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Interpreting regional and local diversities of the social acceptance of agricultural AD plants in the rural space of the Moravian-Silesian Region (Czech Republic)

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Abstract:
Agricultural anaerobic digestion plants have recently become a typical part of rural landscape in the Czech Republic due to massive governmental subvention programmes. Yet, their potential as an effective tool how to response to global climate changes at a local level is rather underused (maize used as a primary input mainly, usage of waste heat is limited etc.). This situation is caused by misguided subvention policies. The aim of this contribution is first to analyse the agricultural anaerobic digestion plants in the rural space of the Moravian-Silesian Region, and second, to deepen the knowledge on the perception of the digestion plants among the population of municipalities in which such facility was constructed. A questionnaire survey has been carried out in three model municipalities (n=369) located in the Moravian-Silesian Region. Several recommendations and notes for public administration and potential investors concerning the

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location of future anaerobic digestion plants projects and settings of supportive programmes have been defined.

Keywords:
Agricultural AD plants, Czech Republic, rural geography, spatial distribution, perception, acceptance

Introduction

The total amount of energy that is consumed in the Czech Republic oscillates annually around 70 TWh. Despite a slightly decreasing tendency in the national electricity consumption (by 1,9 % in comparison to 2010), which is probably caused by a recent sharp increase in energy prices, the discussions about breaking the limits for coal mining in the Czech Republic are getting stronger. Coal still belongs to one of the most important primary sources of energy covering almost two-fifths of the electricity generated in the Czech Republic, and providing jobs to almost 23,000 people. On the other hand, the extraction of coal as a non-renewable resource of energy in suitable natural conditions and at a reasonable cost is limited, and it causes indisputable huge social and environmental implications (Frantal, 2016; Frantal and Novakova, 2014; Setti and Balzani, 2011). Thus, coal extraction using up-to-date technologies will last merely several decades, while the costs for negative externalities related to mining are enormous (Morrice and Colagiuri, 2013). A question arises then, how the coal, representing an important source of energy, might be replaced. In the Czech Republic, nuclear energy is very popular by tradition (its share in the energy mix of the Czech Republic has increased from one-tenth to circa one-fifth in the last quarter of a century), yet this type of energy raises plenty of controversies related to both the safety of its operation and the storage of radioactive waste (Pasqualetti and Pijawka, 1996; Fiorini, 2014 or Frantal et al., 2016). It seems that an effective use of renewable energy sources or utilisation of waste energy (Zechina, 2014) might be an option, and it could partially reduce the dependency of the country on exhaustible resources of energy. Yet, there is still a set of barriers when generating renewable energy (Foxon et al., 2005). Despite its environmental benefits, it has to be stressed out that there have been a plenty of scandals accompanying the development of renewable resources applied in the Czech Republic, resulting from the recent misguided supportive policies (Suchacek et al., 2014) and thus, the image of renewable sources has been significantly damaged among the public. However, their environmental benefits when located properly (Van der Horst, 2007) and used reasonably in the context of adaptation to ongoing global climate changes, are obvious.
One of the renewable energy production systems whose benefits (along with the difficulties associated with their operation) might be claimed not only by their operators but also by rural population, are anaerobic digestion (AD) plants. The aim of the paper is i) to evaluate agricultural AD plants in the Moravian-Silesian Region (the Czech Republic) from the perspective of their location, installed capacities, agricultural hinterland, the type of the operator and socio-economic characteristics of municipalities of their location (19 AD plants); ii) to assess how three agricultural AD plants (Pustejov, Hodonovice/Baska, Lodenice/Holasovice) in the Moravian-Silesian Region are perceived by its local population. In its final part, the paper formulates suggestions for public administration, and potential investors for AD plants are proposed so that the potential of agricultural AD plants for the sustainable development of the areas is developed as much as possible and at the same time, its negative impacts on the environment and local population are minimised.

Theoretical framework

The issue of renewable resources of energies presents us with a plenty of potential research topics for human geographers. We may assume that geography as a science that investigates its spatial consequences, relations and dependencies among natural and social environs can provide us with

suitable methodological tools how to evaluate the location suitability of individual renewable energy production systems under the given circumstances. Such approach is of no use unless the locations of renewable energy production systems are designed in such a way that they consume as much energy potential as possible and at the same time, their negative impacts on social environs of communities are reduced (Devine-Wright, 2009). This way, the location of certain renewable energy production systems should always be a compromise between the local physical-geographical conditions and the requirements and preferences of the local population (Musall and Kuik, 2011), who will be affected by the construction and operation of the systems on a daily basis. (Kabai, 2017; Szendi, 2016).

Considering the location of agricultural AD plants, they are frequently situated within agricultural farms, which produce huge amounts of agricultural waste that could be energetically processed (Chodkowska-Miszczuk et al., 2017; Balat and Balat, 2009). Unfortunately, this is hardly the case in the Czech Republic, , where the main input material for agricultural AD plants involves purposely grown maize. This development will be evidenced in the text bellow. Obviously, it is a subject of many controversies (see the discussion by Troost et al. (2015) on the example of Germany), as more than 300 agricultural AD plants have emerged across the agricultural landscape of the Czech Republic during the last decade affecting the structure of sowing areas, which as a consequence significantly changed in favour of purposely grown energy crops (maize, rape plant etc.).

The research on AD plants shows that the attitude of the operators (mostly farmers) toward the technology is significantly affected by various factors (profit, personal visions of farming and sustainability etc.). The key topics that may shape the public and stakeholder attitudes toward AD plant projects in a wide range of contexts are the site (location, size and transport accessibility), input materials (purpose grown crops, agricultural waste, households waste etc.), utilisation of AD plants products for local needs (power, heat) and the extent of impact on its local community. As the analyses of other renewables suggest the decision-making processes may also be affected by various perceptions such as beliefs that the local communities will have a chance to participate (Wüstenhagen et al., 2007); the distributional fairness or the scale and sharing of costs and benefits (Bristow et al 2012; Soland et al., 2013); trust in the intentions of policymakers, companies, and other stakeholders and actors involved in the development and the information they provide. The previous research also indicated higher rates of a local acceptance of anaerobic digestion plants in the areas with a larger effect of the provided economic benefits (e.g. small communities in less-favoured peripheral areas, post-industrial regions with environmental degradation, etc; see Van der Horst, 2005).

