**Title:** Best Practice Forever? Dynamics behind the Perception of Farm-Fed Anaerobic Digestion Plants in Rural Peripheries

**Author:** Stanislav Martinat, Justyna Chodkowska-Miszczuk, Marián Kulla, Josef Navratil, Petr Klusácek, Petr Dvorák, Ladislav Novotný, Tomáš Krejcí, Loránt Pregi, Jakub Trojan, Bohumil Frantál

**Citation style:** Martinat Stanislav, Chodkowska-Miszczuk Justyna, Kulla Marián, Navratil Josef, Klusácek Petr, Dvorák Petr, Novotný Ladislav, Krejcí Tomáš, Pregi Loránt, Trojan Jakub, Frantál Bohumil. (2022). Best Practice Forever? Dynamics behind the Perception of Farm-Fed Anaerobic Digestion Plants in Rural Peripheries. „Energies" (T. 15, 2022, nr 7, art. nr 2533, s. 1-14), DOI:10.3390/en15072533 energies

MDPI

*Article*

# Best Practice Forever? Dynamics behind the Perception of Farm-Fed Anaerobic Digestion Plants in Rural Peripheries

**Stanislav Martinát [1,2,*], Justyna Chodkowska-Miszczuk [3], Marián Kulla [4], Josef Navrátil [2], Petr Klusáček [5], Petr Dvořák [6], Ladislav Novotný [4], Tomáš Krejčí [7], Loránt Pregi [4], Jakub Trojan [7] and Bohumil Frantál [8]**

1 Social, Economic and Geographic Sciences Group, The James Hutton Institute, Craigiebuckler, 8, Aberdeen AB15 8QH, UK
2 Faculty of Natural Sciences, Institute of Social and Economic Geography and Spatial Management, University of Silesia in Katowice, Będzińska 60, 41-205 Sosnowiec, Poland; josef.navratil@us.edu.pl
3 Department of Urban and Regional Development Studies, Faculty of Earth Sciences and Spatial Management, Nicolaus Copernicus University in Torun, Lwowska 1, 87-100 Torun, Poland; jchodkow@umk.pl
4 Institute of Geography, Faculty of Science, Pavol Jozef Šafárik University in Košice, Jesenná 5, 040 01 Košice, Slovakia; marian.kulla@upjs.sk (M.K.); ladislav.novotny@upjs.sk (L.N.); lorant.pregi@upjs.sk (L.P.)
5 Department of Regional Development, Faculty of Regional Development and International Studies, Mendel University, Třída Generála Píky 2005/7, 613 00 Brno, Czech Republic; petr.klusacek@mendelu.cz
6 Department of Social Geography and Regional Development, Faculty of Science, University of Ostrava, Chittussiho 10, 710 00 Ostrava, Czech Republic; petr.dvorak@osu.cz
7 Department of Environmental Security, Faculty of Logistics and Crisis Management, Tomas Bata University, Studentské nám. 1532, 686 01 Uherské Hradiště, Czech Republic; tierra@centrum.cz (T.K.); trojan@utb.cz (J.T.)
8 Department of Geography, Faculty of Science, Palacký University in Olomouc, 17. listopadu 12, 771 46 Olomouc, Czech Republic; bohumil.frantal@upol.cz
* Correspondence: stanislav.martinat@hutton.ac.uk



**Citation:** Martinát, S.; Chodkowska-Miszczuk, J.; Kulla, M.; Navrátil, J.; Klusáček, P.; Dvořák, P.; Novotný, L.; Krejčí, T.; Pregi, L.; Trojan, J.; et al. Best Practice Forever? Dynamics behind the Perception of Farm-Fed Anaerobic Digestion Plants in Rural Peripheries. *Energies* **2022**, *15*, 2533. https://doi.org/10.3390/en15072533

Academic Editors: Antonio Zuorro and Ulugbek Azimov

Received: 16 February 2022
Accepted: 29 March 2022
Published: 30 March 2022



**Abstract:** Anaerobic digestion (AD) plants undoubtedly represent an integral and irreplaceable element in rural energy transition and sustainable waste management. In our study, we focus on an advanced understanding of the dynamics behind the changing perceptions of AD plants in host communities in Poland, Slovakia, and the Czech Republic. The surveyed AD plant case studies were selected to represent best-practice examples of AD plant operations in their countries. By means of a comparative survey in three host communities, we seek to learn more about the shift in perceptions of AD plants between their planning and operational phases. We find that, although our cases are considered best-practice examples of AD plant operations, their overall support in their communities dramatically dropped in the operational phase consequent to real-life experience with living in the neighbourhood of an AD plant. Additionally, our findings indicate that respondents who reported the most severe deterioration of AD plant perceptions were, surprisingly, those who had participated in the planning process more than other respondents. The most frequently mentioned type of participation in the planning phase was reported to be visits to the local administration office to inspect an AD plant's planning documentation. We argue that deteriorating perceptions of best-practice examples of AD plant operations negatively impact the further development and acceptance of the biogas sector in Eastern Europe. The element of acceptance by the locals of AD plant operations urgently requires reflection in the definition of best practices to inspire and upgrade both existing and planned biogas energy projects.

**Keywords:** biogas; anaerobic digestion plants; preferences; rural change; energy transition; Eastern Europe; Central Europe

## 1. Introduction

Anaerobic digestion plants (AD plants) producing biogas energy, heat, and secondary energy play a decisive role in the greening and diversifying of the energy sector in Europe [1–3]. Development of the renewable energy sector in post-socialist Central and

Eastern European (CEE) countries is especially important due to incredibly high carbon emissions per capita in this part of Europe. (The Czech Republic is fourth, Poland seventh and Slovakia sixteenth among the EU-27.) Although the possibilities for the utilization of renewable energy sources such as hydropower, wind, or solar energy are relatively abundant, under prevailing societal perceptions their use has been rather limited so far [4]. On the other hand, AD plants—with widely available food- and farm-waste as their feedstock—have been recognized as being among the most promising renewable energy sources [5,6] for their great contribution to progress towards the sustainability of national energy systems.

It is well known that an unprecedented inflow of European incentives after the EU accession of CEE countries in 2004 induced rapid growth in biogas energy and the spread of AD plants in all these countries [6,7]. Currently, more than 550 AD plants with an installed electrical capacity of 367 MWe can be found in the Czech Republic, 129 AD plants in Poland (127 MWe), and 113 (115 MWe) in Slovakia. The potential of biogas energy for sustainable and more resilient rural development is often emphasized, especially for peripheral rural areas [8]. It has also been shown in many studies that energy generation from farm-fed AD plants also suitably contributes to the advancement of multifunctional approaches and sustainability principles in agriculture, as well as a more diversified offer of rural jobs [9–11]. AD plants and their products also have a clear potential for social advancement in rural peripheries.

Generous support from the EU has greatly assisted Poland, Slovakia, and the Czech Republic in meeting their obligations to the European Union and have contributed to their energy transition, but they have also led to many unintended environmental and social consequences [12]. It has been shown in many studies that the operation of farm-fed AD plants might involve many environmental, social, and economic benefits for the host community, but the real or even perceived negative impacts also need to be seriously taken into account at the same time [13–15]. Farm-fed AD plants in the CEE countries are primarily fed by purpose-grown maize and utilize only a limited amount of agricultural waste [16]. The limited amount of biowaste from farms processed for energy certainly makes these AD plants less beneficial for the environment [17,18]. Even the planning and construction phases of individual AD plant projects frequently lead to severe local tensions and controversies in their host communities [14,19], which generally reinforce the negative perceptions associated with biogas generation [20]. It has also already been revealed in previous studies that this phenomenon is highly affected by individual personal experiences with the operation of AD plants, [14] which frequently are not in line with the expectations of the host community [6,8,21].

