Analysing a Bottom-up Methodology for Developing Communal Biogas Plants in Croatia

Mak Đukan*[*1], Zoran Aralica[2]
[1]Wegener Center for Climate and Global Change, Karl-Franzens University of Graz, Brandhofgasse 5, Graz, Austria
e-mail: mak.dukan@uni-graz.at
[2]The Institute of Economics, J. F. Kennedy Square 7, Zagreb, Croatia
e-mail: zaralica@eizg.hr

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ABSTRACT

This research presents a bottom-up methodology for assessing biogas potentials applied in a local community in Croatia. The research is based on analysing the flow of resources on a local level and capability of local actors to innovate and cooperate. Our method grades the local actors – in this case, owners of family farms in Gundinci municipality in Croatia – based on their farms' biogas potential (or the amount and quality of manure they produce) and an indicator which we refer to as innovative-cooperation capacity. This methodology builds upon the biogas potential analysis by identifying farmers who are willing to improve their farms manure management system and cooperate in the field of biogas production in Gundinci. The replication of this methodology could stimulate rural development, through pinpointing realizable biogas projects, which could generate new money flows for the local economies and help farmers meet the norms of the European Union Nitrates Directive which regulates manure management, in order to control nitrogen flows in agriculture.

KEYWORDS

Biogas potential analysis, Innovative-cooperation capacity, Rural development.

INTRODUCTION

Current studies on biogas potentials in Croatia have largely been top-down and have relied on attributing biogas yields to all statistically recorded animals. While Kulišić and Par (2009) [1] and Kralik (2012) [2] use as their main data source the latest Agricultural Census, Pukšec and Duić (2010) [3] rely on a pig and beef overview from the Croatian Agricultural Agency. In this paper we argue that such studies are overly simplistic, because they rely on averages that fail to capture regional biogas hot spots or locations that overshoot the average number of animals attributed to that region.

The present approach of biogas potentials analysis simplifies systems wherein biogas plants are developed, through ignoring the complexities of interactions between their individual segments. For instance, human interactions between stakeholders are not taken into account. Analysed systems are in fact complex and characterized by non-linear interacting relationships within social, economic, legal and cultural dimensions [4]. Regarding this, a biogas project is only viable, as much as the willingness of the local community to cooperate with a biogas developer and with each other.

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[*] Corresponding author

Instead of the above-described top-down approach we propose a bottom-up method for analysing local biogas potentials. The methodology consists of analysing the farmer's material and energy flows and innovative-cooperation capacity, after which the economic potential and feasibility of a sought plant is evaluated. This is done through a standard cash flow analysis, which produces the project's Internal Rate of Return (IRR). Our methodology was tested in Gundinci municipality, which is located in one of the least developed regions of Croatia [5] and has historically been mostly agricultural. This methodology has not yet been applied in Croatia, and to the best of our knowledge we have not encountered any literature that introduces the innovative-cooperation analysis of local actors.

The results indicate the availability of 31,000 t of different kinds of animal manure in Gundinci, with an energy value that is double the yearly electricity consumption of the municipality. Through applying our methodology we excluded 13% of the originally located manure, since this is originating from farms with little innovative and cooperative capacity and/or small biogas potential. After this we modelled the economics of a potential biogas project, using the leftover manure and 13,500 t of corn silage. Based on our analysis, the plant would have an IRR of 16%, which varies with changes in input variables and is mostly sensitive to changes in investment costs.

The paper first discusses the applicability of the proposed bottom-up approach in developing biogas projects and provides a comparison with the conventional statistics-based potentials analysis. After describing our methodology and data, we discuss the economics of a potential biogas plant in Gundinci. Finally we provide concluding remarks.

THE BOTTOM-UP ANALYSIS OF BIOGAS PRODUCTION POTENTIALS

The intricacy of material and energy systems requires an approach to potentials analysis that takes into account system complexity and focuses on satisfying local environmental, social and economic needs. This necessitates taking a bottom-up approach for the analysis, where a particular project location is viewed within the sphere of local material and energy flows and the innovative-cooperation potential of the local population. Other attempts to analyse the local biogas potential focused mainly on biogas feedstock and its energy value as mentioned above.

The bottom-up approach is suitable for locations where local communities initialize biogas projects themselves (e.g., village). In this way rural and small-scale energy needs could be met in a reliable, affordable and environmentally sustainable way [6]. However, this approach also highlights contextual and demand-side issues and may stimulate easier technology acceptance. This could also enable development of community-focused financing schemes to improve the affordability of biogas systems [7]. In terms of cooperation, our approach is similar to that of Mallet [8] who asserts that active interaction between participants from various sectors increases social acceptance of renewable energy innovations.

Our analysis seeks to understand the innovative-cooperation capacity of local actors. This includes the analysis of the near future innovation performance of the actors in a specific location and their willingness to cooperate [9]. We define innovative capacity as an ability of conducting innovation activities with innovation output variables i.e. innovation products and/or processes as the visible results of innovation inputs i.e. innovation investments [10]. Their innovative capacity is determined through examining elements of the farmer's (dynamic) development over time, such as their number of animals and land under cultivation and investments into private land and manure management systems, with the aim of producing new products and/or services. On the other hand, the farmer's cooperation capacity is determined through their willingness to supply manure, grow energy crops and invest jointly into a communal biogas plant.

The advantages of the bottom-up approach over the conventional (top-down) approach of biogas potential analysis are presented below (Table 1).

