on the combustion of lignite—authors' note). It has gone so far that I wonder what will happen to these power plants.*

The problem in Poland is the current legal regulations do not allow surplus electricity to be sold or transferred for free to other people or institutions. As it turns out, greater legal freedom to dispose of the energy produced may encourage saving energy from PV, as well as further investments in additional panel power. As Polish prosumers claim:

- *If they paid for all the surplus electricity put into the grid, we would save.*
- *Firstly, we would save, secondly, it would make sense to install more panels.*
- *Yes, it's true. After installing the panels, we don't save electricity at all. Nobody turns off the lights at home and there is no stress; I used to go and turn off all the lights everywhere all the time. If it were possible to manage this surplus electricity, it would be different.*

The PV technology itself does not guarantee that prosumers save energy—environmental motivations of users (Wittenberg and Matthies, 2016) and a citizen-friendly legal framework (Inês et al., 2020) are also needed for prosumers to organise and manage their electricity production. The ability to independently manage surplus energy turns out to be the key to both saving energy and the creation of supra-individual energy activities. The same factor plays a significant role in considering the switch to an off-grid system.

6.3. Self-sufficiency and Off-grid

Prosumers think about the possibility of switching to an off-grid system in the future primarily for two reasons. The first is the lack of enthusiasm for energy companies such as Tauron or PGE, which are the main sellers and distributors of energy in Poland. The second is power grid outages, which are quite frequent, primarily outside the big cities. It is not only about breakdowns caused by unfavourable weather conditions, but also the fact that the electricity network is not prepared for large prosumer production. As one of the participants claimed:

- *The current is not constant in the network. We have shutdowns because I reach 260 volts on the grid and the inverter turns off. The explanation of the lady from Tauron is trivial. There is no electricity because birds are sitting on the wires. Too high current, because we are the first to wire the transformer. She talks nonsense. Of course, a used battery from an electric car is less than 70% efficient, is relatively cheap and can be connected to it, and it is enough. However, we do not store this electricity for the winter periods. This is the problem.*

Other prosumers, however, pointed to technological limitations and the problem with electricity storage:

- *I did a little research on these topics. At the moment, there are no batteries in the world that can store electricity with a loss of 20%. It is just unreal. They are still so expensive that it is not profitable to put them on, the batteries occupy half of the garage...*

The aspect of additional financial investments for the purchase of a battery is treated as an additional burden. This is not only a problem for prosumers in Poland, but also for residents of countries such as Switzerland, where “the installation of batteries is only considered if the savings are large enough to justify the investment costs (i.e., the payback time of the batteries is shorter than their lifetime)” (Zapata Riveros et al., 2019). On the other hand, the temptation to become independent from energy companies is considered to be an argument for an off-grid system:

- *If we want to store energy ourselves, this current variant with billing according to the 0.8 index is fairly fair. If we wanted to store energy ourselves, we would have to invest a lot more in batteries. On the other hand, I would be tempted to buy such a battery and I would have my own electricity. To cut off from them. From these energy companies.*

When discussing the potential of an off-grid system, the participants also had philosophical and political reflections. One of the prosumers emphasised the possible political consequences of popularising an off-grid system:

- *I would be afraid to completely cut off from the network. If the panels break down, I prefer to have an alternative that exists with this network. If everyone switched to their own electricity, the energy system would crash. I cannot imagine the state functioning without a power plant, and that everyone has their own electricity. It would be beautiful, but it is probably not the time yet.*

This statement confirms the opinion that the uneven development of off-grid systems in the world is caused by political differences and the level of quality of democracy: law-abiding countries with stronger democratic institutions provide better conditions for developing an off-grid system and facilitate long-term investments (Aklin, 2021). In countries where there is a threat of changing regulations and authoritarian governments that make decisions without any public consultation, there is distrust and distance among citizens towards innovative activities that require long-term investments. Under such conditions, there is a tendency towards pragmatic and safe solutions. Such trends were also observed among Polish prosumers. Most of the participants were pragmatic and preferred reselling surplus electricity to the grid as the optimal solution at the moment:

- *If Tauron accepted these surpluses, I would be happy to sell them. Tauron should do this. It should be this way, in my opinion. If you have surpluses, they should be taken naturally, and not like now, that they will be lost after a year.*
- *You could add energy to the grid and get billed for it. It would be fair.*
- *I think that a large number of people would opt for a larger installation if there was a surcharge for electricity, for larger production.*

At the same time, prosumers noticed that selling electricity to the grid or even giving it free of charge violates the interests of energy companies in Poland and affects the condition of the mining industry:

- *The question is whether energy companies benefit or lose from it. From what they say, they lose from it. They also cannot store this energy.*
- *So, let's not burn so much coal.*
- *You can't, because the miners are so hard-headed.*

6.4. Social Potential for Developing the Prosumer Movement and the Unpredictable “They”

In addition to the ecological, technological and energetic aspects, the economic and political aspects are of key importance in prosumerism, regardless of the motivations of individual prosumers. Namely, the appearance of a new actor in the energy market not only disturbs the current balance established by energy and political hegemony, but it can also completely change the existing rules of the game. The very fact that current passive consumers are becoming active prosumers not only changes their economic position in terms of energy costs, but may also give them considerable political potential in the debate on the state's energy policy and undermine the prevailing institutional and market logic (Wittmayer et al., 2021). The appearance of prosumers certainly changes the ownership structure of energy production and is a form—though so far limited in scope—of socialisation of the energy production and distribution process. This limited range should be understood not only in the quantitative sense (the number of prosumers), but also in the class sense: the phenomenon of prosumerism so far primarily concerns residents of single-family houses. This class feature, which makes the middle class an over-represented category in the prosumer community, applies not only to Poland, but also to the United Kingdom (UK) (Sovacool et al., 2019) and other countries. In the debate on smart grids in the UK and the Netherlands, in addition to the positive aspects for sustainable development and energy transition, it was emphasised that “access might be restricted to more affluent parts of a population and reinforce monetary injustices faced by economically vulnerable citizens” (Milchram et al., 2018). This aspect of grassroots civic energy requires further critical analysis.

However, energy transition, of which prosumers are a significant part, threatens the current political and energy elites anyway. They may, however, have different attitudes to bottom-up transition processes (Sovacool and Brisbois, 2019): they may block grassroots civic activity in the energy sphere, attempt to colonise these forms of activity or join the main energy trend. Which of these models dominates depends on the political culture, the quality of democracy and the possibility of organising an open public debate in a given country. This was also noted by prosumers in Poland:

- *My point is that it is probably much easier to do such things in Scandinavia—in Denmark, Sweden—than in Poland. We would immediately say no because there are a hundred thousand different reasons. This problem with Tauron, it's about the infrastructure, it's about the transmission grid. Besides, the state is afraid of independent action. In the near future, within two, three, four years—it may seem like a utopia*

at the moment—the prosumer movement may become a form of political pressure on the state in regulating energy policy. It would be a manifestation of civil society.

Although in other countries, when entering the area of energy activity, the development of energy cooperatives and other grassroots civic entities encounters resistance from the existing solutions and state bureaucracy (Capellán-Pérez et al., 2018), this type of activity hardly exists in Poland. It was only in 2021 that the first energy cooperative in Poland, EISALL, based in Raszyn in the Mazowieckie province, was entered in the National Court Register (Gramwzielone.pl, 2021). Although the provisions of the 2019 energy law allow for creating energy cooperatives in Poland, they also significantly limit their development: the number of cooperative members may not exceed one thousand, and the installation capacity—30 MW. The biggest problem is that, according to the regulations, cooperatives cannot operate in municipalities, energy cannot be sold to anyone, 70% of generated energy must be used for their own needs, and the surplus can be stored in the grid, for which the grid operator will deduct as much as 4% of its volume (Ruszkowski, 2020). Prosumers also pay attention to these issues:

- *If it were reasonable, profitable and financially beneficial, I would definitely get involved in such a cooperative.*

The participants also indicated other solutions that exist in other countries and gave, for example, Germany as a model:

- *I think that we could adapt the German solutions. When the Germans built their wind farms, there was social resistance until they made local cooperatives. Suddenly, there was no such problem, because a number of people contributed to their wind turbine and they benefited from it every year.*

Due to the lack of trust in the decisions of the state apparatus, the lack of stable legal regulations and the conviction that the state wants to have a monopoly on the energy sector, some prosumers consider the organisation of collective prosumer entities to be a risky, or even dangerous, activity in Polish conditions:

- *It is a very dangerous topic in Poland. Because there is a very large tax for various home media and the government earns from it. And that is why it is so uncertain because when you choose anything from this pool, the state budget will receive less money. For this reason, it is a dangerous topic, and therefore it is not touched upon. Because if it was safe, many would have jumped out with such demands and would have started it a long time ago.*

The unpredictability of the state's decisions and the lack of permanent regulations defining the framework for prosumer activity not only block the collective actions of prosumers, but also hinder the decisions of people who have not yet become prosumers to invest in PV:

- *We have the idea of a cooperative. Everything is great, cool, beautiful. But note that when you talk to people who do not have PV, they say if it pays off, put it in, but you don't know what they will change in this law. Will it pay off? Most people fear that the government may change the rules at any time. It is difficult to plan here. And an activity such as an energy*

cooperative needs clear rules of the game, which the Polish state does not provide.

The personal pronoun “they” used in this statement is a symbol of authoritarian state authority: “they” are unpredictable, hostile to our activities, “they” can harm us, “they” create problems, “they” increase energy prices, and “they” do not like competition. This division into “we” (society) and “they” (the state apparatus) is typical of the populist-authoritarian power model. The example of the situation in Poland may illustrate this division in the energy sector. Referring to the model proposed by Ryan Thombs, who has distinguished four possible types of energy model (libertarian energy decentralism, technocratic energy centralism, democratic energy centralism and democratic energy decentralism), we can classify Poland as a typical example of “technocratic energy centralism,” which is “characterized by monopolistic control over political, economic, and civil institutions that are reliant on centralized energy systems” (Thombs, 2019). This issue shows how important but challenging it is to implement and study energy transition in societies that have a problem with democracy, the rule of law and a weak civic sphere.

6.5. PV as a Form of Mutual Aid and Energy Solidarity

Due to distrust of the state, grassroots energy activity is sometimes perceived by prosumers themselves as a type of activity that, on the one hand, cannot count on the support from the ruling elite but, on the other hand, is perceived as having a bottom-up (or, more radically, anti-systemic) potential: as an area of independent social activity and a support tool for specific social groups. This is a completely new approach: civic energy not only as an element of energy transition, a way to protect the climate, an element of economic activity, a way of creating one’s own identity, but also as an expression of social assistance. The energy surplus can be—just like a financial transfer—a way to support and express solidarity with specific institutions or communities. In its most moderate version, free surplus energy can be used for charity:

- *That would be as good as a tax write-off.*
- *Nice handing over some for a good cause. I don’t know anyone who would not make such a decision.*

The statements of prosumers about transferring energy surplus to someone in need were most often in opposition to Tauron, which, in their eyes, was a symbol of evil and a representative of state-owned energy companies:

- *If Tauron is to eat it, let someone better use it.*
- *Exactly. It could be like 1% (in annual tax returns in Poland, you can donate 1% of tax to a selected non-governmental organisation—authors’ note). Instead of giving it back to the state, you decide who you want to support.*
- *I have, for example, such befriended institutions, an education foundation that runs a “forest kindergarten.” I would be very happy to give them my surplus electricity—I simply sympathise with them, and I know that they have very big financial problems.*
- *But everyone in their local area knows someone like that. I have various foundations declared. I would love to give it to anyone. Except to Tauron.*