It seems that avoiding controversies will have an immense impact on the further prospects of AD plants as an indispensable source of clean and sustainable energy in rural areas. We are aware that multiple previous studies were predominantly aiming for a better understanding general perceptions of biogas production [6,14,15,21–24]; therefore, we have defined the aim of our paper as follows: to detect and compare the consequences of the occurrence of farm-fed AD plants before their construction and during their operational phase, as reflected in changes in the preferences of local inhabitants of AD plant host communities. Specifically, we focus in our study uniquely on cases of AD plants in three CEE countries that are widely recognized as examples of good practice, and which thus have the potential to serve as flagships for the further development of their respective national biogas sectors.

## 2. Conceptual Background

### 2.1. Special Features of Anaerobic Digestion Plants in Post-Socialist Eastern Europe

The emergence of AD plants in CEE countries dates back to just after their accession to the European Union in 2004 [23]. For instance, in Poland the first AD plant appeared in 2005, and since then the development of farm-fed AD plants has proceeded in waves according to changes in Polish renewable energy policy [8]. The first AD plant in Slovakia began operation also in 2005, but considerable development of farm-fed biogas energy did not begin until the end of the decade. The decisive drivers were the approval of the Act on the Promotion of Renewable Energy Sources (Act No. 309/2009 Coll.) and the National Action Plan for RES (National Action Plan for RES, 2010). Both policy documents provided generous support for feed-in tariffs, which stimulated the rapid development of the biogas sector in Slovakia. The slower development of the biogas sector in Poland is due to business uncertainty caused by the constantly changing feed-in tariff policies [8]. On the other hand, institutional support for AD plants in the Czech Republic is somewhat older, as it commenced already in 2002 with the introduction of a feed-in tariffs policy; moreover, the country's first experimental AD plant was built already in the mid-1970s. It can be concluded that that in the Czech Republic, as in Poland and Slovakia, the establishment and development of the biogas sector is strongly dependent on national-level support for both the construction and operation of AD plants. Additionally, the decision was made by these national governments that that the buyout prices for biogas energy would be legally guaranteed to support the stability of the emerging renewable energy sector [5,7].

Especially in Poland, AD plants are developed as stand-alone business projects separate from farms [15]. These off-farm AD plants therefore do not have one major feedstock provider, rather ensuring their feedstock supplies via short-term contracts with numerous individual farmers. On the other hand, due to the presence of traditionally large farms in Slovakia (around 100 hectares) and the Czech Republic (130 hectares), the AD plant installations in these countries tend to be rather large scale (around 1 MWe of installed electrical capacity). In all three studied countries, we were not able to find much experience with the operation of small-scale AD plant installations, because these were not eligible for subsidy programs [5]. There is no doubt that both the off-farm AD plant installations in Poland and the large-scale on-farm AD plants dependent on agricultural production in Slovakia and the Czech Republic have stimulated recent changes in agriculture. We claim that the position of farm-fed AD plants within the national agricultural sectors in Slovakia, Poland, and the Czech Republic is specific compared to what we know about AD plants in Western Europe [16,21,24,25].

### 2.2. Factors Affecting the Perception of Anaerobic Digestion Plants

In previous Eastern European biogas studies, increased attention was paid to the problem of the acceptance of biogas production, especially in rural areas [22], where the vast majority of farm-fed AD plants are located. Specifically, a number of studies indicate that the perception of AD plants is rather negative among rural populations [14]. Among other reasons given to justify the negative image of AD plants, the following factors were listed: a perceived reduction in the quality of the environment (including odor leakages) and a reduction in the attractiveness of the community for tourism [6]. The image of biogas production was further tarnished by the not especially environmentally friendly, ethically controversial processing of purpose-grown energy crops, grown on good-quality arable land, in AD plants [26]. The displacement of food production away from farm-fed AD plants and changes in regional farming systems in the CEE countries have become apparent. However, by far the greatest controversy surrounding AD plants is connected with their impact on host communities and their immediate vicinities [27]. We know that the performance of biogas businesses can be substantially superimposed by how these are reflected in local public perception [14].

A general lack of awareness when planning AD projects regarding the pros and cons of biogas production and limited knowledge about the anticipated impacts of AD plants on the surrounding localities are often the cause of biogas controversies [28]. Companies operating AD plants carry out many informal educational activities and informational events to convince the public of the benefits of AD, while potential negative impacts are frequently suppressed or concealed. Moreover, the real impact of these events is usually lower than expected as their attendance is typically low, especially in the post-socialist space. More attractive ways of engaging the public who will be most impacted urgently need to be sought. There is no doubt that a lack of transparency and clarity in sharing information about a particular biogas project has the potential to lead to further controversies [14]. The most frequently organized events include joint public hearings with investors and visits to AD plants already in operation [8]. In other words, inadequate or even no involvement by the local community in the planning phase, failure to provide sufficient information, provision of misinformation, and concealment of key aspects of the project and its expected impacts on the community all have the clear potential to increase the level of opposition toward an AD project and to generate avoidable tensions within host communities [19,29].

Most social science studies that touch on the issue of AD plants and their location in communities examine the factors behind their acceptance and study the different methods of participation and involvement in the planning phase [14,26,30,31]. Considerably less attention has been paid to what happens in communities after a renewable energy project reaches its operational phase [20,32]. There is clear evidence that the social acceptance of renewable energy projects tends to increase once a facility is finally in the operational phase [27,33]. However, it has proved invaluable to consult and discuss an AD plant project with affected residents not only in the pre-investment stage but also, even more intensively, during AD plant operation [32]. Many studies have shown that the two-way flow of information between the public and the operators of AD plants leads to positive changes in the perception of biogas through personal real-world experiences [34,35]. In order to successfully operate AD plants in host communities in the long-term without conflicts, there is an urgent need to mitigate changing preferences and attitudes towards biogas energy and to ease the transition from the planning phase to the operational phase. The key factors affecting the perception of AD plants are summarized in Table 1.

**Table 1.** Key factors affecting the perception of AD plants.

| Data | |
|---|---|
| Rather negative general perception of AD plants among rural population. | [14] |
| Real or perceived reduction in the quality of the environment around AD plants (including odor leakages and increased traffic). | [6] |
| Reduction in the attractiveness of the community for tourism. | [6] |
| Ethically controversial processing of purpose-grown energy crops grown on good-quality arable land in AD plants. | [26] |
| Displacement of food production away from farm-fed AD plants. | [26] |
| Changes in regional farming systems due to AD plant operations. | [26] |
| Impact on host communities and immediate neighborhoods. | [27] |
| Lack of awareness and limited knowledge of the anticipated impacts of AD plants on surrounding neighborhoods. | [28] |
| Lack of transparency and clarity in sharing information about AD plant projects. | [14] |
| Lack of participation by the local population in the planning phase. | [14,26,30,31] |
| Less attention to AD plants in the operational phase. | [20,32] |

In the research presented, we sought to capture changes in the perception of AD plants from the planning to the operational phase. We were also eager to better understand how these changes are affected by the performance of individual AD plants. In particular, we aimed to fill a gap in existing biogas studies with a more nuanced interpretation of perceptions of the following:

- The intensity and relevance of how residents were informed of the planned construction of an AD plant;
- The possibilities for participating in the planning process of an AD plant;
- Active participation in the planning process of an AD plant;
- Conflict situations resulting from the operation of an AD plant.

In order to gain a more in-depth understanding of the changing perceptions of AD plants between their planning and operational phases, three examples of AD plants (one in

Poland, one in Slovakia, and one in the Czech Republic), widely accepted in their respective countries as examples of good practice, were selected for our study.

## 3. Materials and Methods

### *3.1. Study Area*

The aim of our study was to scrutinize perceptions of AD plants in three CEE countries, namely Poland, Slovakia, and the Czech Republic. Based on previous studies, one operating AD plant was selected in each country (see Figure 1) [5,6,8,22]. We focus on examples of best-practice operations of AD plants because we argue that problematic AD installations usually have unique consequences seated in unique sociocultural contexts that are hardly comparable. In trying to avoid such biases in our study, the following conflict-free AD installations were selected for our research: the Boleszyn AD plant in Poland, the Kameničany AD plant in Slovakia, and the Uherčice AD plant in the Czech Republic (Figure 1). The individual AD plants studied are briefly introduced below.