Table 1. Comparison of conventional and bottom-up approach in biogas potentials analysis

Conventional approach	Bottom up approach
Simplistic approach	Embraces complexity
Decision making is guided by statistical averages	Decision making based on location specific material and energy flows
Calculates the biogas potential based on the entire location specific amount of feedstock	Calculates the biogas potential based on the feedstock from farmers with innovative-cooperation potential
Includes as feedstock only the available manure	Includes as feedstock all available organic materials on site that are economically usable
Takes into account the techno-economic aspects of developing a biogas plant	Takes into account the techno-economic and human aspects through analysing local stakeholders
Oriented towards achieving the greatest economic returns	Oriented towards achieving the most sustainable outcome in terms of economic, social and environmental goals
Derives conclusions from off site available data	Derives conclusions from local knowledge

METHODOLOGY AND DATA

Our methodology analyses three basic aspects that make a biogas project viable:

- Local material and energy flows;
- Farmers innovative-cooperation capacity;
- Economic and technical feasibility of the project.

The availability of suitable feedstock for conversion into biogas is the first aspect in determining the local biogas potential. However, this information is useless without knowing if local farmers would be willing to supply a biogas plant with manure. Finally, we need to consider if the determined biogas potential can be converted economically into energy. This largely depends on the amount of energy potential, where the feasibility improves with the project's size. Determining basic financial parameters like IRR defines if a bankable project can be developed.

Data was collected through forty-three structured interviews with family farm owners and households. This was chosen over other methods – like questionnaires – because the data is complete and recovered immediately. Moreover, the interviewer can guide the respondent during the talk, which assures accuracy. Additional information, outside the structured questions can also be gathered. We also conducted a semi-structured interview with the mayor who provided us with data such as number of households and farms in the municipality and local waste management system.

The structured interview consisted of forty questions that were subdivided into main categories as presented in Figure 1. Apart from manure quantities and source, which was the base for Material Flow analysis, the interviews assessed the farms in terms of the size, ownership and use of land holdings, quality of manure management system and speed with which they increased the number of animals and land under cultivation in the past five years and ambition for future development. These questions were aimed at evaluating their innovative capacity or capability to grow their business. Finally we investigated the farmer's willingness to supply manure, grow energy crops and invest into a biogas project in their community, which we used to evaluate their cooperation capacity. Altogether, these qualitative aspects of our assessment make what we term innovative-cooperation capacity (for more detail, please see the second step of the methodology).

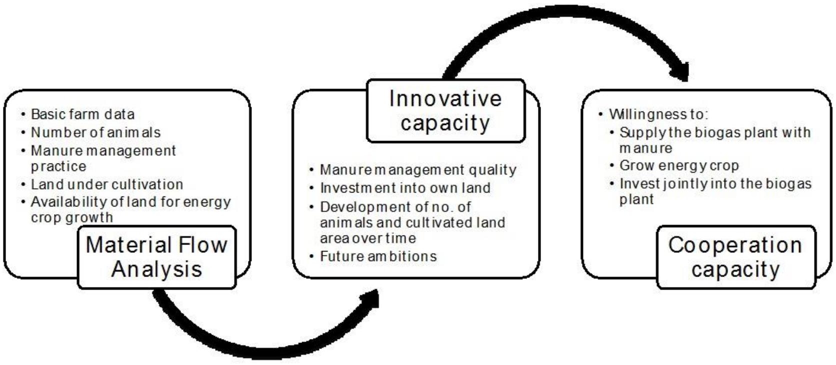

Figure 1. Contents of the structured interviews

Therefore, the first step of our methodology determines the amount of material and energy flows arising in Gundinci municipality. Initial desktop research and interviews with the mayor and community members revealed two main waste flows, suitable for biogas production:

- Agricultural waste including animal manure and dead animals;
- Municipal solid waste.

Municipal solid waste was excluded from further analysis because only 345 t [11] are produced per year and this has a relatively low organic content. Namely, the locals use their food waste as animal feed or compost. Dead animals that could be used for biogas production – after treatment and sterilization – were also excluded because they are collected and processed into technical fat. Therefore, the focus of our material and energy flow analysis was animal manure.

Table 2 shows the data sample (obtained through a semi-structured interview with the mayor of Gundinci), which consists of thirty-three family farms and ten households and small farms. Big family farms (more than 50 livestock units) constitute the majority of the sample and among these 43% were cattle farms, 31% pig fattening facilities and 26% broiler fattening operations. Unlike the big family farms that were targeted through the help of our semi-structured interviews, households and small farms were chosen randomly.

The animal numbers that were obtained were converted into Livestock Units (LU)[†] using standardized conversion rates [12]. The LU's were then multiplied with yearly manure production estimates, which were obtained through literature review [13].

The data quality was crosschecked by comparing the animal numbers obtained through the research, with the official Croatian Agricultural Agency data on total municipal animal numbers, for the period between 2010 and 2012. There is a divergence with official data, since the number of broiler and pig livestock units surveyed is 279% and 247% higher. Considering this, another field visit was arranged and this included

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[†] 1 LU equals 500 kg worth of animal mass.

95% of originally recorded pig and 79% broiler *LU*. Little variation was found from the original data, as pig farmers reported 7.2% less animal numbers than the first time, while there were also 2.1% fewer broilers recorded [13]. This confirmed that the official statistics greatly diverge from the real ground situation, justifying the need for research of this type.