The agriculture in the Czech Republic has been recently under a large pressure to reduce its food production (Picha et al., 2017) and replace it with some other, non-food activities, and so agricultural AD plants serve as an alternative source of income for farmers rather than representing an environmentally friendly way how to deal with global environmental problems on the local level (Martinat et al., 2016). A shift from perceiving agriculture as a pure food producer to a producer of (renewable) energy is related to a European-wide tendency, which follows agricultural change from its primarily production functions to post-productive functions. Such post-productive tendencies include the diversification of farmers activities (in favour of non-agricultural activities), the extensification of their activities (as a result of an excessive intensification of agriculture in the past), an increase in the added value of agricultural products produced on farms or a development of environmentally friendly farming and a care for landscape (Demeny and Centeri, 2008; Ilbery, 2014). It can be generally stated that the post-productive stage of an agricultural change (Wilson, 2001; Walford, 2003; Calleja et al., 2012; Hruska, 2014; Konecny, 2014) emphasises the importance of the products of immaterial nature, while the former key material thesis perceived farming as a primary food producer (Zasada, 2011). It seems that the concept of multifunctional agriculture might serve to some extent as a compromise between the above-mentioned extreme perceptions of an agricultural change (Groot et al., 2007). Multifunctional farming interconnects

both approaches (productive and post-productive) and puts an emphasis on the necessity to preserve agriculture as a food producer (Marsden and Sonnino, 2008; Renting et al., 2009; Tamasy, 2013; Davis and Carter, 2014). The key function of agriculture lies in providing food safety as well as guaranteeing that other functions of agriculture will be taken into account so that food production is not crowded out (Holden et al., 2006).
One of the outcomes of post-productive agriculture is agricultural AD plants operation (Igliński et al., 2012) or a massive occurrence of unused, abandoned and neglected buildings and sites after farming (the so-called agricultural brownfields - Svobodova and Veznik, 2009; Smith et al., 2011; Klusacek et al., 2013; Krzysztofik et al., 2016). Such a development gets reflected in the changing perceptions of agricultural (and non-agricultural) activities by farmers (Zagata, 2009), public administration or local rural population (Janeckova Molnarova et al., 2017) in various natural and socio-economic conditions (Chodkowska-Miszczuk and Szymańska, 2013).

Methodology and data

The initial phase of this research was the development of a database of agricultural AD plants for the areas of the Moravian-Silesian Region (an area of 5 445 km^2 in the eastern part of the Czech Republic). Basic information on individual AD plants was collected using the databases of the Energy Regulatory Office in the Czech Republic (www.eru.cz) and the Czech Biogas Association (www.czba.cz). The basic database was supplied with a set of indicators to evaluate the individual agricultural AD plants (installed capacities, type of the operator, input material, the location of AD plant within the municipality) and an evaluation of municipalities (population growth, price of agricultural land, agricultural regions, less favourite areas) in which the surveyed plants are located. Individual indicators were collected from multiple sources such as the Ministry of Agriculture of the Czech Republic (www.eagri.cz), Czech Statistical Office (www.czso.cz), or a database of documentations for the Environmental Impact Assessment process for projects of agricultural AD plants (www.cenia.cz/eia). The collected data was accompanied by a detailed field inspection of individual AD plants (19) in the surveyed region.
After all the necessary data was gathered and analysed, three case study municipalities with agricultural AD plants located in various natural and socio-economic conditions were selected for a deeper research on the perception of AD plants by the local population. The selection of individual case study municipalities respected the diversity of locations, so that various locations would be covered – such as municipalities with fertile soils (sugar beet agricultural production area – Holasovice, Pustejov), municipalities in less favourite areas for agricultural activities (potatoes agricultural production area – Baska), municipalities located in the hinterland of larger cities (Baska) or in more peripheral areas (Pustejov). The case study municipalities were also selected with respect to their rural nature, the limited population number (less than population one thousand) and diverse locations of AD plants (out of the settled area of a municipality in case of Pustejov and Baska; within the settled area in case of Holasovice). To examine how the local AD plants are perceived, the semi-structured interviews with the local population were selected as the most suitable method. Skilled interviewers (mostly university students) addressed people in the streets of a particular municipality in close proximity of the operating agricultural AD plants. A preliminary survey was carried out during September 2014 using a sample of ten respondents to make sure that the questions are comprehensible and formulated accurately. The questions in the questionnaire (or better a guidebook on how to perform the interviews) were inspired by a set of previous studies carried out in different countries (Lanz et al., 2007; Emman et al., 2013). The survey was carried out in Baska, Holasovice and Pustejov during the autumn of 2014. The local population (older than 18 years) living in the close proximity of an agricultural AD plant was asked to express its opinion on the operation of the plant. Out of the total of 406 respondents, only 37 respondents refused to participate in the survey. The sample gathered included case study municipalities with a low population number, a suitable structure of age, education and gender (see Table 1 for the structure

of the sample; 123 questionnaires were collected in Pustejov, 116 in Lodenice/Holasovice, 130 in Hodonovice/Baska). The gathered data was digitalized and evaluated both separately and as one unit to identify the specifics of the particular case study municipality. The representativeness of the sample was tested by means of Chi-square test and was secured regarding the gender structure in all three case study municipalities. In case of the educational structure the samples from only two municipalities meet the criteria of representativeness (Pustejov, Lodenice), the sample from the third municipality (Hodonovice) is slightly unrepresentative (see Table 2 for information concerning the representativeness of the sample). It was not possible to test the representativeness of the sample relating to the age structure as the age categories used by the Czech Statistical Office differ from those used by the authors of the survey (there is a 50% overlap between the categories of the Czech Statistical Office and the categories of the authors of the survey). In general though we may proclaim that the number of questionnaires gathered from the elderly people is lower as the primary concern of authors of the survey were the opinions of economically active population (18-65 years).