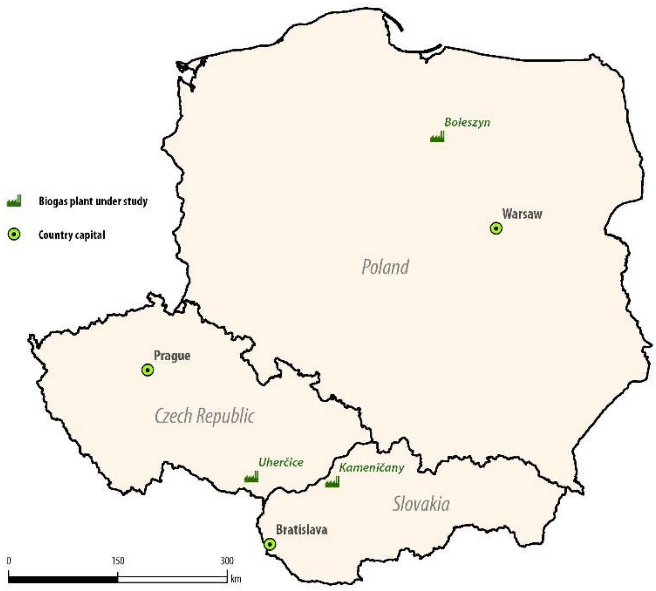


**Figure 1.** Location of the three studied AD plants in Slovakia, Poland, and the Czech Republic.

The Boleszyn AD plant is among the largest AD plants in Poland (3.6 Mwe). It consists of three AD units for biogas energy generation in a cogeneration system: one with a capacity of 2 MWe and two with a capacity of 0.8 Mwe [36]. The AD plant in Boleszyn is fed by agricultural residues. The whole AD project was co-funded from EU funds within the Operational Program Infrastructure and Environment (2007–2013), and was put into operation in 2012. The main factor behind the AD plant location is related to the provision of feedstock from a nearby piggery. However, as the AD plant developed over time, the feedstock structure has changed significantly. In addition to the aforementioned pig manure, maize from the investor's own farm is also used. In addition, the energy recovery of waste from dairy and chip production started in the AD plant in the early 2010s. Since 2015, out-of-date food products supplied by retail chains and food processing plants have also been incorporated into the feedstock. The AD plant is located in the northwestern outskirts of the village of Boleszyn (the Grodziczno community, The Warmińsko-Mazurskie Voivodeship, Poland), with a population 484 in 2021. In the immediate vicinity of the AD plant, arable land can be found. The distance from dense residential development is approximately 300 m. Since the beginning of this AD project, the inhabitants of Boleszyn and the neighboring Mroczno village have been utilizing the heat generated by the AD plant. Both private and public buildings are connected to this heat pipeline.

The Kameničany AD plant in western Slovakia was built in 2012 with an installed electrical capacity of 1 MWe as a joint venture by a nearby farm focused on cattle breeding and a company specializing in biogas energy generation from agricultural residues and energy crops. The feedstock supplied to the plant is composed of maize, hay, and manure. All the feedstock (circa 30,000 tons annually) is produced on its own farm, which is located in the neighboring Bolešov community. The AD plant entered into its operational phase before national regulations were introduced in Slovakia requiring at least 50% of the heat generated as a by-product to be utilized. However, the operator actively sought out these options. In 2014, large-scale greenhouses (3 hectares) used for tomato production were built, and as much as 70% of their heating is covered by the AD plant. The AD plant is situated in the northern part of the Kameničany community (population 560 in 2020) in the Trenčín Region, circa 300 m from the nearest residential homes.

The AD plant in Uherčice in the South Moravian Region (Czech Republic) was also built in 2012. The project was initiated by the owner of a local agricultural farm, and it has an installed electrical capacity of 2 MWe. The main feedstock processed is maize, which makes up about 70% of the total; the rest is covered by beet cuttings or hay. All the feedstock (circa 40,500 tons annually) is produced on the farm and land owned by the AD operator within the Uherčice and the neighboring Starovice communities. The AD plant utilizes the electricity produced for its own on-site consumption, while simultaneously supplying surplus electricity to the grid. The heat produced was initially used solely by the AD plant, but since 2017 about 70% of the heat production has been supplied via a hot water pipeline (2.5 km long) to heat large-scale greenhouses in the neighboring community of Velké Němčice. The AD plant is situated in the eastern part of the Uherčice community (population 1056 inhabitants in 2020), circa 200 m from the nearest residential homes.

All three studied AD plants are considered examples of best practices in their national contexts, conflict- and controversy-free AD installations with very good relations with the populations of their host communities. We are aware that the definitions of best practices for the operation of AD plants vary across Europe, and largely depend on national legal requirements and advances in technological solutions. Recognizing the limited direct comparability of sites operating in different legal frameworks with different expectations on the part of local residents, our endeavor was not to compare sites but rather to identify transferable similarities more generally. The guiding principles in selecting AD plants for our study were conflict-free operation and a high level of acceptance by local communities. All three studied AD plants were built in the same year (2012), process for energy primarily feedstock originating from farms, and are located in rural peripheries in close proximity to residential areas.

### *3.2. Data Collection and Questionnaire*

To achieve the aim of our research, a standardized questionnaire survey was carried out among the inhabitants of the above-described host communities with issue-free operating anaerobic digestion plants. Only the adult population (over 18 years) was surveyed. The same number of respondents (150) was anonymously interviewed in each location. A total of 450 people were contacted, and 296 fully completed questionnaires were received. One questionnaire took on average about 20 min to complete. Respondents were thoroughly informed about the purpose of the research and informed consent was expressed prior to the interview. The data collected was transcribed in an Excel file, which was safely stored in an offline repository to prevent any misuse. The anonymity of individual responses was ensured in several stages.

To ensure the validity of the questionnaire items, a pre-test was conducted in March 2018 on a sample of 20 respondents. Revised versions of the questionnaires in three national languages (Polish, Slovak, and Czech) were gathered in April 2018. Individual respondents were approached in their communities and randomly selected to ensure a representative sample structure by gender and age. The on-site interviews took place during the time of the COVID-19 pandemic, when social isolation and spatial immobility was required. These circumstances significantly affected our opportunities to reasonably interact with local residents. However, despite the difficult conditions, the sample obtained can be considered satisfactory, especially as the expected saturation rates for each category were achieved [37].

The questionnaire (included as the Supplementary Materials) consisted of two main sections. The first part was dedicated to collecting data to test our hypotheses, the second to collecting descriptive data regarding the sample. First, it was necessary to determine the change in the community's perception of its AD plant. For this purpose, respondents were asked at the very beginning of the questionnaire to what extent they had agreed with the construction of the AD plant in their community. Then, after the other questions mentioned above, respondents were asked at the end of the first section to indicate to what extent they were currently satisfied with the operation of the AD plant in their community. These two questions served as the source of our dependent variable in the data analysis.

Other questions asked in the first part of the questionnaire focused on the collection of dependent variables. The level and importance of how residents were informed about the planned construction of the AD plant were measured using two questions. These two questions were defined as follows: "Do you agree with the statement that local people were sufficiently informed about the intention to build an AD plant at the time of the decision-making?" and "Do you agree with the statement that the information about the planned AD plant was relevant, impartial, and described the plan realistically?" The opportunity for residents to participate in the planning process was measured by the response to the following question: "Do you consider opportunities for participation in the AD plant planning sufficient?" The active participation of the interviewed residents of the selected communities in the process of planning the construction of the AD plant was measured by the following question: "Did you have a chance to participate in the planning process in any way?" If the answer to this was "yes", then participation was measured in five participatory activities—having taken place in all three localities—as follows: (i) an excursion organized for the residents to visit an AD plant in another community; (ii) a public hearing organized by the local council or the AD plant project's investor; (iii) inspection of documentation for the AD plant project that was freely available for study in the local administration office; (iv) a public opinion poll organized to find out the attitudes of the local population towards the AD plant project; and (v) discussion organized with an independent expert. The perceptions of potential conflict situations arising from the operation of the AD plant were investigated using two questions: "Do you agree with the statement that the operator of the AD plant in your community takes seriously objections by local people to the AD plant and deals with them?" and "Do you agree with the statement that the operator of the AD plant in your community is competent and aware of how to safely operate their AD plant?" Responses to all questions (except for the question about the active participation of respondents) were measured on a 5-point ordinal scale, where 1 indicated strong disagreement, 2 indicated disagreement, 3 indicated uncertainty, 4 indicated agreement, and 5 indicated strong agreement.