Table 2. Data sample coverage rate

Building type	Total in Gundinci	Included in research	Coverage rate
Household	363	7	2%
Family farm	300	36	12%
Big farms	43	33	77%
Small farms	257	3	1%
Public buildings	5	5	100%
Other	3	0	0%

Finally, the farms biogas potential was determined using the following equations:

$$BY_{FM} = 1 \times \big(DM_F \times oDM_F \times (B_{oDM} \times 1{,}000)\big) \times M_S \tag{1}$$

$$BP_F = Q_{LU} \times Q_M \times BY_{FM} \times M_{EP} \tag{2}$$

where BY_{FM}, biogas yield per tonne of fresh matter ($\mathrm{m^3CH_4/t}$); DM_F, dry matter content, oDM_F, organic dry matter (% of DM_F); B_{oDM}, biogas yield per tonne of organic dry matter ($\mathrm{m^3/kg}_{oDM}$); M_S, share of methane in biogas (%); BP_F, farm biogas potential (kWh/a); Q_{LU}, number of livestock units on farm; Q_M, manure produced by one livestock unit (t/year); M_{EP}, methane energy potential ($\mathrm{kW_{th}/m^3}$), assumed to be 10 $\mathrm{kW_{th}/m^3}$.

The feedstock characteristics – dry matter content, organic dry matter content, biogas yields and share of methane – were derived from the Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL) biogas calculator [14]. Apart from calculating the energy potential for every farm, this was also aggregated for the entire feedstock quantity surveyed (see Figure 2).

In the second step, the farmer's biogas potentials were qualified with his capacity to innovate and cooperate. The capacity to innovate is based on the farmer's development in terms of number of animals and cultivated land over time and future ambitions regarding his/her business goals.

Here two types of data were used – the first compares present animal and land holdings, with values five years ago, while the second indicates the farmer's expectations and ambitions in the next five years. While this can be considered as speculative data, it is useful to know if a famer expects to expand or close down her/his business, especially if the biogas potential is high, meaning that the deficit of her/his feedstock could imperil the normal functioning of a biogas plant.

Moreover, the share of own land and manure management system quality indicates the extent of investments made in their business. The farms that grew in comparison to past five years and had clear development ambitions and had invested in land and manure management are regarded as farms with high innovative capacity. On the other hand, the farmers capacity to cooperate is based on their willingness to supply manure, grow energy crops and invest in the project. This evaluates their willingness to support a local biogas project.

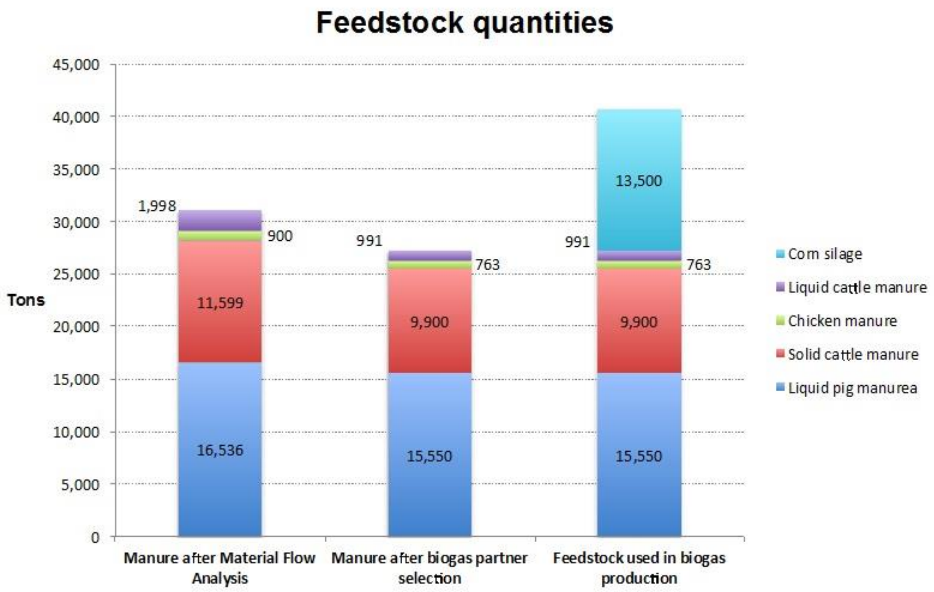


Figure 2. Material flow analysis results and biogas feedstock mixture

The application of the innovative-cooperation methodological approach eliminates from the biogas potentials analysis, those farmers who are unwilling to cooperate and incapable or unwilling to innovate their production process. This is achieved using a biogas partner selection tool. The method develops three indicators named Biogas Potential, Cooperation Capacity and Innovative Capacity – which are given different weights depending on their importance and these are 40%, 30% and 30% respectively. Biogas Potential was given a higher weight because in our assessment the availability of local feedstock constitutes the most important aspect of developing a biogas project. These weights are discussable and could be adjusted in future research.

Each indicator is composed from a subset of variables examined by the structured interviews (see Figure 1). Assigning different points distinguishes the variables weights within an indicator. After allocating the points to each variable and summing them up, a final grade is assigned. This is expressed as the percentage of the total possible points. The farmers that have failed to achieve more than 50% of the points are excluded from further examination.

Biogas Potential is determined through the energy value of manure and size of land that could be devoted for energy crop growth and this was graded based on norm-referenced grading. Using this method the entire sample sets the standard to which an individual farmer is compared, meaning that an individual farmer is benchmarked in relation to her/his peers.

Innovative Capacity grades the farmers based on the change in number of animals and land under cultivation in comparison to last five years, future ambition and goals, share of own land and manure system quality. The farmers that have increased the number of animals and land under cultivation in the last five years, have clear and positive future goals, own most of the land they cultivate (in comparison to leasing it, which would indicate a risk factor in their ability to grow energy crops) and have manure management systems in line with the European Union Nitrates Directive have received the most points.

Finally, the farmers that would willingly supply their manure, grow energy crops and invest jointly in the plant are regarded as having the highest Cooperation Capacity (see Appendix for results and grading method of the biogas partner selection tool).