Table 1. The structure of the respondents in three case study municipalities

	categories	Pustejov (%)	Lodenice / Holasovice (%)	Hodonovice / Baska (%)
age (years)	18-26	13.0	25.0	23.8
	26-35	19.5	19.0	24.6
	36-45	26.8	19.8	22.3
	46-55	18.7	16.4	16.2
	46-65	13.8	11.2	5.4
	66 <	8.1	8.6	7.7
education	primary	12.2	17.2	8.5
	secondary	75.6	70.7	80.8
	tertiary	12.2	12.1	10.8
gender	male	60.2	51.7	53.1
	female	39.8	48.3	46.9

Source: questionnaire survey (Pustejov n=123; Lodenice/Holasovice n= 116; Hodonovice/Baska n= 130)

Table 2. The representativeness of the sample

	Pustejov	Lodenice/Holasovice	Hodonovice/Baska
gender	Chi-Square = 3.074; d.f. = 1; p = .080	Chi-Square = .138; d.f. = 1; p = .710	Chi-Square = 1.148; d.f. = 1; p = .28
education	Chi-Square = 5.456; d.f. = 2; p = .064	Chi-Square = 2.103 d.f. = 2; p = .349	Chi-Square = 7.895; d.f. = 2; p = .019

Note: d.f. = degrees of freedom
Source: Own calculations

Repeated Measures ANOVA was applied on three case study sites to compare the differences in the opinions of the local population on how they perceive the agricultural AD plant before and after the construction (i.e. during the planning period vs. the period of its full operation). The Repeated Measures ANOVA was applied as each subject was evaluated twice (before the construction and after the realisation) and we assume that these records are not independent of one another and thus the factorial ANOVA could not be used (Quinn and Keough, 2002). The assumption of proper use of The Repeated Measures ANOVA were tested using the Levene´s test (to test the normality of the distribution of the responses in each municipality), and the analysis of histograms and p-plots of predicted values and residuals was employed (to identify a possible multicollinearity and heteroscedasticity). Multiple comparisons were applied to decide which municipalities are different. Besides, the Tukey post-hoc test for an unequal n was employed, as the number of responses from each municipality was different.
After that, the respondents were divided into two groups – the first group (labelled as “the discontented”) included those respondents whose opinion on the local agricultural AD plant had not

improved after its construction; the second group consisted of the rest of the respondents (and might be labelled as "the contented"). To find out which factors influence whether the respondents identify themselves either with the first or the second group, the logistical regression was applied. The group was selected as a dependent variable (bicategorial) and responses were used as independent predictors. The Logit link was applied, as such an approach is quite usual in suchlike studies (e.g. Robinson, 1998). The commonly used goodness-of-fit indices for logistic regression models were applied (the Hosmer-Lemeshow test and the Nagelkerke Pseudo R^2). The significance of the Hosmer-Lemeshow test tells us that there are statistical differences between the measured and the modelled data, thus, it can reveal an inappropriate model for our data. The Nagelkerke Pseudo R^2 is a standardised form for the Cox & Snell's Pseudo R^2 and similar to ordinary least squares R^2; it can be interpreted as an explained variability of the dependent variable by variability of independent predictors.

Agricultural AD plants in the countryside of the Moravian-Silesian Region

As a consequence of a massive governmental support of renewable energies in the Czech Republic, the sector of AD plants experienced an enormous growth during the last decade. If we take a look back to the beginning of the new millennium, there were just ten of such facilities across the Czech Republic. Nowadays there are more than 550 AD plants operating with 392.35 MWh of total installed capacities and they annually generate more than 2.5 TWh of electricity. Such an amount of energy makes an AD plants sector an important producer of electricity, with 2.6 % share in total electricity generation in 2014 (in comparison with the year 2008 when the share was merely 0.3 %). The biogas sector contributes by one-quarter to the electricity generated from renewable sources (2014), which makes this sector the most important one among the renewable energy production systems (PVs being the second most important sector contribute by one-fifth of the generated renewable energy). Agricultural AD plants represent with circa 320 plants the most important part of the biogas sector within the rural space of the Czech Republic.

When we focus on the Moravian-Silesian Region, we locate 19 agricultural AD plants in operation in 2014 with 17.14 MW of the total installed electricity capacity and 17.564 MW of heat installed capacity (see the overview of individual plants in Table 3 and their geographical location in Figure 1). It is obvious that the distribution of agricultural AD plants is rather uneven within the Moravian-Silesian Region. The highest concentration of agricultural AD plants (7 plants) is along the Odra River, which is the most fertile part of the region. Less important clusters are located in the western part of the region outside Opava city (2 plants), Krnov city (2 plants) and Osoblaha city - representing one of the most peripheral parts of the region. In the eastern part of the region, the occurrence of agricultural AD plants (Stonava, Baska, Horni Tosanovice) is just sporadic. Here, the AD plants located on wastewater treatment plants are more crucial (due to high population density in the wider Ostrava agglomeration). If we direct our attention to the municipal level, the largest agricultural AD plant by far is located in the fertile agricultural area in Pustejov (with the installed capacity of 1,680 MW, southwest of Studenka), while the smallest agricultural AD plants can be found in the submountain conditions in the proximity of Vitkov (with installed capacities around 0,500 MW). A unique example of agricultural AD plant is in Velke Albrechtice (near Bilovec – see Figure 1), where two agricultural AD plants (the oldest ones, built in 2001) are part of a large pig farm (11 000 pig heads), where pig manure is energetically processed. The above-mentioned biggest AD plant in Pustejov also belongs to one of the oldest AD plants in the region (since 2007), while the most recent plants (built in 2013, the support for new AD plants stopped since then) are located in the less favourite conditions for agricultural activities with somewhat smaller installed capacities (around 0.5 MW).

Table 3. Basic characteristics of agricultural AD plants in the area of the Moravian-Silesian Region