The second part of the questionnaire was designed to gather data on the demographic and socioeconomic structure of the respondents. For each respondent we collected information about gender, age, level of education, and economic status.

### 3.3. Data Analyses

The change in perceptions of an AD plant within the host community was derived from the comparison of the perceptions of the AD plant before construction (in the planning phase) to those during the operational phase. Specifically, subtraction between the level of agreement with construction of the AD plant before and after construction was used. According to differences measured among the answers, two groups of respondents were selected out of the whole sample of respondents (see Table 2). A worsening of perceptions of the AD plant was found among 56 respondents (19% of respondents), and an improving of perception was found in the case of 86 respondents (29% of respondents). The presence in the group of respondents with a worsened perception of the construction of the AD plant was coded as 1 (labelled as the WORSE group throughout the text). Respondents found with an improved perception were coded as 0 (labelled as the BETTER group throughout the text). This variable was then used as a dependent variable in further analyses.

**Table 2.** Characteristics of respondents.

| Data | WORSE Group ($n$ = 56) | BETTER Group ($n$ = 86) |
|---|---|---|
| gender (%) | | |
| female | 53.6 | 45.4 |
| male | 46.4 | 54.6 |
| age (mean in years) | 41.9 | 42.1 |
| level of education (%) | | |
| primary | 8.9 | 8.1 |
| secondary | 28.6 | 31.4 |
| secondary with leaving exam | 42.9 | 33.7 |
| tertiary | 19.4 | 26.7 |
| economic status (%) | | |
| businessperson | 17.8 | 11.6 |
| employee | 58.9 | 55.8 |
| parental leave | 7.1 | 5.8 |
| retiree | 10.1 | 17.4 |
| student | 1.8 | 8.1 |
| unemployed | 3.6 | 1.1 |

Before testing our hypotheses, we performed tests to ensure the comparability of our two selected groups of respondents. This was a necessary step, as previous studies have found gender to be a factor significantly differentiating preferences about different renewable energy systems; additionally, age was detected to be another variable underlying differences in the pro-environmental inclinations of respondents [38]. This factor also varies in the preferences for different types of renewable energy systems. Moreover, the level of education was detected to be responsible for various preferences about different types of energy production systems [39,40]. Chi-square tests were used for testing potential differences among the two groups of respondents in gender, level of education, and level of economic status. A two-sample $t$-test was used for potential differences in the age of respondents.

The Mann–Whitney U test was used to test differences between the groups described above in all independent variables (excluding the bivariate variable connected to the activity of the respondents), as the responses were measured on an ordinal scale. To test differences between our two groups of respondents in the number of activities attended during the planning process, the chi-square was used. Then, for testing the differences in participation in each activity, the chi-square test with Yates correction or the Fisher exact test were performed. Finally, the influence of all our independent variables on the type of respondent was tested. The dependent variable was the respondent's affiliation with the group showing worsened perceptions of the AD plant. The binomial generalized linear model (binomial logistic regressions) with logit function was used to identify the potential predictors of the dependent variable. As not all independent variables were found to be statistically significant for the type of respondent, a forward selection of independent variables was used. The statistical importance of independent variables was tested by the type III likelihood test and the Wald test. The regression coefficients were tested by the Wald statistics for their difference from a zero value and assessed by 95 confidence intervals of regression coefficient and its standard error. The odds ratios and their 95 confidence intervals were used to assess the importance of all selected independent variables.

All calculations were carried out in the Tibco Statistica software [41].

## 4. Results

We have not found any differences between our two groups of respondents in gender (Pearson chi-square = 0.918, d.f. = 1, $p > 0.3$), age (t-test = −0.062, d.f. = 140, $p > 0.9$), education (Pearson chi-square = 1.587, d.f. = 3, $p > 0.6$), or economic activity (Pearson chi-square = 5.486, d.f. = 5, $p > 0.3$). Therefore, the testing of our hypotheses is not influenced by a differentiation of respondents between the two groups under study.

Contrarily, the two groups of respondents significantly differ in their perceptions of the AD plant when the planning and operational phases are compared. The level of support for the construction of the AD plant in the planning phase was significantly higher for the WORSE group (Mann–Whitney U test = 935, $p < 0.001$, Figure 2).

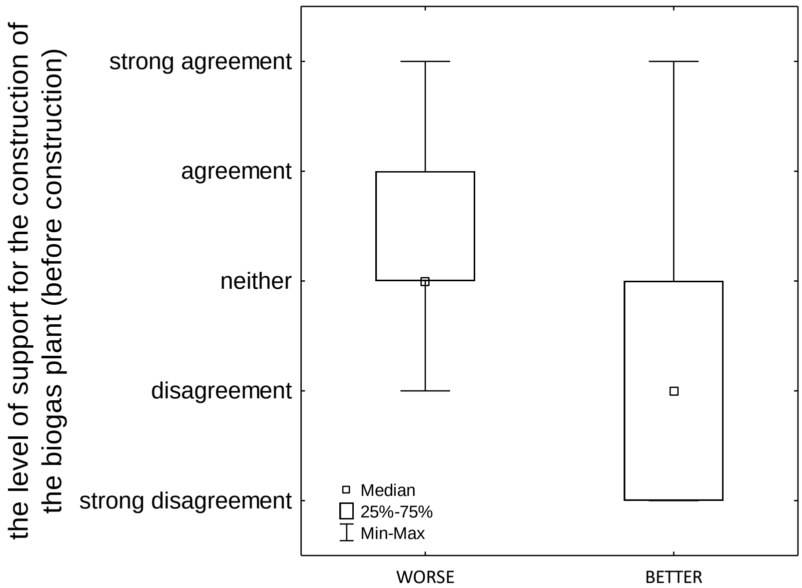


**Figure 2.** The level of support for the construction of the AD plant during its planning phase.

The decrease in the level of support for the construction of the AD plant was by far more intensive in the WORSE group than the increase in the level of support for the construction of the AD plant in the BETTER group (see Figures 2 and 3). Based on these two results, we can conclude that worsening perceptions of AD plants is probably influenced by too high expectations on the part of the local population. Improved perceptions were expressed by those with extremely low expectations during the planning phase.

No difference was found in agreement with the sufficiency of information provided regarding the plan for construction of the AD plant at the time of decision making (Mann–Whitney U test = 2376.5, $p > 0.8$), with a median value, "disagreement", for both groups of respondents. On the other hand, we have found differences between these two groups regarding their perceptions of the relevance, accuracy, and completeness of the presentation of the plan in a realistic way. For respondents from the WORSE group, the information was less relevant and complete (Mann–Whitney U test = 1908.5, $p < 0.05$, Figure 4).

We have ascertained that the respondents from the WORSE group were significantly more active during the planning process, as they claim to have taken part more frequently in the participatory activities (Mann–Whitney U test = 1885.5, $p < 0.05$, Figure 5). We followed five participatory activities in our survey (a visit in the local administration office to see the AD plant documentation, an excursion to an AD plant nearby, attendance at a public hearing concerning the AD plant project, participation in an opinion poll surveying attitudes towards AD, and discussion with an independent expert). It was detected that the group of respondents with worsened perceptions of the AD plant in the operational phase was clearly (and surprisingly) more active in the planning phase.