In the third step, the remaining manure quantities are used to calculate the biogas plant installed capacity, which is then analysed in terms of economic feasibility, using cash flow analysis. Apart from manure, corn silage would be added to the feedstock mix due to its higher energy density, which increases the economics of a plant.

Asking the farmers the total land area they cultivate and how much they could allocate for energy crop growth estimated the land availability for energy crops. In total the farmers said they could allocate 433 ha of land for this purpose.

Corn silage was selected based on a study of most suitable energy crops for biogas production. The study compares sunflower, Jerusalem artichoke, sorghum, sugar beets, amaranth and maize from an environmental, technical and economic perspective [15] and concludes maize has the best overall characteristics (corn silage being a product of maize cultivation). Apart from this, maize is traditionally grown in the region and our research indicates it's the most cultivated crop in Gundinci.

The overall installed capacity of the plant was derived in two steps. First we calculated the theoretical installed capacity, based on the available energy potential of the feedstock.

The theoretical capacity was derived in the following way:

$$IC = \frac{GEP_{\text{total}}}{L_f} \tag{3}$$

$$GEP_{\text{total}} = \sum BP_F \tag{4}$$

The electrical and thermal capacities were obtained through applying the following:

$$IC_{el} = IC \times \eta_{el} \tag{5}$$

$$IC_{th} = IC \times \eta_{th} \tag{6}$$

The theoretical capacity is just an estimate of the potential size a project could have, and it is based on the energy value of feedstock. However, this is also a starting point to determine the actual project size. Therefore, we conducted interviews with two biogas project developers to determine the real installed capacity and investment costs we would base our economic analysis on. They also consulted us on the optimal feedstock mixture, based on its energy value, nutrient and dry matter content. Also we interviewed them on technologies for producing pellets and organic fertilizer from biogas digestate, including their costs and production quantities.

Apart from electricity, which the project would sell under the current feed-in tariff law in Croatia [16], pellets also constitute part of the revenue. These are made from the anaerobic digestion remains (digestate) and waste sawdust. Heat from the biogas plant is used in drying one portion of the digestate (45%) and preparing it for pellets production, while the other part would be given back to farmers as organic fertilizer (55%).

RESULTS

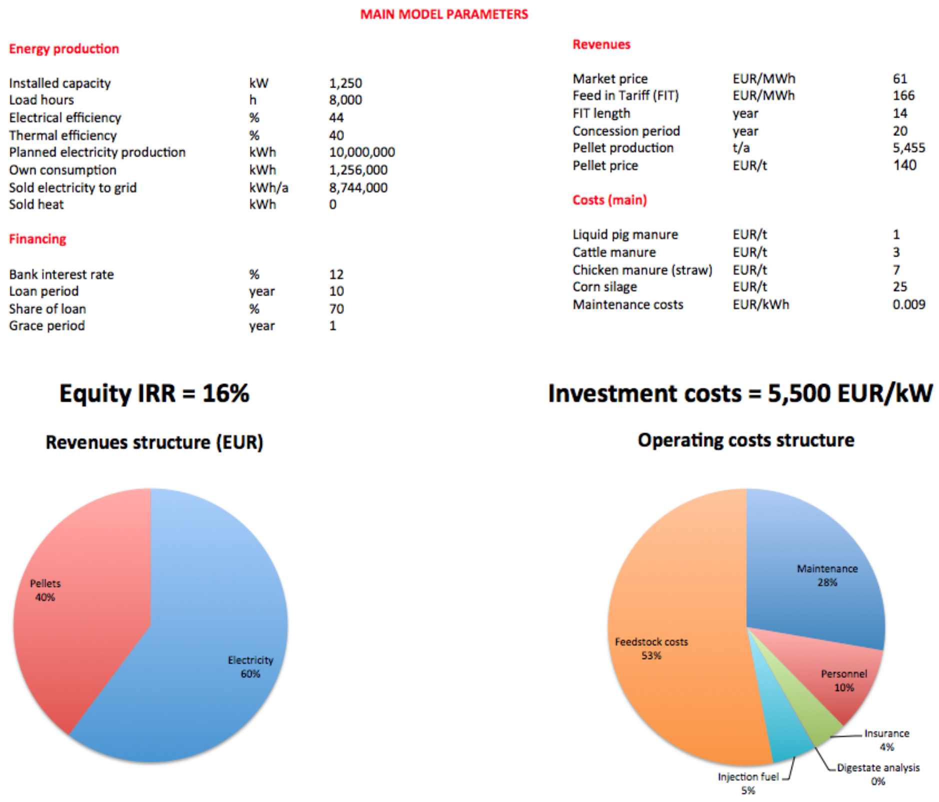
The research collected data through 43 structured interviews with owners of local family farms and households in Gundinci. Our survey found 31,000 t of usable manure from different husbandry operations, with an approximate technical energy potential of 6.5 GWh, which is double the yearly electricity consumption in Gundinci [17].

Furthermore, we determined that the farmers operate 393 ha of land which could be used for growing energy crops, since it is not currently in use for growing animal feed for their own farms. In our analysis we did not determine the potential energy value of energy crops that could be grown on that same land, because these are not a waste flow and were not within the scope of our analysis.

Our methodology develops a grading mechanism that evaluates farmers in terms of their biogas potential and innovative-cooperation capacity. Using this method we were able to exclude from further analysis those farms, which are stagnating and lack willingness to provide biogas feedstock or support a biogas project financially. As a result we excluded from detailed analysis approximately 15% of the originally located biogas potential, which can be seen in Figure 2. Considering the traditional experience in producing corn silage in the region and literature review [15] we decided to add 13,500 t to our biogas mixture. The final mixture then constitutes of 33% corn silage and 67% manure, where corn silage yields 70% of the final energy content.