- *At least you know what it is spent on. There, in Tauron, everything is lost in bureaucracy. So is our money. Especially since I also had bad experiences with it. I say, hell, give them electricity for free if they cannot serve the customer?*
- *Knowing that we do not give it back to Tauron, but it goes to elsewhere, no matter where. No matter where, except to Tauron.*

These statements combined resistance against Tauron with the desire to help social organisations. But there were also opinions that prosumer activity could be a form of supranational aid and solidarity. If only there were technical and legal possibilities, the mass transfer of surplus energy on the international stage could be a strong voice of solidarity in international civil society and an element of social campaigns on specific issues. As one of the prosumer women stated:

- *I saw the bombing of Gaza on TV. There were also children there. If I had the opportunity, I would be happy to help these children by, for example, donating surplus electricity to one of the schools in Gaza.*

This statement is a perfect illustration of “energy solidarity” as one of the forms of moral progress, understood in the spirit of Richard Rorty:

as the ability to see more and more traditional differences (of tribe, religion, race, customs, and the like) as unimportant when compared with similarities with respect to pain and humiliation—the ability to think of people wildly different from ourselves as included in the range of “us” (Rorty, 1989, p. 192).

6.6. PV as a Social Breakthrough and Social Change

All the surveyed prosumers agreed that the appearance of PV in individual households was a social breakthrough and the beginning of wider changes in everyday life. As one of the participants stated:

- *I absolutely agree that energy should be based on renewable sources. This will speed up the change of cars. I have already started, like everyone here, wondering about an electric car. Of course, it is quite expensive at the moment and not easily available. However, I know that there is a Polish model of an electric car that is to enter the production phase. They have already shown it and it will somehow come soon. I think this PV speeds up and contributes to the cleaning of the environment. Within a few years, we will start switching to electric cars. It makes sense, because then commuting to work is also free. Not only electricity for the house, but also transport. This is a breakthrough solution for me, this PV. As I look at the possibilities of using this. It is for practically everything. Just add panels and you can have a self-sufficient house. Heating, electricity, driving a car. We have the most three important factors for free from PV. This is a breakthrough.*

This statement portrays PV as a functional breakthrough in an individual’s life in terms of home heating, transport and the use of electricity. This change concerns the social, economic and cultural spheres of lifestyle and is also a re-evaluation of how to look at social reality. Although the participants describe changes in their personal lives from an individual perspective, in the long run,

these changes will affect the rules of the game at the macrosocial level. These logical relationships between the micro-, meso- and macrosocial levels trigger a process of change whose overall effects are difficult to accurately describe. Prosumers, however, can sense the scale of these changes:

- *I think it will develop. If there is so much interest in PV and so many people are convinced of it, it will continue to progress.*
- *It is developing quickly. Like dynamite. One neighbour puts it on, the other one too. The third comes right away.*
- *It's a domino effect. Nobody wants to pay companies.*

This silent energy revolution, which began in Poland despite fears and the formal and legal obstacles put in place by the state, will certainly continue to develop. Like other countries, in addition to winners, there will be losers in these changes (Sovacool, 2021). In Poland, the candidates for the role of major losers so far are the centralised energy companies and the decaying coal industry.

7. CONCLUSIONS

Technological changes that undermine economic influence and existing socio-political structures are never neutral. Their potential for change is not always immediately noticeable. The rapid development of PV, which is based primarily on micro-installations in Poland, illustrates this thesis. Under Polish conditions, the process of energy transition reveals particularly clearly how technological changes combined with social changes can hit the existing energy and political order. This is due to several reasons. Firstly, the dominance of coal as the primary fuel in the energy system gives any alternative energy source a heretical rebel trait. Secondly, there is the political context, in which the populist right-wing government treats energy transition and the goals of the European Green Deal as another attack by the EU on the political and energy sovereignty of the country and the abandonment of coal (considered a national treasure for decades) not only means a technological change, but also entails cultural, political and social transformations. Thirdly, the social landscape dominated by centralised state structures overshadowed by low social activity and weak civil society make the mass movement of prosumers an important enclave of independent social activity. Due to all these factors, both in Poland and the whole of Eastern Europe, civic energy is gaining additional value and importance that goes far beyond the narrow aspect of energy.