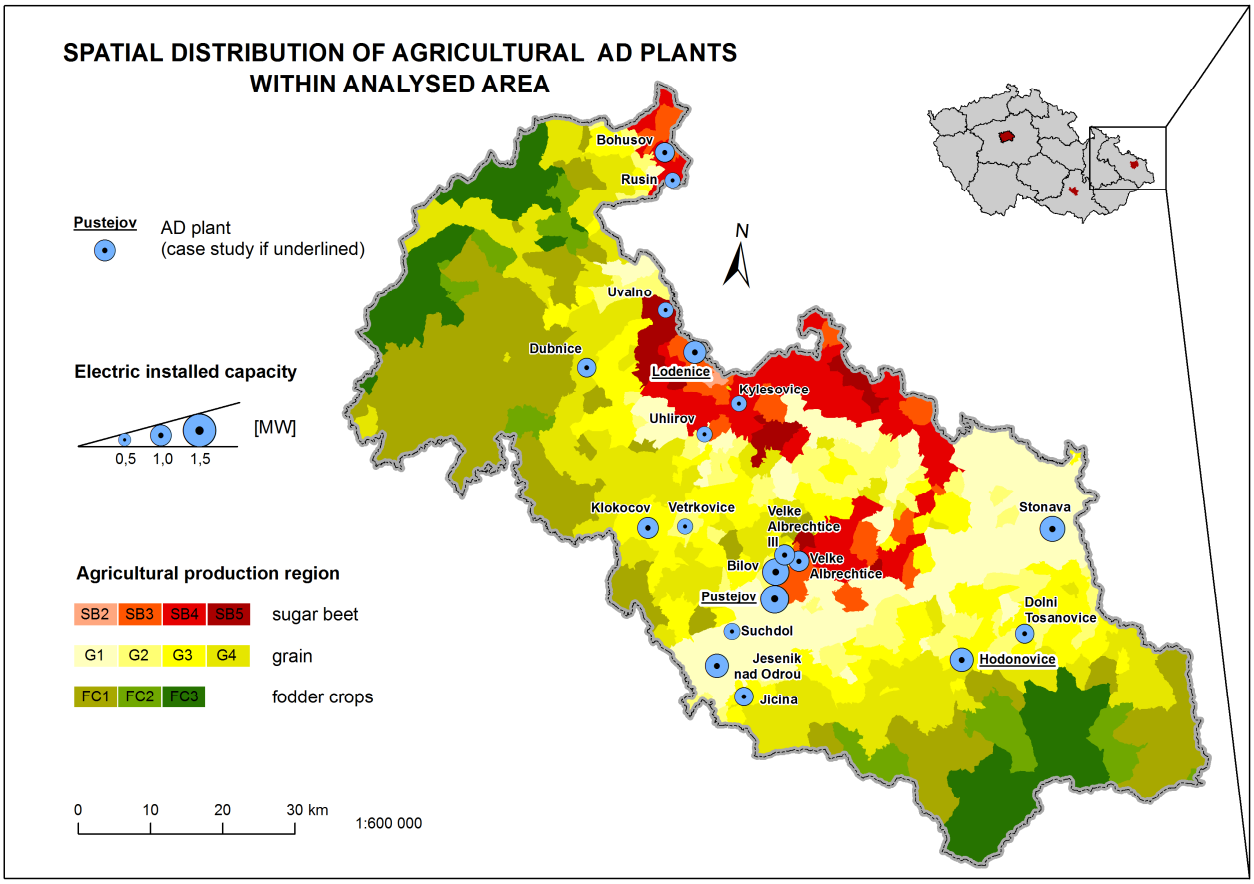
name of AD plant	type	operator (legal form)*	electric installed capacity (MW)	heat installed capacity (MW)	municipality/municipality with extended powers**	start of operation
Bilov	agricultural	Ltd.	1.487	1.472	Bilov/Bilovec	2013
Bohusov	agricultural	Ltd.	0.800	0.781	Bohusov/Krnov	2012
Dolni Tosanovice	agricultural	Ltd.	0.780	0.712	Dolni Tosanovice/Frydek-Mistek	2008
Hodonovice	agricultural	PLC	1.186	0.697	Baska/Frydek-Mistek	2011
Dubnice	agricultural	Ltd.	0.750	0.696	Horni Benesov/Bruntal	2010
Jesenik nad Odrou	agricultural	PLC	1.189	1.177	Jesenik nad Odrou/Novy Jicin	2012
Jicina	agricultural	PLC	0.760	0.750	Stary Jicin/Novy Jicin	2012
Kylesovice	agricultural	PLC	0.550	0.629	Opava/Opava	2013
Lodenice	agricultural	Coop.	1.090	1.016	Holasovice/Opava	2010
Rusin	agricultural	Ltd.	0.550	0.580	Rusin/Krnov	2013
Stonava	agricultural	Phys. pers.	1.380	1.313	Stonava/Karvina	2008
Suchdol	agricultural	Ltd.	0.590	0.655	Suchdol nad Odrou/Novy Jicin	2008
Uhlirov	agricultural	PLC	0.526	0.532	Uhlirov/Opava	2012
Uvalno	agricultural	PLC	0.550	0.580	Uvalno/Krnov	2013
Vetrkovice	agricultural	Coop.	0.526	0.538	Vetrkovice/Vitkov	2010
Velke Albrechtice	agricultural	PLC	0.900	1.242	Velke Albrechtice/Bilovec	2001
Velke Albrechtice III	agricultural	PLC	0.860	1.202	Velke Albrechtice/Bilovec	2001
Klokocov	agricultural	Ltd.	0.986	1.234	Vitkov/Vitkov	2006
Pustejov	agricultural	PLC	1.680	1.758	Pustejov/Bilovec	2007

Source: Energy Regulatory Office (www.eru.cz), Czech Biogas Association (www.czba.cz)

* Joint stock company (Jsc.), Public limited company (PCL), Cooperative (Coop.), Physical person (Phys. pers.)

** Municipality with extended powers – administrative district

Figure 1. Spatial distribution of agricultural AD plants in the Moravian-Silesian Region (2016)



Source: authors processing

When we consider the population numbers of municipalities with the surveyed agricultural AD plants (see Table 4), we can notice that one-half of the surveyed facilities is located in the municipalities with the population less than one thousand, eight AD plants in small settlements (villages and towns) with the population no more than six thousand, and only one plant is situated in the immediate hinterland of a larger city (an AD plant in Kylesovice, which is Opava city part with the population of circa 58 thousand). The majority of the surveyed agricultural AD plants are primarily concentrated in the rural areas, where they are expected to be closely linked to the local agricultural activities. Yet, as we will see bellow it is not always the case.

The most common legal form of operation of the surveyed agricultural AD plants are agricultural business companies (PCL, Jcs.), two plants are cooperatives, and only one AD plant is operated by a physical person (not a company) in Stonava. It has to be stressed out that the differences in legal forms of operation of AD plants are in fact insignificant, since due to their historical preconditions the surveyed farms are usually large companies (even the mentioned farm in Stonava administratively operated by a physical person has around 650 hectares of agricultural land). The rest of the three agricultural AD plants are operated by a company with no links to local agricultural activities.

