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Calculating Biogas Potential in Croatia: Case of a PIG Farm and Small-scale Digestion

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Abstract With Croatia becoming a member of the European Union in 2013, the country faces numerous challenges and opportunities. The energy production from organic waste is less than 3 % of total energy production, although the potential is 10 times higher. It becomes evident that the agricultural sector can play an important role in reaching the country's renewable energy target. Moreover, research and field trials indicate the opportunities for digestate as a replacer of mineral fertilizer. In order to boost the agro- energy sector, Sisak–Moslavina County joined the FP7 funded project - INEMAD (Improved Nutrient and Energy Management through Anaerobic Digestion, 2012-2016) - whose main goal is to reconnect livestock and crop production in a sustainable way. In order to investigate potentials, SMC, together with two Belgian partners (DLV Belgium, Innova Energy) prepared a feasibility study of the biogas potential for the pig farm K. from Osijek – Baranja County. The pig farm has a production capacity of 7.200 pigs. The feasibility study showed that for a farm of this size an optimal solution would be an installation of a small-scale digester. In the specific case, the plant of 38 kW_{el} would allow the framer to spread the manure/ digestate more easily and generate electricity that could be used on the farm. However, the plant of 11 $kW_{el.}$ would be enough for covering the farm´s energy needs which allows farmer to use specific renewable energy sources focused governmental subsidies. Based on the biogas calculation tool, developed by DLV Belgium, the biogas unit of 11 $kW_{el.}$ could produce 54.000 m^3/year of biogas (approximately 59.600 m^3/year of biomethane). Another added value of the biogas plant implementation would be an improved nutrient management that would result in creating highly valuable organic fertilizer - digestate. This contribution provides insights in the feasibility study preparation and answers to farmer ownership questions on biogas production in organic farming that is similar in size and capacity.

Keywords: *biogas, pig manure, INEMAD project, small-scale, Croatia*

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1. Introduction

With Croatia becoming a member of the European Union in 2013, the country faces challenges and opportunities of agriculture on the environment. One of the most expressed challenges is the one related to the renewable energy investments. This paper focuses on the implementation of the anaerobic digestion (AD) process at small–scale farm level and its feasibility when applying national subsidy systems [e.g. 2014-20 European Agricultural Fund for Rural Development (EAFRD) programmes].

Furthermore, the paper will present a biogas calculator that is a tool, which developed for Croatia, within the INEMAD project.

2. Agricultural and Renewable Sector in Croatia

2.1. Agricultural Sector in Croatia

In general, the Croatian agricultural sector can be characterized small in terms of land area used (5.6 ha/holding in 2010) but also of livestock (5.3 LSU/holding in 2010) [9].

Numerous statistical and financial parameters indicate the importance of agricultural sector in the Croatian economy, meaning that it counts for 4.1 % of the Gross Domestic Product (GDP) (period of 2011 – 2015) [8]. Moreover, the EU´s labor force survey from 2010 indicates that agricultural sector employed cca 229,200 persons aged over 15 in Croatia [9]. In addition, the latest survey performed by the Croatian Payment Agency for Agriculture showed that country has more than 181,645 agricultural producers registered (decrease of 21 % when compared to 230,000 active producers registered in 2010), who utilize more than 1,316,010 ha of agricultural land [10].

Nearly two-thirds of all agricultural producers are cultivating crops, while the rest is divided between livestock production and other agricultural sectors [7]. In addition to that, 22.6 % of the total number of holdings in Croatia was classified as mixed crop and livestock farm in 2010 [9].

From the total livestock production in Croatia, the biggest part goes to cattle and pig production. National statistic reports indicate that since 2006 both sectors experienced heavy time which resulted in a reduction of the total production capacity (pig production reduced by 34 to 45 %, depending on the animal category) [11].

2.2. Renewable Energy Sector in Croatia

In contrast to the agricultural sector, which is characterised as being small to medium in size, the biogas sector has been focusing on investments in 1 MW_{el} installations. Although the register of the Renewable Energy Sources (RES) investments (govern by the Ministry of Economy, Labor and Entrepreneurship - MINGO) indicates that there are 56 biogas installations planned (total 70.38 MW_{el}), in reality there are only 12 installations running (total 13.14 MW_{el}). More than 90 % of the biogas installations running are either 1.00 or 2.00 $MW_{el.}$ The only small size installation belongs to the chicken farm Dvor in Sisak – Moslavina County (0.14 MW_{el}).