This must certainly make the entire social and energy situation more dynamic and face obstacles from the existing energy and political regimes. Prosumers coming into conflict with the existing energy and political regime may—as was the case in the United States where development of distributed solar energy was blocked (Hess, 2016)—use various strategies: enter into coalitions with political parties that support the development of niche technologies and oppose financing the coal industry from public money in Poland; obtain support from businesses that support sustainable development; and enter into broad coalitions of social movements (ecological and climate) that reject coal energy and, at the same time, do not want to base energy transition on nuclear energy. Each of these strategies will make prosumers a collective social actor and show the political potential of supporters of distributed renewable energy.

The data presented in this article show that the uncertainty related to energy prices and the state's energy policy may encourage citizens to invest in PV. This can secure their private expenses caused by the policy of constant increases in electricity prices. On the other hand, however, uncertainty with regard to legal regulations, the low level of citizens' trust in the state's policy and administration, as well as political unpredictability and the authoritarian model of relations between the state and its citizens make it difficult for prosumers to move from the level of individual activity to the level of collective forms of prosumer activity. The organisation of prosumers in various types of institutionalised forms of collective action (energy cooperatives, energy communities, non-governmental organisations active in the energy sector) requires a friendly social environment and clear and stable legal regulations.

In Poland, the development of civic energy and attempts to break the state monopoly on energy production encounter the energy/power obstacle—various types of socio-political mechanisms try to maintain the existing order, preventing its decentralisation and loss of influence by the business and political establishment (Żuk and Żuk, 2022a).

Further research on prosumers should cover a number of dimensions of social life: the influence of prosumers on the development of the civic sphere; changes in the programmes of political parties and their policies for civic energy; and the relationship between the development of PV and the changing potential of the ecological movement. In countries that have a problem with political authoritarianism, broad civic coalitions with the participation of prosumers and their impact on the democratisation of public life and conflicts between the energy and political regime and civic energy should also be analysed. This process has only begun and we are facing many analytical and practical challenges related to the development of bottom-up and decentralised energy.

ACKNOWLEDGEMENT

Financial support for the research underpinning this article was provided by Research grant from the Uniwersytet Ekonomiczny we Wrocławiu. The publication of the article was supported by The National Science Centre, Poland (NCN), under the Grant No.: 2019/33/B/HS6/00139.

REFERENCES

- Aklin, M. (2021), The off-grid catch-22: Effective institutions as a prerequisite for the global deployment of distributed renewable power. *Energy Research and Social Science*, 72, 101830.
- Brown, D., Hall, S., Davis, M.E. (2020), What is prosumerism for? Exploring the normative dimensions of decentralised energy transitions. *Energy Research and Social Science*, 66, 101475.
- Campos, I., Marín-González, E. (2020), People in transitions: Energy citizenship, prosumerism and social movements in Europe. *Energy Research and Social Science*, 69, 101718.
- Capellán-Pérez, I., Campos-Celador, Á., Terés-Zubiaga, J. (2018), Renewable energy cooperatives as an instrument towards the energy