Table 4 provides us with a comparison of local agricultural conditions in the hinterland of the individual agricultural AD plants. Eleven stations are located in the most fertile agricultural production region (the sugar beet agricultural production region), four of them even in the most fertile subcategory of this agricultural region along the Odra River. By contrast, the rest of the AD plants (8 plants) are located in the agricultural conditions of below-average quality, i.e. potato agricultural production region (in case of Dolni Tosanovice and Hodonovice, it is a subcategory with the soil of the worst quality). Considering the administrative price of agricultural land (which

evaluates solely the quality of agricultural land, without considering its market attractiveness), we can notice a wide span between the highest and the lowest price (almost 10 CZK/m^2 of agricultural land in Lodenice in Opava lowlands or Rusin in Osoblaha, and at the same time very low values in Dubnice by Horni Benesov, Klokočov by Vitkov or Hodonovice by Baska, where the price oscillates around 2 CZK/m^2 of agricultural land).
Let´s concentrate now on agricultural AD plants located in the areas with the so-called less favourite conditions for agricultural activities. Only six of the surveyed plants are located in such bad agricultural conditions that they have to be supported by a specific EU Common Agricultural Policy subvention system (Bilov, Hodonovice, Jicina, Dubnice, Vetrkovice, Klokocov). Which leaves us with two-thirds of the surveyed agricultural AD plants that are located in the areas with at least average agricultural conditions for farming. Regarding the location of AD plants, just half of them are located out of the settled areas of municipalities. In other words, nine agricultural AD plants were constructed within the settlements or in the immediate proximity of the settled areas (in the areas of large agricultural farms).

Table 4. Selected socio-demographic and agricultural characteristics of municipalities in the Moravian-Silesian Region where agricultural AD plants are located

name of AD plant	population number (2015)	population density (population/km^2)	agricultural production region (APR)*	price of agricultural land (CZK/m^2) **	less favourite areas (LFA)***	location of AD plant within settled part
Bilov	589	53.9	potatoes 2	4.61	O4	yes
Bohusov	385	19.7	sugar beet 1	7.96	out	no
Dolni Tosanovice	331	86.2	potatoes 3	4.11	out	no
Hodonovice	3756	289.4	potatoes 3	2.33	O2	no
Dubnice	2296	39.9	potatoes 1	1.89	O2	no
Jesenik nad Odrou	1939	66.2	sugar beet 3	7.06	out	no
Jicina	2785	81.1	potatoes 1	3.21	O3	yes
Kylesovice	57772	640.7	sugar beet 2	6.19	out	yes
Lodenice	1366	84.7	sugar beet 1	9.82	out	yes
Rusin	150	10.4	sugar beet 1	8.67	out	yes
Stonava	1898	133.7	potatoes 2	6.26	S1	no
Suchdol	2598	112.4	sugar beet 3	6.85	out	yes
Uhlirov	338	87.9	sugar beet 2	7.20	out	yes
Uvalno	975	67.2	sugar beet 1	5.87	out	no
Vetrkovice	745	42.1	potatoes 1	4.27	O4	yes
Velke Albrechtice	1077	80.5	sugar beet 3	6.67	out	no
Velke Albrechtice III	1077	80.5	sugar beet 3	6.67	out	no
Klokocov	5825	108.0	potatoes 1	2.15	O2	yes
Pustejov	988	115.4	sugar beet 3	6.00	out	no

Source: Czech Statistical Office (www.czso.cz), Ministry of Agriculture of CZ (www.eagri.cz), field research
* agricultural production region (APR) – agricultural regionalisation of the Czech Republic based on agro-ecological and economic conditions of the area
** price of agricultural land – administrative price of agricultural land that takes into account just the soil quality (not the market attractiveness), governed by the Ministry of Treasure of the Czech Republic
*** less favoured areas (LFA) – Common Agricultural Policy mechanism for maintaining the countryside in areas where agricultural production or activity is more difficult because of natural handicaps

It is obvious that the type and the amount of input material for agricultural AD plants belong to the crucial elements which should be selected carefully to produce energy effectively, but also to ensure that the negative impact on the local population is reduced and the environmental benefits of AD plants operation are utilised. Table 4 illustrates the structure of input material for agricultural AD

plants as declared by the operators during the environmental impact assessment process, i.e. during the permission process. Since the permission for an individual AD plant is issued for the given structure of input material, we may assume that the input material, as it will be illustrated bellow, reflects the reality to some extent. The documentations assessing the environmental impact of AD plants were available for 15 plants (out of 19), which is enough to perceive it as a representative sample.

The 15 surveyed agricultural AD plants are assumed to annually consume 414 thousand tons of biomass. Almost one-third out of this amount (31 %) accounts for purpose grown maize, followed by cow (23 %) and pig (22 %) manure. Grass silage and hay (10.5 %) and sugar beet chips as the remains of sugar beet processing (6.6 %) are not of minor importance either. As it is obvious from Table 5, the diversity of used input material is quite big, nevertheless, all of the above-mentioned input materials represent more than nine-tenths of the total material used for feeding of the surveyed AD plants. As we can see above, agricultural waste is an important part of the input material, yet agricultural AD plants in the Moravian-Silesian Region annually consume more than 128 thousand tons of purpose grown maize, which represents almost 40 % of the total harvest of maize (green and silage) in this region. In three cases the use of cereals (barley, triticale) as an energy source was detected, its production reaching to an annual amount of 13 thousand tons (in the most fertile areas). The operation of agricultural AD plants thus affects significantly the structure of sowing areas of maize in the Moravian-Silesian Region. Only two out of all surveyed agricultural AD plants did not prove to use maize as input material (Vetrkovice, Velke Albrechtice), while an AD plant in Bohusov consumes maize alone, and three other agricultural AD plants proved to use maize as a decisive input material (more than two-thirds of the total). Considering the variety of the input material, the maximum of 6 different types of material were identified in case of AD plant Velke Albrechtice and 5 types in case of three AD plants (Kylesovice, Baska, Pustejov). The AD plants next to Bohusov (1) in Rusin and Uhlirov (2) make use of a limited variety of the input material. Agricultural waste accounts for the majority of input material for agricultural AD plants in nine cases, in four cases purpose grown crops prevail (Bohusov, Rusin, Jesenik nad Odrou and Bilov), in two cases the structure of wastes and the purpose-grown material is equal. We can state that in agricultural AD plants located in the areas with a good soil quality the energy generation based on purpose grown crops is preferred, while in AD plants in worse agricultural conditions the utilisation of agricultural wastes prevail. Yet it seems that this hypothesis depends more on the decisions of the operators and is based on the economic effectiveness rather than on the location of the given AD plant from agricultural and environmental point of view (for example the AD plant in Bilov is located in average agricultural conditions and its operation is primarily based on maize). It seems that the intentions of the operators of agricultural AD plants are quite diverse and the idea of improving the environment through the energy use of agricultural waste is of minor importance.