After qualifying the farmers based on their innovative-cooperation capacity we calculated the theoretical installed capacity using eq. (3) and eq. (4), after which we derived the electrical and thermal theoretical capacities using eq. (5) and eq. (6). These are 1,223 kW_{el} and 1,112 kW_{th}. Based on this we asked a project developer to determine the real capacity, according to industry Combined Heat and Power (CHP) engine unit size. After consultations, our analysis continued with a real electrical capacity of 1,250 kW_{el}.

Our analysis indicates the project would have equity IRR of 16%. The biogas hurdle rate in Croatia is 8% [18, 19], making this project very attractive for investors. In our analysis we used input variables that are presented in Figure 3. The main revenue streams of this project are electricity sales under the Croatian Feed-in Tariff (FIT) system and pellets, which are produced from remaining solid digestate and saw dust.



MAIN MODEL PARAMETERS

Energy production

Installed capacity	kW	1,250
Load hours	h	8,000
Electrical efficiency	%	44
Thermal efficiency	%	40
Planned electricity production	kWh	10,000,000
Own consumption	kWh	1,256,000
Sold electricity to grid	kWh/a	8,744,000
Sold heat	kWh	0

Financing

Bank interest rate	%	12
Loan period	year	10
Share of loan	%	70
Grace period	year	1

Revenues

Market price	EUR/MWh	61
Feed in Tariff (FIT)	EUR/MWh	166
FIT length	year	14
Concession period	year	20
Pellet production	t/a	5,455
Pellet price	EUR/t	140

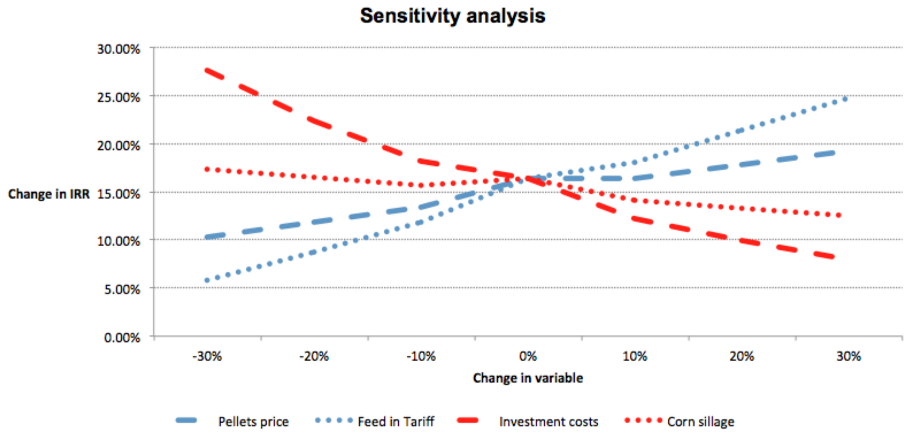
Costs (main)

Liquid pig manure	EUR/t	1
Cattle manure	EUR/t	3
Chicken manure (straw)	EUR/t	7
Corn silage	EUR/t	25
Maintenance costs	EUR/kWh	0.009

Figure 3. Main input variables, results, revenues and operational costs

Producing and selling pellets has several benefits, the most prominent one being use of heat. Biogas projects in Croatia receive support only if they convert more than 50% of used primary energy into useful electricity and heat [16]. Through producing pellets, our project would have an estimated overall efficiency of 67%. Apart from this, with a market price of 140 EUR/t - determined through consultations with industry experts - pellets are very profitable and in this case yield 40% of the project's revenues.

Finally, we conducted a sensitivity analysis to determine the effects of changing market conditions on the project's IRR. Our analysis shows that the project is mostly sensitive to changes in investment costs and feed-in tariff, followed by pellets and corn silage price, in order of magnitude (Figure 4).



Variable Change	**-30%**	**-20%**	**-10%**	**10%**	**20%**	**30%**	**DELTA**
Pellets price	10%	12%	13%	16%	18%	19%	**9%**
Feed in Tariff	6%	9%	12%	18%	21%	25%	**19%**
Investment costs	28%	22%	18%	12%	10%	8%	**20%**
Corn sillage	17%	17%	16%	14%	13%	13%	**5%**

Figure 4. Project sensitivity analysis

CONCLUSIONS

We explained and empirically tested the bottom-up approach with the aim of evaluating the biogas potential of Gundinci municipality in Brodsko-Posavska County in the region of Slavonia. We found that the bottom-up approach has advantages compared to the conventional (top down) approach. It embraces complexity, decision-making is based on location specific material and energy flows and it calculates the biogas potential based on feedstock from farmers with innovative cooperation potential.

This methodology determines the suitability of any location for developing a biogas project, based on analysis of the following aspects:

- Local material and energy flows;
- Farmers innovative-cooperation capacity;
- Economic and technical feasibility of the project.

Using this methodology reveals local biogas potentials and empowers local communities to start a biogas project. This is achieved by improving their knowledge on local material and energy flows and project costs. Knowing this enables them to make first contact with project developers, investors and funding institutions. Alternatively, this also enables biogas project developers to focus on locations with sufficient biogas potential and communities that are willing to innovate and cooperate.

The replication of this methodology could pinpoint locations in Croatia with substantial biogas potential. Instead of relying on statistics, we propose conducting such bottom-up research to determine real projects. But apart from this, we consider that analysing the human aspect of developing such projects i.e. the willingness of local population to accept it and help it succeed (through supplying manure for instance) is also vital. This is why we have introduced the innovative-cooperation potentials as a decision-making criterion.