- transition in Spain. *Energy Policy*, 123, 215-229.
- Chard, R., Walker, G. (2016), Living with fuel poverty in older age: Coping strategies and their problematic implications. *Energy Research and Social Science*, 18, 62-70.
- Chen, X., Liu, B., Qiu, J., Shen, W., Reedman, L., Dong, Z.Y. (2021), A new trading mechanism for prosumers based on flexible reliability preferences in active distribution network. *Applied Energy*, 283, 116272.
- Coy, D., Malekpour, S., Saeri, A.K., Dargaville, R. (2021), Rethinking community empowerment in the energy transformation: A critical review of the definitions, drivers and outcomes. *Energy Research and Social Science*, 72, 101871.
- Czyżak, P., Hetmański, M., Szpor, A. (2019), *Przyszły Miks Energetyczny Polski-Determinanty, Narzędzia i Prognozy*. Working Paper 6/2019. Warszawa: Polski Instytut Ekonomiczny.
- Forman, A. (2017), Energy justice at the end of the wire: Enacting community energy and equity in Wales. *Energy Policy*, 107, 649-657.
- Furtak, E., Czoik, T. (2021), Koniec Rozmów Rządu Z Górnikiem. Jest Projekt Porozumienia W Sprawie Likwidacji Kopalń Do 2049 Roku. *Gazeta Wyborcza*. Available from: <https://www.katowice.wyborcza.pl/katowice/7,35063,27010087,koniec-rozmow-rzadu-z-gornikiem-jest-projekt-porozumienia.html> [Last accessed on 2022 Jun 24].
- Gramwzielone.pl. (2021), Powstała Pierwsza w Polsce Spółdzielnia Energetyczna. Available from: <https://www.gramwzielone.pl/energia-sloneczna/105478/powstala-pierwsza-w-polsce-spoldzielnia-energetyczna> [Last accessed on 2022 Jun 24].
- Hess, D.J. (2016), The politics of niche-regime conflicts: Distributed solar energy in the United States. *Environmental Innovation and Societal Transitions*, 19, 42-50.
- Hess, D.J. (2018), Energy democracy and social movements: A multi-coalition perspective on the politics of sustainability transitions. *Energy Research and Social Science*, 40, 177-189.
- Horstink, L., Wittmayer, J.M., Ng, K. (2021), Pluralising the European energy landscape: Collective renewable energy prosumers and the EU's clean energy vision. *Energy Policy*, 153, 112262.
- Inderberg, T.H.J., Tews, K., Turner, B. (2018), Is there a prosumer pathway? Exploring household solar energy development in Germany, Norway, and the United Kingdom. *Energy Research and Social Science*, 42, 258-269.
- Inês, C., Guilherme, P.L., Esther, M.G., Swantje, G., Stephen, H., Lars, H. (2020), Regulatory challenges and opportunities for collective renewable energy prosumers in the EU. *Energy Policy*, 138, 111212.
- Institut Energetyki Odnawialnej. (2021a), Aktualizacja Prognozy Rozwoju Krajowego Rynku Fotowoltaiki do 2025 Roku. Available from: <https://www.ieo.pl/pl/aktualnosci/1525-aktualizacja-prognozy-rozwoju-krajowego-ryнку-fotowoltaiki-do-2025-roku> [Last accessed on 2021 Jul 03].
- Institut Energetyki Odnawialnej. (2021b), *Rynek Fotowoltaiki w Polsce*. 9th ed. Warszawa: Instytut Energii Odnawialnej.
- Islar, M., Busch, H. (2016), We are not in this to save the polar bears!- the link between community renewable energy development and ecological citizenship. *Innovation: The European Journal of Social Science Research*, 29(3), 303-319.
- Keiner, D., Ram, M., De Souza, L., Barbosa, N.S., Bogdanov, D., Breyer, C. (2019), Cost optimal self-consumption of PV prosumers with stationary batteries, heat pumps, thermal energy storage and electric vehicles across the world up to 2050. *Solar Energy*, 185, 406-423.
- Kuchler, M., Bridge, G. (2018), Down the black hole: Sustaining national socio-technical imaginaries of coal in Poland. *Energy Research and Social Science*, 41, 136-147.
- Mashlakov, A., Pournaras, E., Nardelli, P.H.J., Honkapuro, S. (2021), Decentralized cooperative scheduling of prosumer flexibility under forecast uncertainties. *Applied Energy*, 290, 116706.