Table 5. The structure of the declared input material of agricultural AD plants in the Moravian Silesian Region (selected cases*, in %)

AD plant / material	maize for silage	cow ma-nure	pig ma-nure	grass silage and hay	sugar beet chips	cereals	sludge from wood pulp	rests of plants	meat and bone meal	distillers soluble s	vegeta-ble oil	total
Bilov	65.4	22.0	0.0	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Bohusov	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Baska	18.6	14.9	44.6	6.5	0.0	0.0	0.0	15.4	0.0	0.0	0.0	100.0
Dubnice	44.8	32.1	0.0	14.3	8.8	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Jesenik nad Odrou	64.5	10.0	0.0	13.0	0.0	12.5	0.0	0.0	0.0	0.0	0.0	100.0
Jicina	8.2	70.6	0.0	19.8	0.0	0.0	0.0	1.4	0.0	0.0	0.0	100.0
Kylesovi-ce	18.0	54.5	0.0	4.3	1.7	21.5	0.0	0.0	0.0	0.0	0.0	100.0
Lodenice	37.1	0.0	37.1	0.0	25.8	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Rusin	87.7	0.0	0.0	12.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Stonava	36.8	0.0	42.0	3.0	17.9	0.0	0.0	0.0	0.0	0.0	0.3	100.0
Uhlirov	41.3	58.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Uvalno	47.6	29.4	0.0	7.5	15.6	0.0	0.0	0.0	0.0	0.0	0.0	100.0
Vetrkovice	0.0	41.7	0.0	50.0	0.0	0.0	0.0	8.3	0.0	0.0	0.0	100.0
Velke Albrechti-ce	0.0	0.0	60.1	20.2	2.4	0.0	9.6	0.0	3.8	3.8	0.0	100.0
Pustejov	19.4	25.8	25.8	0.0	19.4	9.7	0.0	0.0	0.0	0.0	0.0	100.0
Total	31.0	22.7	21.6	10.5	6.6	3.1	1.8	1.4	0.7	0.7	0.0	100.0

Source: Environmental Impact Assessment (EIA) documentations for individual AD plants (www.cenia.cz/eia)
* Documentations for EIA process were available just for 15 (out of 19 in total) AD plants; the share of water necessary for mixing the material is not included

The perception of agricultural AD plants in model areas

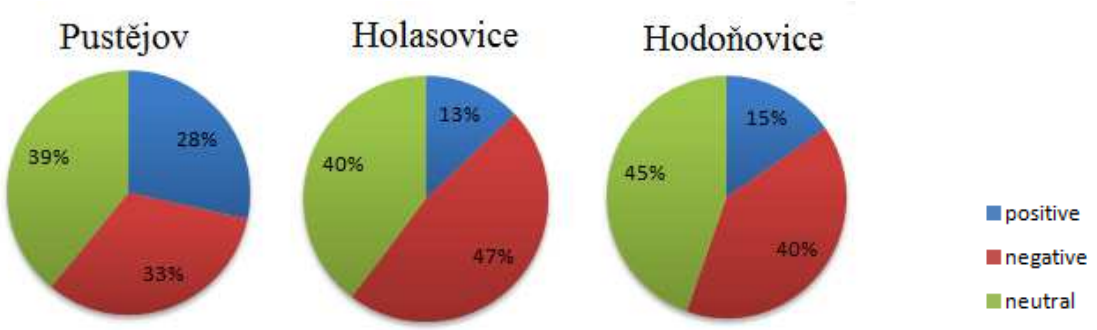
Let´s focus on the perception of agricultural AD plants by its population in case of three municipalities in which AD plants are located. The respondents were asked to express their opinions on the local agricultural AD plant before its construction (during the planning period) and after the realisation of the AD plant project (at the time of its full operation). By comparing the responses we might be able to measure the differences in the perception of AD plants between the two mentioned periods and to evaluate the differences among the individual cases.

To learn more on case study AD plants, specifics of planning, construction and operation of individual AD plants were ascertained in the local newspapers and media, which were followed by interviews with the operators of the given AD plants and its local mayors to identify and verify the driving forces and hints of the various levels of the perception of individual AD plants. Three case study municipalities with AD plants (Pustejov, Lodenice/Holasovice and Hodonovice/Baska – see their location in Figure 1) were selected to cover the diversity of various types of natural, agricultural and locational conditions for operating of agricultural AD plants.

It was found out that during the planning period of the surveyed agricultural AD plants a scepticism toward their operation was detected in case of Lodenice/Holasovice (almost 47 % of the respondents perceived this plan in a negative way) in contrast to Pustejov, where just one-third of the respondents were discontent (see Figure 2). This may be interpreted as a consequence of the planned location of AD plants. In Lodenice/Holasovice, the AD plant was meant to be located in a settled part of the municipality, while in Pustejov the planned location was outside the settled part of the municipality**.** It was in Pustejov where the most positive expectations concerning the planned AD plant were met (28 % of the respondents supported this idea). When we compare this with the

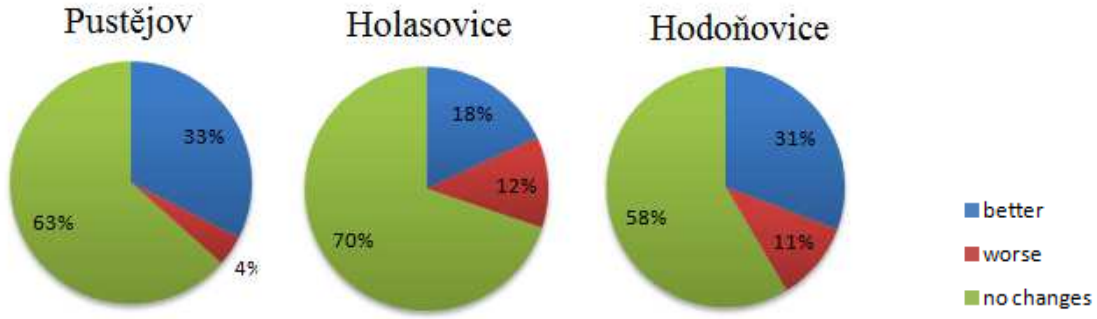
opinions of the respondents on the local AD plant after its construction, some important specifics can be also seen in case of Lodenice/Holasovice (see Figure 3). While in Loděnice/Holasovice just 18 % of the respondents changed their opinion about the local AD plant, in case of Pustejov and Hodonovice/Baska the percentage was much higher (almost one-third of the respondents). This result resonates with the location of the local AD plants in Pustejov and Hodonovice/Baska, where both plants are situated in more peripheral areas of the municipalities, where the quality of life of the local population cannot be affected (in Pustejov just 4 % of the respondents perceived the changes that brought the local AD plant along in a negative way). The fact that 60 to 70 % of the respondents did not register any significant changes during the operation of AD plants is also noteworthy. A relatively lower share of such respondents was found in case of Hodonovice/Baska, where the polarity of opinions concerning local AD plant seems to be stronger (the support for the AD plant is balanced here, it is perceived both positively and negatively here).