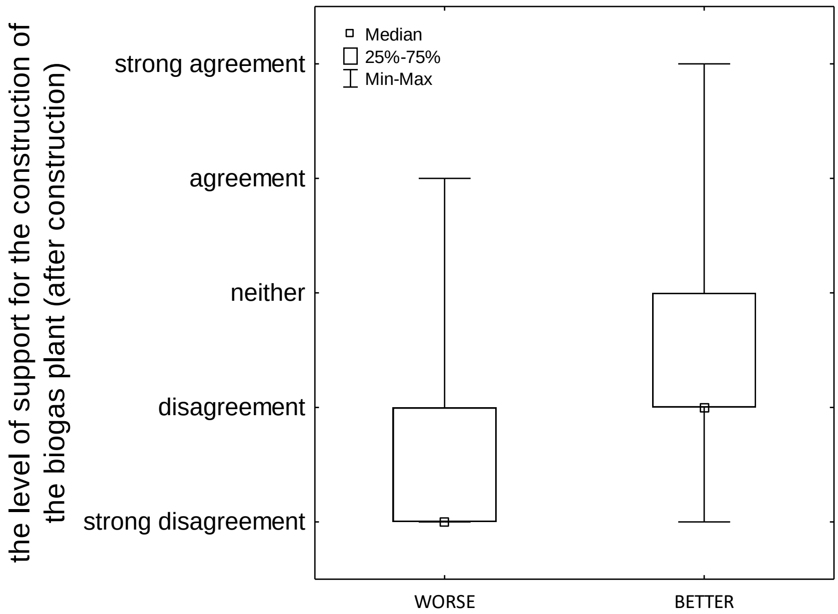


**Figure 3.** The level of support for the construction of the AD plant in its operational phase.

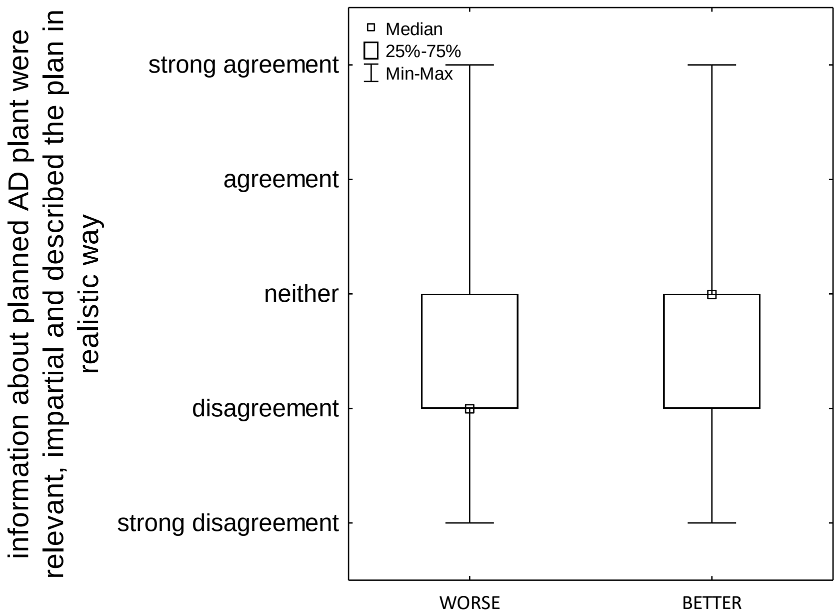


**Figure 4.** The perception of the relevance and completeness of the presentation of the AD plan in a realistic way.

The activity most frequently participated in among the surveyed options was found to be a visit to the local administration office to study the documentation for the AD plant project. This is also a rather surprising finding. This option was utilized by both observed groups equally (Pearson chi-square = 3.039, d.f. = 1, $p > 0.05$). In all four other participatory activities, the WORSE group was surprisingly found to be more active, which means that these people more frequently participated in excursions organized to visit AD plants in other municipalities (Pearson chi-square with Yates correction = 4.72, d.f. = 1, $p < 0.05$) and more frequently took part in public hearings organized by local councils or investors in the AD plant projects (Pearson chi-square = 5.279, d.f. = 1, $p < 0.05$). Moreover, the WORSE group more frequently participated in public opinion polls organized to find out attitudes towards the AD plant project (Fisher exact test, $p < 0.01$) and also took greater part in the discussions arranged with independent experts to learn more about the planned AD plant (Fisher exact test, $p < 0.001$).

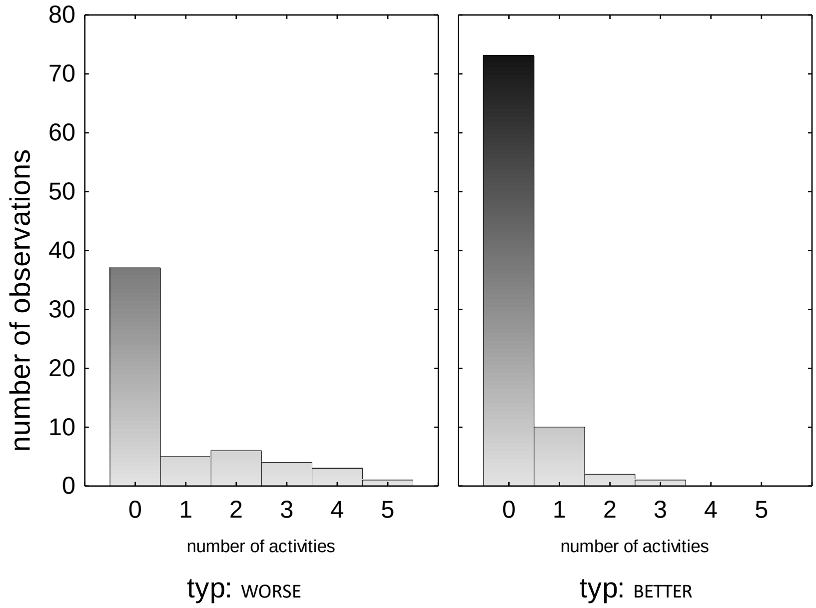


**Figure 5.** Histograms for the number of participatory activities attended by respondents in both groups under study.

Now we know that respondents from the WORSE group were more active in the participatory activities, but both groups of respondents (WORSE and BETTER) do not differ in their perceptions of the sufficiency of possibilities for participation in the planning phase of the AD plant project (Mann–Whitney U test = 2221.5, $p > 0.4$). Results of further analyses deepen our understanding of this information, revealing that the WORSE group was more critical when asked how seriously objections towards the AD plant projects had been taken into account and dealt with (Mann–Whitney U test = 1624.5, $p < 0.01$, Figure 6). However, such a critical assumption seems not to be detected regarding the perception of the competence of the operator to run an AD plant smoothly (Mann–Whitney U test = 2069, $p > 0.1$).

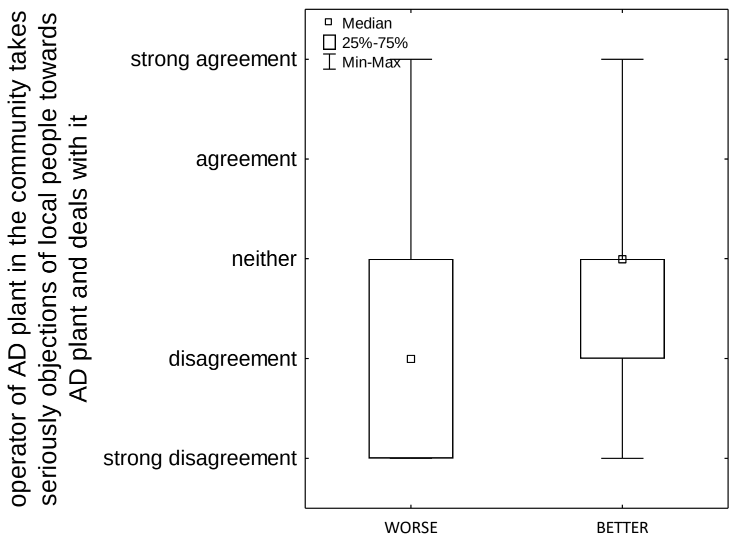


**Figure 6.** The level of agreement with how seriously the operator of the AD plant in their community takes objections of local people towards the AD plant and deals with them.