- Milchram, C., Hillerbrand, R., van de Kaa, G., Doorn, N., Künneke, R. (2018), Energy justice and smart grid systems: Evidence from the Netherlands and the United Kingdom. *Applied Energy*, 229, 1244-1259.
- Minister Klimatu i Środowiska. (2021), Projekt Ustawy o Zmianie Ustawy-Prawo Energetyczne i Ustawy o Odnawialnych Źródłach. *Energii*. Available from: <https://www.legislacja.rcl.gov.pl/projekt/12347450> [Last accessed on 2022 Jun 24].
- Ministerstwo Klimatu i Środowiska. (2021), *Polityka Energetyczna Polski do 2040 r. Załącznik do Uchwały nr 22/2021 Rady Ministrów z Dnia 2 Lutego 2021 r.* Warszawa: Ministerstwo Klimatu i Środowiska. Available from: <https://www.gov.pl/attachment/3209a8bb-d621-4d41-9140-53c4692e9ed8> [Last accessed on 2022 Jun 24].
- Mój Prąd. (2021), *Informacje Szczegółowe o Programie*. Available from: <https://www.mojprad.gov.pl/informacje-szczeg%C3%B3lne/C5%82owe-o-programie-m%C3%B3j-pr%C4%85d> [Last accessed on 2021 Jul 03].
- Palm, J., Eidenskog, M., Luthander, R. (2018), Sufficiency, change, and flexibility: Critically examining the energy consumption profiles of solar PV prosumers in Sweden. *Energy Research and Social Science*, 39, 12-18.
- Polskie Towarzystwo Przesyłu i Rozdziału Energii Elektrycznej. (2021), *Mikroinstalacje w Polsce*. Available from: <http://www.ptpiree.pl/energetyka-w-polsce/energetyka-w-liczbach/mikroinstalacje-w-polsce> [Last accessed on 2021 Jul 03].
- Rorty, R. (1989), *Contingency, Irony, and Solidarity*. Cambridge, New York, UK: Cambridge University Press.
- Ruszkowski, J. (2020), *Najwyższy Czas na Spółdzielnie Energetyczne*, Rzeczpospolita. Available from: <https://www.energia.rp.pl/opinie/22130-najwyzszy-czas-na-spoldzielnie-energetyczne> [Last accessed on 2022 Jun 24].
- SolarPower Europe. (2020), *EU Market Outlook for Solar Power 2020-2024*. Available from: https://www.solarpowereurope.org/wp-content/uploads/2020/12/3520-SPE-EMO-2020-report-11-mr.pdf?cf_id=23124 [Last accessed on 2022 Jun 24].
- Soutar, I., Mitchell, C. (2018), Towards pragmatic narratives of societal engagement in the UK energy system. *Energy Research and Social Science*, 35, 132-139.
- Sovacool, B.K. (2021), Who are the victims of low-carbon transitions? Towards a political ecology of climate change mitigation. *Energy Research and Social Science*, 73, 101916.
- Sovacool, B.K., Brisbois, M.C. (2019), Elite power in low-carbon transitions: A critical and interdisciplinary review. *Energy Research and Social Science*, 57, 101242.
- Sovacool, B.K., Lipson, M.M., Chard, R. (2019), Temporality, vulnerability, and energy justice in household low carbon innovations. *Energy Policy*, 128, 495-504.
- Stikvoort, B., Bartusch, C., Juslin, P. (2020), Different strokes for different folks? Comparing pro-environmental intentions between electricity consumers and solar prosumers in Sweden. *Energy Research and Social Science*, 69, 101552.
- Szabo, J., Fabok, M. (2020), Infrastructures and state-building: Comparing the energy politics of the European Commission with the governments of Hungary and Poland. *Energy Policy*, 138, 111253.
- Thombs, R.P. (2019), When democracy meets energy transitions: A typology of social power and energy system scale. *Energy Research and Social Science*, 52, 159-168.
- Thronsdén, W., Skjølvold, T.M., Ryghaug, M., Christensen, T.H. (2017), From Consumer to Prosumer: Enrolling Users into a Norwegian PV Pilot. *ECEEE Summer Study Proceedings*. Available from: <http://www.hdl.handle.net/11250/2457629>
- Turnheim, B., Geels, F.W. (2013), The destabilisation of existing regimes: Confronting a multi-dimensional framework with a case study of