An interesting topic for further research would be discussing ownership models of communal biogas plants, which can be either third party or community owned [20]. Combinations of these are also possible, in the case of partnerships between the community and an outside investor. However, more benefits for the locals are achieved if the project is in their ownership. This would require a high degree of self-organization, which could be achieved through forming energy cooperatives.

Finaly the analysis of formal and informal institutions such as social, cultural and legal norms which underline economic activities will be required in the future. Doing so could underline many incentives and constraints that form economic behaviour in connection with developing a biogas project in a community.

NOMENCLATURE

BY_{FM}	Biogas yield per tonne of fresh matter	[m^{3}CH$_4$/t]
B_{oDM}	Biogas yield per tonne of organic dry matter	[m^{3}kg$_{oDM}$]
BP_F	Farm biogas potential	[kWh/a]
DM_F	Dry matter content	[%]
oDM_F	Organic dry matter content	[%]
IC	Installed capacity	[kW]
IC_{el}	Installed electrical capacity	[kW$_{el}$]
IC_{th}	Installed thermal capacity	[kW$_{th}$]
IRR	Internal rate of return	[%]
η_{el}	Electrical efficiency	[%]
η_{th}	Thermal efficiency	[%]
GEP_{total}	Total gross energy potential	[kW]
LU	Livestock units	[kg]
L_f	Load factor	[-]
M_S	Share of methane in biogas	[%]
M_{EP}	Methane energy potential	[kW$_{th}$/m^3]
NPV	Net present value	[%]
Q_{LU}	Number of livestock units on farm	[-]
Q_M	Manure produced by one livestock unit	[t/year]

Abbreviations

CHP	Combined Heat and Power
DCFA	Discounted Cash Flow Analysis
FIT	Feed in Tariff
KTBL	Kuratorium für Technik und Bauwesen in der Landwirtschaft
MFM	Material Flow Management
MFA	Material Flow Analysis

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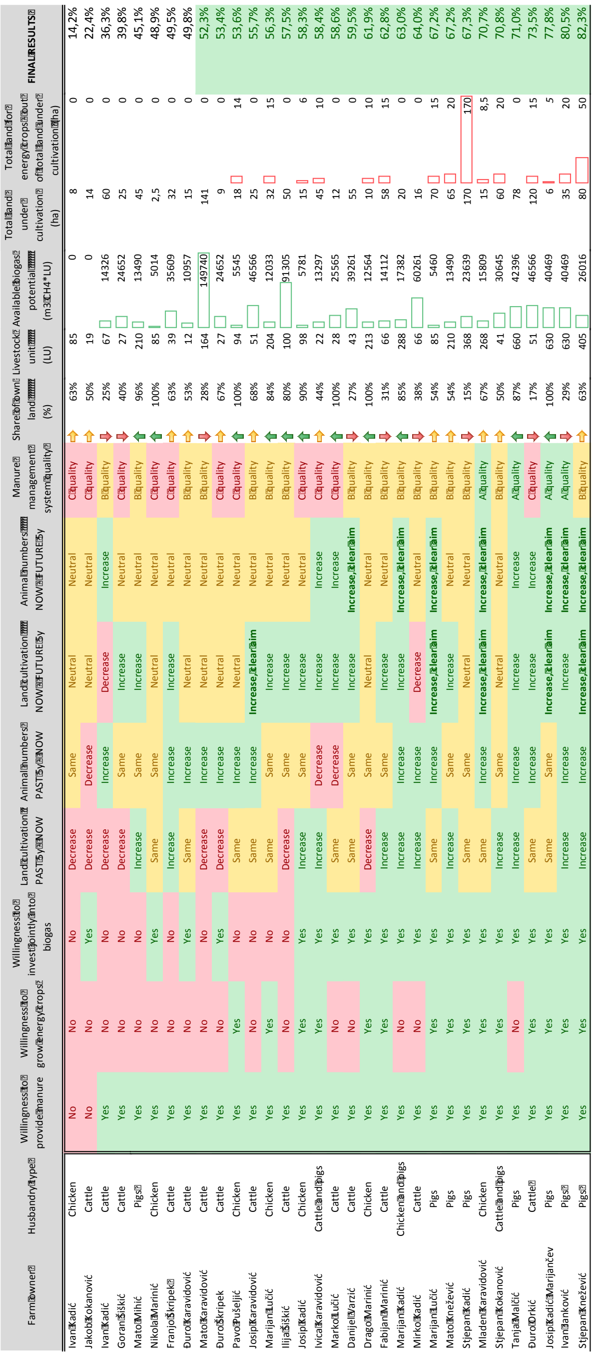
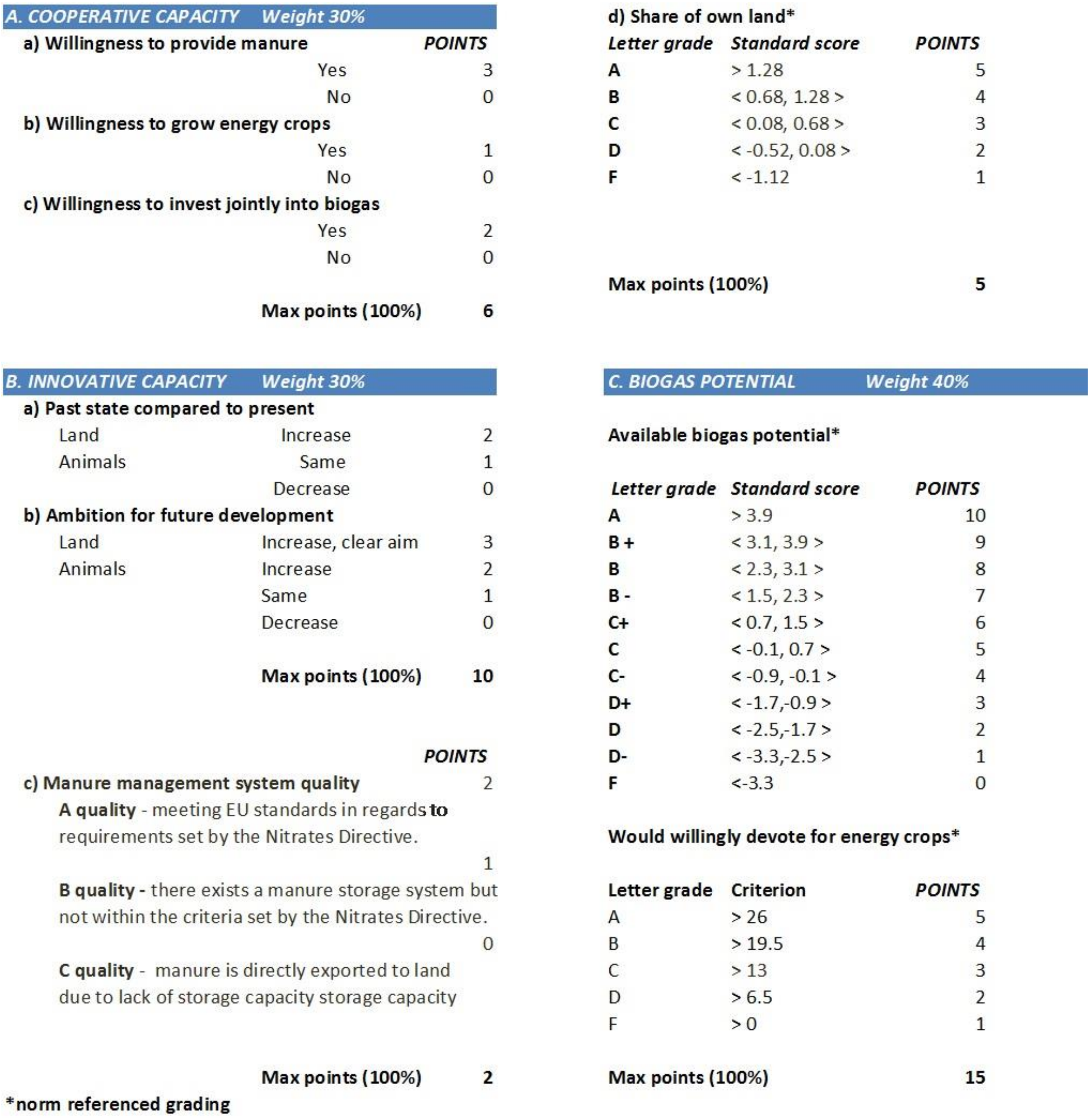
APPENDIX