We have discovered in previous analyses that both followed groups of respondents significantly differ in many variables we originally selected for in-depth investigation. Thus, in the last step of the analysis, we attempted to learn more about the most important factors relevant for differentiations of these two groups. Binomial logistic regression with logit link and forward selection of independent variables were accommodated to conduct this task. Two variables were chosen by the model (please see Table 3).

**Table 3.** Results of binomial logit regression model (Hosmer Lemeshow = 6.480, $p$ = 0.100; Nagelkerke pseudo $R^2$ = 0.217).

| | Type III Likelihood Test | | | | Test of All Effects | | |
|---|---|---|---|---|---|---|---|
| | **d.f.** | **Log-Likelihood** | **Chi-Square** | ***p*** | **d.f.** | **Wald Stat.** | ***p*** |
| Intercept | | | | | 1 | 1.628 | 0.202 |
| How seriously the operator of an AD plant in the community takes objections by local people. | 1 | −88.153 | 10.655 | 0.001 | 1 | 9.609 | 0.002 |
| Number of activities undertaken by respondents before AD plant construction. | 1 | −89.580 | 13.511 | 0.000 | 1 | 9.917 | 0.002 |

Respondents from the WORSE group are especially those whose perceptions of the performance of the operator of their AD plant are lower. This group also describe themselves as more active during the planning process (Table 4). The number of participatory activities reported by respondents in the planning phase was revealed to be the most important independent variable in our regression model (Table 5).

**Table 4.** Regression estimates.

| | Estimate | 95.00% Lower CL | 95.00% Upper CL | S.E. of Estimate |
|---|---|---|---|---|
| Intercept | 0.579 | −0.311 | 1.469 | 0.454 |
| How seriously the operator of an AD plant in the community takes objections by local people. | −0.585 | −0.954 | −0.215 | 0.189 |
| Number of activities undertaken by respondents before AD plant construction. | 0.760 | 0.287 | 1.233 | 0.241 |

**Table 5.** Odds ratios of regression model.

| | Odds Ratio | 95.00 Lower CL | 95.00 Upper CL |
|---|---|---|---|
| How seriously the operator of an AD plant in the community takes objections by local people. | 0.557 | 0.385 | 0.807 |
| Number of activities undertaken by respondents before AD plant construction. | 2.139 | 1.332 | 3.432 |

## 5. Discussion

Although the AD plants the perceptions of which we have thoroughly explored in this research are frequently mentioned in media and by professional organizations as examples of good practice in AD plant operations, we detected that one fifth of respondents reported worsened perceptions from the planning to the operational phase. This finding is quite surprising as it signals an excessively straightforward and static definition of best practices in the operation of AD plants [42] that lacks temporal perspective. It is beyond doubt that public attitudes are not frequently considered when thinking about the examples of best practice for AD plants, while technical advancements and economic profitability are usually highlighted and celebrated. The voices of the people living in the vicinity of AD plants, who are affected the most, are usually not heard [15]. We call for a more dynamic approach when defining best practices in the operation of AD plants, wherein a wider spectrum of relevant perspectives is incorporated and their importance well balanced.

We revealed that residents who changed their minds concerning their support for the AD plant and whose perceptions have significantly worsened during the operational phase were more actively involved in the planning of the project and thus supported the idea of an AD plant in their community. It seems that real-life experience with living nearby AD plants has affected their support for biogas, no matter how beneficial for the environment the facility is. The impact on personal well-being and immediate experience seems to be decisive when considering support for biogas. An enormous number of studies have been dedicated to advancing the understanding of the motivations and attitudes of opponents of renewable energy projects [19,26,43], but dynamics within the group of supporters still stand outside the mainstream interest of researchers. We are filling this gap with our study. Among the most influential ways to ensure that the voices of local residents are reflected in decisions regarding the AD plants' operations is surely an increased level of participation not only in the planning phase [44] but also in the operational one, which is usually underestimated [45]. Digital support tools to enhance and extend the level of local participation are frequently mentioned [46] as the way forward. On the other hand, relying solely on digital tools has a clear potential to exclude the involvement of members of vulnerable communities usually living nearby AD plants. It also truly seems that community-owned renewable energy projects are among the most promising social innovations aiming to increase the relevance of local voices in the decision-making process [46]. A long tradition with—and the verified functionality of—cooperatives throughout Europe opens the door for their wider use as a business model in renewable energy planning [47–50].

A lack of accurate and timely information and the impossibility of expressing opinions in the planning phase of an AD plant project was often mentioned as an issue among our respondents. There is a certain group of people who believe that the information provided about the project was misleading and solely driven by the investor's goal of building the planned AD plant project at any cost. Communication issues in both the planning and the operational phases of a project indeed has the potential to determine the negative image of AD plants [51]. Residents in host communities usually tend to be open to discussions about the benefits of the project; however, the lack of opportunity to have a voice in the decision-making process exacerbates their personal feeling that they were not treated well or justly [52]. There is no doubt that inadequacies in communication strategies towards the public [53] and the prevalence of a one-way-only information flows about the project are responsible for unnecessary tensions within communities [14]. We confirmed that this problem occurs even in apparently problem-free communities hosting AD plants.

## 6. Conclusions

In our study, we focused on a more in-depth comprehension of the dynamics behind the perception of AD plants in Poland, Slovakia, and the Czech Republic considered to be examples of best practices in AD plant operations in their respective countries. We were interested in learning more about changes in perceptions between the planning and operational phases. To carry out such a complex task, a set of comparable surveys in three AD plant host communities was carried out (Uherčice in the Czech Republic, Boleszyn in Poland, and Kameničany in Slovakia). Due to complexity of the problem, we compared the opinions of the group of respondents claiming worsening perceptions of AD plants between the planning and the operational phases (WORSE group) with the group claiming an improvement in their perceptions of an AD plant (BETTER group).

Firstly, we revealed that overall support for an AD plant was decreased in the operational phase in comparison with the planning phase among almost one fifth of respondents. This is a surprising result, as all three studied AD plants are considered in their countries as examples of best practices in AD plant operations. This finding signals that immediate experience by residents of an operating AD plant is not taken into account when defining best practices. We also measured a strong imbalance between the levels of how support for an AD plant was reduced in the group reporting worsened perceptions (WORSE group) in comparison to the level of how support increased in the group claiming improved perceptions (BETTER group).

Secondly, we have not found any difference between the groups concerning their evaluation of the sufficiency of information provided regarding the planning of their local AD plant. On the other hand, we did detect differences between the two groups regarding their perceptions of the relevance, accuracy, and completeness of the presentation of the AD plant plan in a realistic way. Specifically, for respondents from the WORSE group, the information was less perceived as relevant and more incomplete.

Thirdly, our findings show that respondents from the WORSE group were surprisingly more active during the planning process, and they claim to have more frequently taken part in the participatory activities. The most frequently mentioned participatory activity was reported to be a visit to the local administration office to study the documentation for the AD plant project. Other options (an excursion to an AD plant nearby, a public hearing concerning the AD plant project, an opinion poll surveying attitudes towards AD, and a discussion with an independent expert) were surprisingly found to be more utilized by members of the WORSE group. These respondents were more active in participation than the BETTER group. The number of participatory activities reported by respondents in the planning phase was revealed to be the most important independent variable in our regression model.

Fourthly, the WORSE group of respondents was found to be more critical of how seriously their objections towards the AD plant have been taken into account and dealt with during the operational phase.