Although the current setup of the biogas sector in Croatia is more focused on large scale installations, one could question whether, due to the mixed farm structure, there is a potential for the development of the viable small- scale digestion. Similar concept has been elaborated in the ARBOR project where economically viable cases of biogas units start on farms with not more than 80 milk cows [14].

3. Case Study

In order to boost the agricultural sector and consider investments in biogas production, Sisak – Moslavina County took part in the FP7 funded INEMAD project. During the project lifetime, intensive consultations were obtained with different target groups (farmers, research institutions, biogas technologists etc.) and one of the project results was the creation of first-of-a-kind biogas manual in Croatia: "The Potential of Biogas Plants in the Croatian Agricultural Sector", where several case studies and success stories were described. In addition, with the support of the Belgian partners (DLV Belgium, Innova Energy), a calculation tool was developed for the basic detection of the biogas potential and size of investment.

One of the case studies is described in this paper as well.

3.1. Selection of an Agricultural Holding

For selecting representative study cases, the project partners chose small to medium-scale livestock farms located in a rural and distant areas. The pig farm K. from Osijek – Baranja County was selected. This pig farm has a production capacity of 7.200 pigs in 3 cycles and 45 ha of arable land at disposal. One of the reasons for choosing this farm was that – due to the remote location - the farm is not connected to the electricity grid, but uses an electrical generating unit.

3.2. Feasibility Study Methodology

The feasibility study was performed by using the calculation tool created by the DLV Belgium. The tool has a function to determine the biogas potential of the agricultural sector by making an inventory of different features of the agricultural company. Agricultural residues, manure and energy crops and other residual streams, the amount of land available for the manure and digestate disposal and the energy profile were, among others, taken into account.

Based on the input data, the tool gives the expected yearly biogas, electricity and heat production, the energy consumption of the digester, the volume of digestate produced and the total area needed to spread the digestate (with the respect to the EU legal requirements).

The abovementioned output data serves as a basis for the calculation of the total project investment. Next to the investment and operational costs, the IRR is calculated and used as a means to estimate the profitability of the investment.

In order to create the template for the financial appreciation, Belgian prices served as a guideline to deduce prices for the Croatian market.

3.3. Feasibility Study Input Data

The yearly capacity of the farm is 600 t of different feedstock (200 t of liquid fraction of pig manure, 200 t of solid fraction of pig manure, 200 t of corn silage).

In addition, it was assumed that the yearly electricity consumption of pig farm was 70,000 kWh with an average electricity price of 0.18 €/kWh. The price of the energy crops used (corn silage) was 35 €/ton. If the electricity is sent back to grid, a feed-in tariff of 0.165 €/kWhe is used.

Crop to manure ratio is 33 %. Based on the tool´s standard nutrient values of manure and energy crops, the C/N ratio was 20.13, while the dry matter content of the feedstock mixture would be 23 %. A hydraulic retention time of 63 days was used in the specific case.

3.4. Feasibility Study Output Data

In the specific case, the plant of 38 kW_{el}. would allow the farmer to spread manure more easily and generate electricity and heat that could be used on the farm.

Based on the tool that calculates the biogas yields, the farm yearly produces 54,000 m^3 of biogas (approximately 59.600 m^3/year of biomethane).

The tool estimates that the total amount of produced electricity in the first year would account for 91,351 kWhe, with a decrease tendency of 0.25 % for each operational year (due to wear on the CHP).

The digestate, which amounts up to 90% of feedstock input is a highly valuable organic fertilizer. It contains more easily acceptable nutrients, while the remaining organic material stays longer in the soil. Studies have shown that digestate improves the sustainability of nutrient management on the farm by reducing emissions of greenhouse gases and by reconnecting nutrient cycles. The total annual production of digestate would amount for 540 t, separated into a liquid phase (85%) of 459 t/year and a solid fraction of digestate (15%) of 81 t/year.