Figure 2. The perception of agricultural AD plants in case study municipalities (Pustejov, Lodenice/Holasovice, Hodonovice/Baska) as perceived during the planning phase



Source: questionnaire survey (n=368)

Figure 3. The perception of agricultural AD plants in case study municipalities (Pustejov, Lodenice/Holasovice, Hodonovice/Baska) as perceived during the operation of the plant



Source: questionnaire survey (n=368)

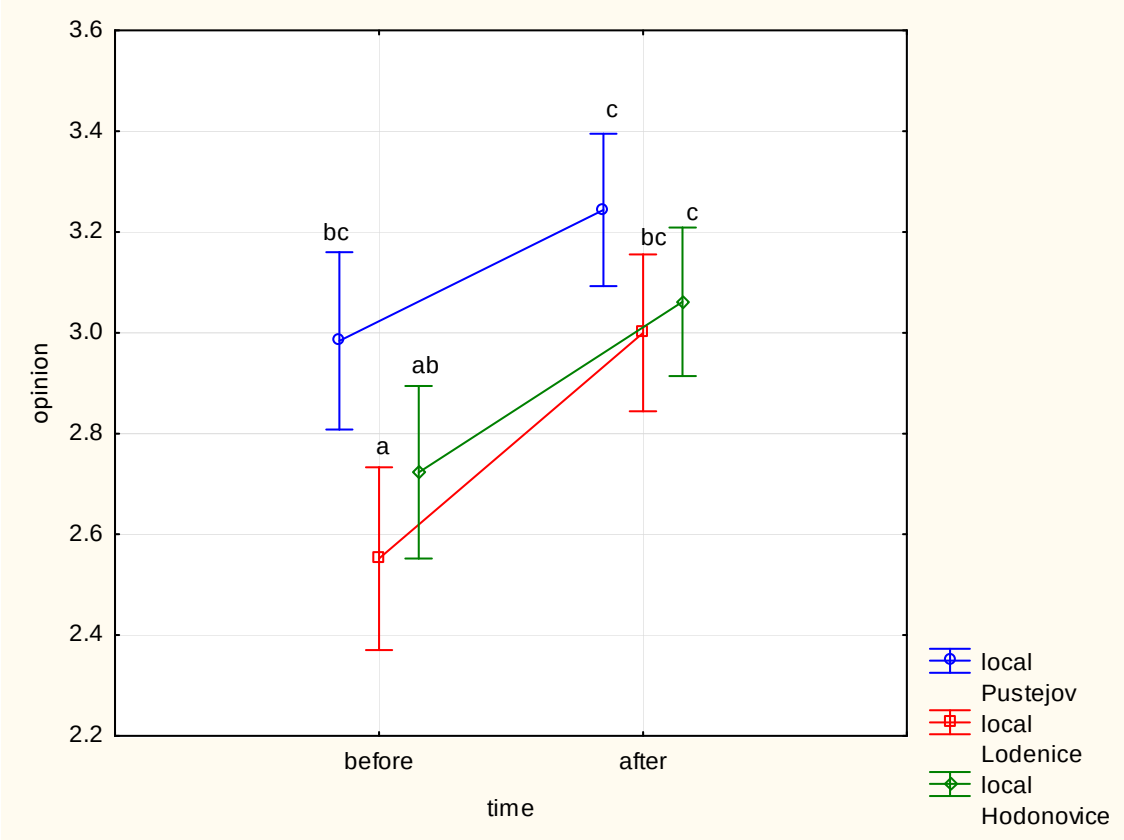
After evaluating the frequencies of answers more sophisticated statistical methods were employed to detect stronger results. Based on histograms, p-plots, and negative results of the Levene´s test we can conclude that the data are suitable for using the Repeated Measures ANOVA to analyse the combined influence of the locality and time on the opinions on the local agricultural AD plant. The difference is not so huge, but unequivocally statistically significant. The mean value of the acceptance is significantly higher after the realisation of the AD plant than before its construction in Hodonovice and Lodenice. The mean value of the acceptance is higher in Pustejov (see Table 6 and Figure 4). On the other hand, there is no difference between times of measurement among localities studied, thus the trend of the change is the same in all three localities.

Table 6: Results of Repeated Measures ANOVA.

Effect	SS	d.f.	MS	F	p
Intercept	6310.446	1	6310.446	5332.249	0.000
Municipality	14.194	2	7.097	5.997	0.003
Error	433.142	366	1.183		
Time	22.419	1	22.419	42.354	0.000
Time*municipality	1.063	2	0.532	1.004	0.367
Error	193.736	366	0.529		

Source: Authors´ processing

Figure 4. The means of the value between the opinions on local agricultural AD plant before its construction (during the planning period) and after the realization of the AD plant project (at the time of its full operation) and among the localities studied. The means with the same letter do not differ significantly – $p > 0.05$ based on Tukey post-hoc test for an unequal n.



Source: Authors processing

Using the logistic regression, the affiliation of the respondent to „the discontented“ group is **given** by the fact that the respondents are from Lodenice, not from Pustejov. Age, education and gender are not statistically significant predictors for the division of the respondents into the two analysed groups. Our model has an adequate fit, as the Hosmer-Lemeshow test criterion is 13.517 with p-value 0.100. The value of pseudo R2 is 0.15 (see Table 7 for the results).

Table 7: The model of the dependency of the affiliation to „the discontented“ group of the respondents after the realisation of the AD plant.

	Estimate	Standard Error	Wald Statistics	p
Intercept	-2.12	0.985	4.649	0.031
Education	0.102	0.272	0.140	0.708
Age	0.017	0.014	1.520	0.218
Pustejov	-1.026	0.364	7.956	0.005
Lodenice	0.934	0.318	8.640	0.003
Do you work in agriculture? Yes	0.109	0.471	0.054	0.816
Gender – male	0.295	0.232	1.620	0.203

Source: Authors´ processing

The driving forces of the acceptance of the AD plants in model areas

To explore the factors or the driving forces that influence the acceptance of the studied AD plants, the interviews with the operators of the given AD plants and the mayors of three municipalities were carried out.