- the British coal industry (1913-1967). *Research Policy*, 42(10), 1749-1767.
- van Veelen, B., van der Horst, D. (2018), What is energy democracy? Connecting social science energy research and political theory. *Energy Research and Social Science*, 46, 19-28.
- Wang, Z., Yu, X., Mu, Y., Jia, H. (2020), A distributed Peer-to-Peer energy transaction method for diversified prosumers in Urban community Microgrid system. *Applied Energy*, 260, 114327.
- Wilkinson, S., Hojckova, K., Eon, C., Morrison, G.M., Sandén, B. (2020), Is peer-to-peer electricity trading empowering users? Evidence on motivations and roles in a prosumer business model trial in Australia. *Energy Research and Social Science*, 66, 101500.
- Winther, T., Westskog, H., Sæle, H. (2018), Like having an electric car on the roof: Domesticating PV solar panels in Norway. *Energy for Sustainable Development*, 47, 84-93.
- Wittenberg, I., Matthies, E. (2016), Solar policy and practice in Germany: How do residential households with solar panels use electricity? *Energy Research and Social Science*, 21, 199-211.
- Wittmayer, J.M., Avelino, F., Pel, B., Campos, I. (2021), Contributing to sustainable and just energy systems? The mainstreaming of renewable energy prosumerism within and across institutional logics. *Energy Policy*, 149, 112053.
- Zapata Riveros, J., Kubli, M., Ulli-Beer, S. (2019), Prosumer communities as strategic allies for electric utilities: Exploring future decentralization trends in Switzerland. *Energy Research and Social Science*, 57, 101219.
- Zapletalová, V., Komínková, M. (2020), Who is fighting against the EU's energy and climate policy in the European Parliament? The contribution of the Visegrad Group. *Energy Policy*, 139, 111326.
- Žuk, P. (2017), The decarbonization of society as a system change. *Society and Natural Resources*, 30(2), 261-263.
- Žuk, P. (2022), "Eco-terrorists": Right-wing populist media about "ecologists" and the public opinion on the environmental movement in Poland. *East European Politics*, 1-27.
- Žuk, P., Szulecki, K. (2020), Unpacking the right-populist threat to climate action: Poland's pro-governmental media on energy transition and climate change. *Energy Research and Social Science*, 66, 101485.
- Žuk, P., Toporowski, J. (2020), Capitalism after communism: The triumph of neoliberalism, nationalist reaction and waiting for the leftist wave. *The Economic and Labour Relations Review*, 31(2), 158-171.
- Žuk, P., Žuk, P. (2017), Retirees without pensions and welfare: The social effects of pension privatization in Poland. *Critical Social Policy*, 38(2), 407-417.
- Žuk, P., Žuk, P. (2021), On the socio-cultural determinants of polish entrepreneurs' attitudes towards the development of renewable energy: Business, climate skepticism ideology and climate change. *Energies*, 14(12), 3418.
- Žuk, P., Žuk, P. (2022a), Energy/power as a tool that disciplines and reproduces the energy order and as a critical-analytical perspective on energy policy. *Energy Policy*, 161, 112750.
- Žuk, P., Žuk, P. (2022b), National energy security or acceleration of transition? *Energy Policy after the war in Ukraine*. *Joule*, 6(4), 709-712.
- Žuk, P., Žuk, P., Pluciński, P. (2021), Coal basin in Upper Silesia and energy transition in Poland in the context of pandemic: The socio-political diversity of preferences in energy and environmental policy. *Resources Policy*, 71, 101987.