Biogas partner selection tool results



Farm owner	Husbandry type	Willingness to provide manure	Willingness to grow energy crops	Willingness to invest jointly into biogas	Land cultivation PAST 5y NOW	Animal numbers PAST 5y NOW	Land cultivation NOW FUTURE 5y	Animal numbers NOW FUTURE 5y	Manure management system quality		Share of own land (%)	Livestock unit (LU)	Available biogas potential (m3 CH4*LU)	Total land under cultivation (ha)	Total land for energy crops out of total land under cultivation (ha)	FINAL RESULTS
Ivan Kadić	Chicken	No	No	No	Decrease	Same	Neutral	Neutral	C quality	⇨	63%	85	0	8	0	14,2%
Jakob Kokanović	Cattle	No	No	Yes	Decrease	Decrease	Neutral	Neutral	C quality	⇨	50%	19	0	14	0	22,4%
Ivan Kadić	Cattle	Yes	No	No	Decrease	Increase	Decrease	Increase	B quality	⇩	25%	67	14326	60	0	36,3%
Goran Šiškić	Cattle	Yes	No	No	Decrease	Same	Increase	Neutral	C quality	⇩	40%	27	24652	25	0	39,8%
Mato Mihić	Pigs	Yes	No	No	Increase	Same	Increase	Neutral	B quality	⇧	96%	210	13490	45	0	45,1%
Nikola Marinić	Chicken	Yes	No	Yes	Same	Same	Neutral	Neutral	C quality	⇧	100%	85	5014	2,5	0	48,9%
Franjo Škripek	Cattle	Yes	No	No	Increase	Increase	Increase	Neutral	C quality	⇨	63%	39	35609	32	0	49,5%
Đuro Karavidović	Cattle	Yes	No	Yes	Same	Increase	Neutral	Neutral	B quality	⇨	53%	12	10957	15	0	49,8%
Mato Karavidović	Cattle	Yes	No	No	Decrease	Increase	Neutral	Neutral	B quality	⇩	28%	164	149740	141	0	52,3%
Đuro Škripek	Cattle	Yes	No	Yes	Decrease	Increase	Neutral	Neutral	C quality	⇨	67%	27	24652	9	0	53,4%
Pavo Pušeljić	Chicken	Yes	Yes	No	Same	Increase	Neutral	Neutral	C quality	⇧	100%	94	5545	18	14	53,6%
Josip Karavidović	Cattle	Yes	No	No	Same	Increase	Increase, clear aim	Neutral	B quality	⇨	68%	51	46566	25	0	55,7%
Marijan Lučić	Chicken	Yes	Yes	No	Same	Same	Increase	Neutral	B quality	⇧	84%	204	12033	32	15	56,3%
Ilija Šiškić	Cattle	Yes	No	No	Decrease	Same	Increase	Neutral	B quality	⇧	80%	100	91305	50	0	57,5%
Josip Kadić	Chicken	Yes	Yes	Yes	Increase	Same	Increase	Neutral	C quality	⇧	90%	98	5781	15	6	58,3%
Ivica Karavidović	Cattle and pigs	Yes	Yes	Yes	Increase	Decrease	Increase	Increase	C quality	⇨	44%	22	13297	45	10	58,4%
Marko Lučić	Cattle	Yes	No	Yes	Same	Decrease	Increase	Increase	C quality	⇧	100%	28	25565	12	0	58,6%
Danijel Varzić	Cattle	Yes	No	Yes	Same	Same	Increase	Increase, clear aim	B quality	⇩	27%	43	39261	55	0	59,5%
Drago Marinić	Chicken	Yes	Yes	Yes	Decrease	Same	Neutral	Neutral	B quality	⇧	100%	213	12564	10	10	61,9%
Fabijan Marinić	Cattle	Yes	Yes	Yes	Increase	Same	Increase	Neutral	B quality	⇩	31%	66	14112	58	15	62,8%
Marijan Kadić	Chicken and pigs	Yes	No	Yes	Increase	Increase	Increase	Increase, clear aim	B quality	⇧	85%	288	17382	20	0	63,0%
Mirko Kadić	Cattle	Yes	No	Yes	Increase	Increase	Decrease	Neutral	B quality	⇩	38%	66	60261	16	0	64,0%
Marijan Lučić	Pigs	Yes	Yes	Yes	Same	Increase	Increase, clear aim	Increase, clear aim	B quality	⇨	54%	85	5460	70	15	67,2%
Mato Knežević	Pigs	Yes	Yes	Yes	Increase	Same	Increase	Neutral	B quality	⇨	54%	210	13490	65	20	67,2%
Stjepan Kadić	Pigs	Yes	Yes	Yes	Same	Same	Neutral	Neutral	B quality	⇩	15%	368	23639	170	170	67,3%
Mladen Karavidović	Chicken	Yes	Yes	Yes	Same	Increase	Increase, clear aim	Increase, clear aim	A quality	⇨	67%	268	15809	15	8,5	70,7%
Stjepan Kokanović	Cattle and pigs	Yes	Yes	Yes	Increase	Same	Neutral	Neutral	B quality	⇨	50%	41	30645	60	20	70,8%
Tanja Malčić	Pigs	Yes	No	Yes	Increase	Increase	Increase	Increase	A quality	⇧	87%	660	42396	78	0	71,0%
Đuro Orkić	Cattle	Yes	Yes	Yes	Same	Increase	Increase	Increase	C quality	⇩	17%	51	46566	120	15	73,5%
Josip Kadić Marijančev	Pigs	Yes	Yes	Yes	Same	Same	Increase, clear aim	Increase, clear aim	A quality	⇧	100%	630	40469	6	5	77,8%
Ivan anković	Pigs	Yes	Yes	Yes	Increase	Increase	Increase	Increase, clear aim	A quality	⇩	29%	630	40469	35	20	80,5%
Stjepan Knežević	Pigs	Yes	Yes	Yes	Increase	Increase	Increase, clear aim	Increase, clear aim	B quality	⇨	63%	405	26016	80	50	82,3%

Biogas partner selection tool results grading methodology



A. COOPERATIVE CAPACITY	*Weight 30%*	
a) Willingness to provide manure		***POINTS***
	Yes	3
	No	0
b) Willingness to grow energy crops		
	Yes	1
	No	0
c) Willingness to invest jointly into biogas		
	Yes	2
	No	0
	Max points (100%)	**6**

B. INNOVATIVE CAPACITY	*Weight 30%*	
a) Past state compared to present		
Land	Increase	2
Animals	Same	1
	Decrease	0
b) Ambition for future development		
Land	Increase, clear aim	3
Animals	Increase	2
	Same	1
	Decrease	0
	Max points (100%)	**10**

	POINTS
c) Manure management system quality	2
A quality - meeting EU standards in regards to requirements set by the Nitrates Directive.	
	1
B quality - there exists a manure storage system but not within the criteria set by the Nitrates Directive.	
	0
C quality - manure is directly exported to land due to lack of storage capacity storage capacity	
Max points (100%)	**2**

***norm referenced grading**

d) Share of own land*

Letter grade	***Standard score***	***POINTS***
A	> 1.28	5
B	< 0.68, 1.28 >	4
C	< 0.08, 0.68 >	3
D	< -0.52, 0.08 >	2
F	< -1.12	1
Max points (100%)		**5**

C. BIOGAS POTENTIAL *Weight 40%*

Available biogas potential*

Letter grade	***Standard score***	***POINTS***
A	> 3.9	10
B +	< 3.1, 3.9 >	9
B	< 2.3, 3.1 >	8
B -	< 1.5, 2.3 >	7
C+	< 0.7, 1.5 >	6
C	< -0.1, 0.7 >	5
C-	< -0.9, -0.1 >	4
D+	< -1.7,-0.9 >	3
D	< -2.5,-1.7 >	2
D-	< -3.3,-2.5 >	1
F	<-3.3	0

Would willingly devote for energy crops*

Letter grade	**Criterion**	***POINTS***
A	> 26	5
B	> 19.5	4
C	> 13	3
D	> 6.5	2
F	> 0	1
Max points (100%)		**15**

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