The factors that significantly caused a higher level of positive perception of the local agricultural AD plant in Pustejov might be summarized in several points: i) the AD plant is located in the peripheral part of the municipality; ii) the petition against the AD plant construction was drawn up during the planning phase, and only a couple of complaints occurred during the operational phase; iii) only limited population live in the immediate proximity of the plant; an elongate shape of the settlement ensures that the other part of the municipality population is not affected by no means; iv) input material for the AD plant is transported by a road which runs outside the settled areas, so the bad impacts such as dust and noise are reduced; v) the operator in cooperation with the municipalities provides regular cleaning of the road. However, it is still controversial that the original promise of the operator of the plant, which was to ensure cheap supplies of energy for its local population, was not observed.

In case of Lodenice/Holasovice, where the local agricultural AD plant was perceived in a less positive way, the following factors can be detected: i) during the planning phase of the AD plant construction a petition against the construction was signed by the local population (a noticeable distrust toward the AD plant was expressed as a result of bad experience with the operation of an AD plant in near Klokocov, but the petition was not taken into consideration); the AD plant emits odours in the day time, some respondents commented it saying that the odour is much stronger than from the former piggery; iii) one of the conditions for getting the permission for building the AD plant was the necessity to build a special road to serve just for the AD plant (by 2015) that would divert the increased traffic from the settled part of the municipality (such road has not been built yet); iv) a significant increase in traffic in the settled part of the municipality was experienced as a result of regular material transport for the AD plant; v) local roads are frequently soiled by the transported material. To create a complete image of the AD plant in Lodenice/Holasovice, it is necessary to mention that in Holasovice another AD plant is located, based on the local landfill (2 kilometres to the north-east of Holasovice).

The AD plant in Hodonovice/Baska, where the most significant polarisation of opinions of the local population toward AD plant was detected, might be described by the following factors: i) the municipal council agreed to have an AD plant within the area of the municipality after their earlier aloof attitude, which had changed after a visit to the nearby AD plant in Stonava; ii) a public hearing regarding the construction plan was organized together with the presentation of experiences with the AD plant operation in Stonava; iii) the public hearing was followed by the permission of municipal council with the AD plant construction; iv) the municipal council respected

the opinion of the local population; v) an odour can be noticed occasionally in the proximity of the station (the plant is located outside the settled area of the municipality); vi) strong fears were connected with a potential disruption of the local tourism by operation of an AD plant; vii) during the same period when an AD plant was being constructed, the sewage system was built in the municipality; viii) the local media have recently opened the issue of an excessive usage of digestate (one of the side products of anaerobic digestion, used as a fertilizer when mixed with water) on local fields.

If we try to generalize the knowledge on the local factors that affect the attitudes of local population towards AD plants which we acquired from the three above mentioned cases, the following points can be defined: i) it was frequently stressed out that the odour from the manure which was previously transported to the local fields was significantly reduced when the AD plant started to operate; ii) the farms where AD plants are located usually belong to one of the most important employers in the municipality (however, an AD plant usually requires no more than 1 or 2 persons of the maintenance staff); iii) the economy of the farms would worsen without an AD plant operation; pig and cow breeding would be reduced (operators support their agricultural activities from the profits of biogas); iv) arable land would remain fallow in greater extent without the AD plant operation (maize growing).

Concluding remarks

Since the accession of the Czech Republic to the European Union, we have been experiencing a massive growth of installed capacities of AD plants across the countryside due to the significant governmental support. The operation of these facilities generates undisputed benefits regarding the economy of the farms (representing an alternative and stable source of income for the farmers), social aspects (employment in the countryside) and environmental aspects (energy processing of agricultural wastes, strengthening of the energy self-efficiency of the countryside). Yet, it is also necessary to understand the negatives of the AD plants construction and operation, which might heavily influence the quality of life of the local population (increased traffic in the municipality, possible odour). It is also necessary to state that the mentioned benefits might be under certain circumstances transformed into not so positive trends (for example a massive use of purpose grown maize and consequent crowding out effect on food production etc.). Thus, it would be desirable when setting the supportive schemes for AD plants that wider interests of society and local communities were taken into consideration, not only the interests of farmers/operators of AD plants. An adjustment of parameters of existing supportive programmes is necessary to avoid unintended consequences of their operation. In the Czech Republic the subvention programmes for AD plants were stopped at the end of 2013, and so except the requirement to use 10 % of the waste heat of the AD plants no other environmentally friendly settings are part of the system anymore. It would be useful to adapt the individual AD plants to the local agricultural conditions regarding the input material, the size of the plant and the possibilities to use effectively as many products of the plants as possible (e.g. heat). It is obvious that such concept would require some investments into the local heat infrastructure, yet it could make AD plants useful for the environment and the local community, too.

It is the local rural population who live in the proximity of the AD plants. Thus, it is necessary to learn more about their opinions, attitudes and preferences regarding the AD plants. The aim of this paper was to evaluate the regional and local specifics of agricultural AD plants operation in the area of the Moravian-Silesian Region (with a close look at three selected case studies - Pustejov, Hodonovice/Baska, Lodenice/Holasovice). It was found out that within the studied region nineteen agricultural AD plants operate in various agricultural conditions. Several spatial clusters of agricultural AD plants were identified (an area along the Odra River, Krnov area, Opava area, Osoblaha area). AD plants are localised in agricultural production regions (APR) suitable for the

production of sugar beet (with soils of a great quality) and potatoes (with soils of not so good quality) in areas of high and under-average administrative price of agricultural land.
It is apparent that the basic requirement for successful operation of an agricultural AD plant from the point of view of the rural development is to maximise the benefits for its local population and minimise the impacts on the quality of their lives. It has to be considered though that a big investment implies certain effects (both positive and negative), whose level of usefulness (or noxiousness) is driven by different points of view of actors and might be evaluated very differently by various types of population. It is obvious that the population that lives in the immediate proximity of an AD plant is more critical to the effects of its operation**.** Yet, a suitable location of AD plants (primarily outside the settled areas of municipalities), respecting the geographical and social conditions of the area, the proper technological management and compensations toward the affected population (supplies of cheap electricity and heat) might lead to a mutual consensus.
Based on the knowledge gained through the research it is obvious that a higher level of support for AD plants is in municipalities where the construction plans of AD plants were regularly consulted with its local population, and where cooperation (and mutual trust) between the operator of the plant and public administration occurs. It is also obvious from the results of the questionnaire survey that examples of good (or not so good) practices and experience of the population and public administration s other municipalities have a significant impact on forming the attitudes of the population on AD plants. This factor might be crucial for the further development of an AD plants sector and ought to be researched more in depth on local, regional, national and international levels.

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