We are aware of certain limitations in our study. To obtain a clearer picture about the dynamics of the perceptions of AD plants in the three studied countries, more cases need be thoroughly studied, not only by means of surveys but also by employing qualitative research methods. This method is especially relevant for revealing the factors and nuances behind the shifts in perceptions of AD plants from the planning to the operational phase. Especially, we need to understand better the local sociocultural contexts of individual host communities so that tensions concerning AD plants are more thoroughly captured.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/en15072533/s1, Questionnaire used to collect data in the surveys conducted.

**Author Contributions:** Conceptualization, S.M., P.D., P.K., M.K. and B.F.; methodology, P.D., P.K., S.M. and B.F.; formal analysis, J.N. and T.K.; investigation, M.K., P.K., L.N., L.P. and J.C.-M.; data curation, J.N., S.M., P.K. and M.K.; writing—original draft preparation, S.M., J.C.-M., M.K., J.N., P.K. and J.T.; writing—review and editing, J.N.; visualization, T.K. and J.N.; project administration, P.D. and M.K.; funding acquisition, S.M., P.D. and M.K. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was supported the institution funding of the participating institutions and the following projects: Adaptation to sustainable transition in Europe: Environmental, socioeconomic and cultural aspects (ADAPTAS), funded by the Ministry of Economy, Industry and Competitiveness, and the State Research Agency of Spain, and the Regional Development Fund (No. CSO2017-86975-R), and the project Spatial redistribution of human capital as an indicator of the formation of the regional system in Slovakia (VEGA 1/0514/21).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available on reasonable request from the corresponding author.

**Acknowledgments:** Authors would like to thank anonymous reviewers for many helpful comments.

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

## References

1. Scarlat, N.; Dallemand, J.F.; Fahl, F. Biogas: Developments and perspectives in Europe. *Renew. Energy* **2018**, *129*, 457–472. [CrossRef]
2. Carvalho, M.D. EU energy and climate change strategy. *Energy* **2012**, *40*, 19–22. [CrossRef]
3. Lucas, J.N.V.; Frances, G.E.; Gonzalez, E.S. Energy security and renewable energy deployment in the EU: Liaisons Dangereuses or Virtuous Circle? *Renew. Sustain. Energy Rev.* **2016**, *62*, 1032–1046. [CrossRef]
4. Frantal, B.; Novakova, E. On the spatial differentiation of energy transitions: Exploring determinants of uneven wind energy developments in the Czech Republic. *Morav. Geogr. Rep.* **2019**, *27*, 79–91. [CrossRef]
5. Van der Horst, D.; Martinat, S.; Navratil, J.; Dvorak, P.; Chmielova, P. What can the location of biogas plants tell us about agricultural change? A Case Study from the Czech Republic. *Deturope-Cent. Eur. J. Reg. Dev. Tour.* **2018**, *10*, 33–52. [CrossRef]
6. Chodkowska-Miszczuk, J.; Martinat, S.; Kulla, M.; Novotny, L. Renewables projects in peripheries: Determinants, challenges and perspectives of biogas plants—Insights from Central European countries. *Reg. Stud. Reg. Sci.* **2020**, *7*, 362–381. [CrossRef]
7. Martinat, S.; Navratil, J.; Dvorak, P.; Van der Horst, D.; Klusacek, P.; Kunc, J.; Frantal, B. Where AD plants wildly grow: The spatio-temporal diffusion of agricultural biogas production in the Czech Republic. *Renew. Energy* **2016**, *95*, 85–97. [CrossRef]
8. Chodkowska-Miszczuk, J.; Kulla, M.; Novotny, L. Biogas energy—A chance for agriculture and rural development? Insight from the post-communist Central Europe. *Deturope-Cent. Eur. J. Reg. Dev. Tour.* **2019**, *11*, 30–53. [CrossRef]
9. van der Ploeg, J.D.; Renting, H.; Brunori, G.; Knickel, K.; Mannion, J.; Marsden, T.; de Roest, K.; Sevilla-Guzman, E.; Ventura, F. Rural development: From practices and policies towards theory. *Sociol. Rural.* **2000**, *40*, 391–408. [CrossRef]
10. Renting, H.; Rossing, W.A.H.; Groot, J.C.J.; Van der Ploeg, J.D.; Laurent, C.; Perraud, D.; Stobbelaar, D.J.; Van Ittersum, M.K. Exploring multifunctional agriculture. A review of conceptual approaches and prospects for an integrative transitional framework. *J. Environ. Manag.* **2009**, *90*, S112–S123. [CrossRef]
11. Jenssen, T.; Konig, A.; Eltrop, L. Bioenergy villages in Germany: Bringing a low carbon energy supply for rural areas into practice. *Renew. Energy* **2014**, *61*, 74–80. [CrossRef]
12. Dincer, I. Renewable energy and sustainable development: A crucial review. *Renew. Sustain. Energy Rev.* **2000**, *4*, 157–175. [CrossRef]
13. Zemo, K.H.; Panduro, T.E.; Termansen, M. Impact of biogas plants on rural residential property values and implications for local acceptance. *Energy Policy* **2019**, *129*, 1121–1131. [CrossRef]
14. Chodkowska-Miszczuk, J.; Martinat, S.; Cowell, R. Community tensions, participation, and local development: Factors affecting the spatial embeddedness of anaerobic digestion in Poland and the Czech Republic. *Energy Res. Soc. Sci.* **2019**, *55*, 134–145. [CrossRef]
15. Chodkowska-Miszczuk, J.; Martinat, S.; van der Horst, D. Changes in feedstocks of rural anaerobic digestion plants: External drivers towards a circular bioeconomy. *Renew. Sustain. Energy Rev.* **2021**, *148*, 111344. [CrossRef]
16. Martinat, S.; Dvorak, P.; Frantal, B.; Klusacek, P.; Kunc, J.; Kulla, M.; Mintalova, T.; Navratil, J.; Van der Horst, D. Spatial consequences of biogas production and agricultural changes in the Czech Republic after EU accession: Mutual symbiosis, coexistence or parasitism? *Acta Univ. Palacki. Olomuc. Fac. Rerum Nat. Geogr.* **2013**, *44*, 75–92.
17. Ciervo, M.; Schmitz, S. Sustainable biofuel: A question of scale and aims. *Morav. Geogr. Rep.* **2017**, *25*, 220–233. [CrossRef]
18. Frantal, B.; Prousek, A. It's not right, but we do it. Exploring why and how Czech farmers become renewable energy producers. *Biomass Bioenergy* **2016**, *87*, 26–34. [CrossRef]
19. Upreti, B.R.; van der Horst, D. National renewable energy policy and local opposition in the UK: The failed development of a biomass electricity plant. *Biomass Bioenergy* **2004**, *26*, 61–69. [CrossRef]
20. Kortsch, T.; Hildebrand, J.; Schweizer-Ries, P. Acceptance of biomass plants—Results of a longitudinal study in the bioenergy-region Altmark. *Renew. Energy* **2015**, *83*, 690–697. [CrossRef]
21. Martinat, S.; Dvorak, P.; Navratil, J.; Klusacek, P.; Kulla, M.; Mintalova, T.; Martinatova, I. Importance of agricultural anaerobic digestion plants for agriculture and rural development: Notes on researches carried out in the Czech Republic and Slovakia. *Rural Dev.* **2013**, *6*, 168–176.