4. Subsidy for Biogas Systems

If the farmers would like to invest in the biogas sector in Croatia, there are different subsidy schemes that they

could apply for. In this paper, the two most common and most widespread are briefly described.

4.1. National Feed-in Tariff

As it is the case in many other EU countries, the Croatian government also organized a subsidy scheme based on the feed-in tariff. The feed-in tariff is defined by the tariff system for the production of electricity from renewable energy sources and cogeneration (Official Gazette 133/2013, 151/2013, 20/2014, 107/2014) and the responsible body is HROTE (Croatian Energy Market Operator).

According to the existing tariff system, agricultural biogas installations up to 300 kW would receive 1.34 kn/kWh (0.175 €/kWh), while agricultural biogas installations from 300 kW up to 2 MW would receive 1.26 kn/kWh (0.164 €/kWh) [12].

4.2. Investment Subsidy System – EAFRD Programme

According to the Croatian Programme for the implementation of Measures of Rural Development, during the period 2014 – 2020, investments in RES will be made [13].

The most promising measure is the Measure 04 of the Programme whose sub-measures 4.1.3. and 4.2.2. plan to support investments in the renewable sector.

The support varied from minimum 5,000 € to the maximum 1,000,000 €. The minimum return rate was 50 %.

In order to use this measure effectively, farmers had to use the produced electricity on their own site, with a minimum of 10 % of the thermal energy used and a maximum of 20 % of all silage corn produced and shifted from the feeding to the energy requirements. Once the project is financed, the installation must be active for a minimum of 5 years.

5. Financial Overview

Concerning the fact that the financial calculation indicated that for the 38 kW_{el} biogas plant, the farmer couldn´t get a subsidy, a financial calculation was performed on the 11 kW_{el}. Installed capacity, as well. This size was selected since it satisfies the farm´s need for electricity and on the other hand allows the farmer to apply for the EAFRD investment subsidy programme (Measure 04).

The total investment cost [digester unit, Combined Heat and Power (CHP) unit, civil works, pumps and piping systems, installation automation, permits expense, grid connection, additional expenses (10%)] was 256,000 €, while the yearly operating costs (including personnel cost, CHP and installation, maintenance, lab analysis, energy crops cost, administrative follow-up, installation insurance cost) amount for an additional 36.075 €.

A huge difference is noticed when the investment cost is compared with different subsidy systems. If the farmer will perform the investment by himself, the total investment cost for the farm will be 6.400 €. On the other hand, if the national investment subsidy system is used (based on the Measures of rural development programme for the period of 2014 – 2020), the investment from the farmer´s side could be reduced from 50 % (3.200 € investment from farmer´s side) up to 70 % (1.920 € investment from farmer´s side).

6. Conclusions

Investigation of the Croatian agro and energy sector indicated that there is an unused potential for the development of the new RES projects. Since the agro sector is based on small to medium sized farms (mixed crop and livestock production), investments in small scale biogas plants could be of interest in the upcoming years.

The feasibility study showed that in the specific case, the plant of 38 kW_{el} would allow the farmer to spread more than 540 t of digestate on 245 hectares of land available. In addition, the farm would produce 54.000 m^3 of biogas yearly which would allow them to satisfy their electricity needs (use of electricity on the farm itself and putting the surplus on the grid). However, in case that a farmer would apply for an EAFRD subsidy system, a smaller installation would have to be considered (11 kW_{el}.), meaning that the farmer can produce electricity only for its own needs.

Abbreviations

AD	Anaerobic Digestion
ARBOR	Accelerating Renewable Energies through valorisation of Biogenic Organic Raw Material
CHP	Combined Heat and Power
C/N RATIO	Carbon / Nitrogen ratio
EAFRD	European Agricultural Fund for Rural Development
EU	European Union
FP7	7th Framework Programme
GDP	Gross Domestic Product
HROTE	Croatian Energy Market Operator
INEMAD	Improved Nutrient and Energy Management through Anaerobic Digestion
IRR	Internal Rate of Return
LSU	Livestock Unit
MINGO	Ministry of Economy, Labor and Entrepreneurship
RES	Renewable Energy Source
SMC	Sisak – Moslavina County

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