22. Chodkowska-Miszczuk, J.; Kola-Bezka, M.; Lewandowska, A.; Martinat, S. Local Communities' Energy Literacy as a Way to Rural Resilience-An Insight from Inner Peripheries. *Energies* **2021**, *14*, 2575. [CrossRef]
23. Dvorak, P.; Martinat, S.; Van der Horst, D.; Frantal, B.; Tureckova, K. Renewable energy investment and job creation; a cross-sectoral assessment for the Czech Republic with reference to EU benchmarks. *Renew. Sustain. Energy Rev.* **2017**, *69*, 360–368. [CrossRef]
24. Martinat, S.; Melnikova, V.; Dvorak, P.; Klusacek, P.; Navratil, J.; Van der Horst, D. Anaerobic digestion plants in rural space: Some comments on their acceptance at community level. In Proceedings of the 16th International Colloquium on Regional Sciences, Valtice, Czech Republic, 19–21 June 2013; pp. 287–296. [CrossRef]
25. Dvorak, P.; Martinat, S.; Klusacek, P.; Van der Horst, D.; Navratil, J.; Kulla, M. Divergent trends in agriculture and in sector of anaerobic digestion plants in the czech republic: Opportunity or threat? In Proceedings of the 16th International Colloquium on Regional Sciences, Valtice, Czech Republic, 19–21 June 2013; pp. 277–286. [CrossRef]
26. Martinat, S.; Navratil, J.; Trojan, J.; Frantal, B.; Klusacek, P.; Pasqualetti, M.J. Interpreting regional and local diversities of the social acceptance of agricultural AD plants in the rural space of the Moravian-Silesian Region (Czech Republic). *Rend. Lincei-Sci. Fis. E Nat.* **2017**, *28*, 535–548. [CrossRef]
27. Wustenhagen, R.; Wolsink, M.; Burer, M.J. Social acceptance of renewable energy innovation: An introduction to the concept. *Energy Policy* **2007**, *35*, 2683–2691. [CrossRef]
28. Acikgoz, C. Renewable energy education in Turkey. *Renew. Energy* **2011**, *36*, 608–611. [CrossRef]
29. Magnani, N. Exploring the Local Sustainability of a Green Economy in Alpine Communities. *Mt. Res. Dev.* **2012**, *32*, 109–116. [CrossRef]
30. Dobers, G.M. Acceptance of biogas plants taking into account space and place. *Energy Policy* **2019**, *135*, 110987. [CrossRef]
31. Emmann, C.H.; Arens, L.; Theuvsen, L. Individual acceptance of the biogas innovation: A structural equation model. *Energy Policy* **2013**, *62*, 372–378. [CrossRef]
32. Soland, M.; Steimer, N.; Walter, G. Local acceptance of existing biogas plants in Switzerland. *Energy Policy* **2013**, *61*, 802–810. [CrossRef]
33. Kontogianni, A.; Tourkolias, C.; Skourtos, M.; Damigos, D. Planning globally, protesting locally: Patterns in community perceptions towards the installation of wind farms. *Renew. Energy* **2014**, *66*, 170–177. [CrossRef]
34. Hadar, L.; Danziger, S.; Hertwig, R. The Attraction Effect in Experience-based Decisions. *J. Behav. Decis. Mak.* **2018**, *31*, 461–468. [CrossRef]
35. McAndrew, C.; Gore, J. Understanding Preferences in Experience-Based Choice: A Study of Cognition in the "Wild". *J. Cogn. Eng. Decis. Mak.* **2013**, *7*, 179–197. [CrossRef]
36. OWR. Rejestr Wytwórców Biogazu Rolniczego. Available online: https://www.kowr.gov.pl/uploads/pliki/oze/biogaz/Rejestr%20wytw%C3%B3rc%C3%B3w%20biogazu%20rolniczego%20z%20dnia%2028.01.2022%20r.pdf (accessed on 5 February 2022).
37. Francis, J.J.; Johnston, M.; Robertson, C.; Glidewell, L.; Entwistle, V.; Eccles, M.P.; Grimshaw, J.M. What is an adequate sample size? Operationalising data saturation for theory-based interview studies. *Psychol. Health* **2010**, *25*, 1229–1245. [CrossRef] [PubMed]
38. Kim, J.H.; Park, J.H.; Yoo, S.H. Public preference toward an energy transition policy: The case of South Korea. *Environ. Sci. Pollut. Res.* **2020**, *27*, 45965–45973. [CrossRef] [PubMed]
39. Bertsch, V.; Hall, M.; Weinhardt, C.; Fichtner, W. Public acceptance and preferences related to renewable energy and grid expansion policy: Empirical insights for Germany. *Energy* **2016**, *114*, 465–477. [CrossRef]
40. Tsagarakis, K.P.; Mavragani, A.; Jurelionis, A.; Prodan, I.; Andrian, T.; Bajare, D.; Korjakins, A.; Magelinskaite-Legkauskiene, S.; Razvan, V.; Stasiuliene, L. Clean vs. Green: Redefining renewable energy. Evidence from Latvia, Lithuania, and Romania. *Renew. Energy* **2018**, *121*, 412–419. [CrossRef]
41. TIBCO. TIBCO Statistica™ Quick Reference. Available online: https://docs.tibco.com/pub/stat/13.3.0/doc/pdf/TIB_stat_13.3_quick_ref.pdf (accessed on 11 December 2021).
42. Bremond, U.; Bertrandias, A.; Steyer, J.P.; Bernet, N.; Carrere, H. A vision of European biogas sector development towards 2030: Trends and challenges. *J. Clean. Prod.* **2021**, *287*, 125065. [CrossRef]
43. Bessette, D.L.; Mills, S.B. Farmers vs. lakers: Agriculture, amenity, and community in predicting opposition to United States wind energy development. *Energy Res. Soc. Sci.* **2021**, *72*, 101873. [CrossRef]
44. Stober, D.; Suskevics, M.; Eiter, S.; Muller, S.; Martinat, S.; Buchecker, M. What is the quality of participatory renewable energy planning in Europe? A comparative analysis of innovative practices in 25 projects. *Energy Res. Soc. Sci.* **2021**, *71*, 101804. [CrossRef]
45. Larsen, S.V.; Hansen, A.M.; Nielsen, H.N. The role of EIA and weak assessments of social impacts in conflicts over implementation of renewable energy policies. *Energy Policy* **2018**, *115*, 43–53. [CrossRef]
46. Hewitt, R.J.; Bradley, N.; Compagnucci, A.B.; Barlagne, C.; Ceglarz, A.; Cremades, R.; McKeen, M.; Otto, I.M.; Slee, B. Social Innovation in Community Energy in Europe: A Review of the Evidence. *Front. Energy Res.* **2019**, *7*, 31. [CrossRef]
47. Yildiz, O.; Rommel, J.; Debor, S.; Holstenkamp, L.; Mey, F.; Muller, J.R.; Radtke, J.; Rognli, J. Renewable energy cooperatives as gatekeepers or facilitators? Recent developments in Germany and a multidisciplinary research agenda. *Energy Res. Soc. Sci.* **2015**, *6*, 59–73. [CrossRef]

48. Herbes, C.; Brummer, V.; Rognli, J.; Blazejewski, S.; Gericke, N. Responding to policy change: New business models for renewable energy cooperatives—Barriers perceived by cooperatives' members. *Energy Policy* **2017**, *109*, 82–95. [CrossRef]
49. Heras-Saizarbitoria, I.; Saez, L.; Allur, E.; Morandeira, J. The emergence of renewable energy cooperatives in Spain: A review. *Renew. Sustain. Energy Rev.* **2018**, *94*, 1036–1043. [CrossRef]
50. Fischer, B.; Gutsche, G.; Wetzel, H. Who wants to get involved? Determining citizen willingness to participate in German renewable energy cooperatives. *Energy Res. Soc. Sci.* **2021**, *76*, 102013. [CrossRef]
51. Nevzorova, T.; Kutcherov, V. Barriers to the wider implementation of biogas as a source of energy: A state-of-the-art review. *Energy Strategy Rev.* **2019**, *26*, 100414. [CrossRef]
52. Benediktsson, K. Conflicting imaginaries in the energy transition? Nature and renewable energy in Iceland. *Morav. Geogr. Rep.* **2021**, *29*, 88–100. [CrossRef]
53. Gnatiuk, O.; Mezentsev, K.; Provotar, N. From the agricultural station to a luxury village? Changing and ambiguous everyday practices in the suburb of Vinnytsia (Ukraine). *Morav. Geogr. Rep.* **2021**, *29*, 202–216. [CrossRef]