Grzegorz WAŁOWSKI, PhD

Institute of Technology and Life Sciences in Falenty
Department of Renewable Energies in Poznań
Biskupińska 67, 60-463 Poznań
e-mail: g.walowski@itp.edu.pl

DOI: 10.15199/180.2020.3.2

EVALUATION OF PROFITABILITY OF COMMERCIAL UNDERTAKINGS CONCERNING BIOGAS PRODUCTION IN AGRICULTURAL INSTALLATIONS

OCENA OPŁACALNOŚCI PRZEDSIĘWZIĘĆ KOMERCYJNYCH DLA PRODUKCJI BIOGAZU W INSTALACJACH ROLNICZYCH

***Summary**: In the paper, the economic aspects of the commercial undertakings of individual farmers in favour of biogas production in agricultural installations were presented. The evaluation of the profitability was carried out basing upon the investment model.*
The barriers to the development of biogas plant building in social, organizational, engineering and economic and legal contexts were described.
The operation of pilot biogas plant, implemented at the agricultural farm was presented. The experimental studies showed that the agricultural biogas plant reached more than 80% methane with the application of pork slurry. The tested cogeneration system in which the so-called biogas treatment at a low pressure was applied, allows the choice of energy-saving heat fittings what results in reliability of automation of the technological process.
The conducted considerations have revealed that investing in agricultural biogas plants may become the area of interest of investors – as individual farmers – possessing the infrastructure in a form of pig houses and the open lagoon where the pork manure has been stored until now.

***Keywords**: individual farm, pork slurry, agricultural biogas, mobile biogas plant*

***Streszczenie**: W artykule przedstawiono aspekty ekonomiczne w oparciu o model inwestycyjny dla ocena opłacalności przedsięwzięć komercyjnych realizowanych przez rolników indywidualnych na rzecz produkcji biogazu w instalacjach rolniczych.*
Opisano bariery rozwoju budowy biogazowni w kontekście społecznym, organizacyjnym, techniczno-technologicznym oraz ekonomiczno-prawnym.
Przedstawiono eksploatację biogazowni pilotażowej wdrożonej na terenie gospodarstwa rolnego wskazując na badania eksperymentalne biogazowni rolniczej osiągającej ponad 80% metanu przy zastosowaniu gnojowicy świńskiej. Testowany obecnie układ kogeneracji, w którym zastosowano tzw. uzdatnianie biogazu na niskim ciśnieniu pozwala na dobór energooszczędnej armatury ciepłowniczej, co przekłada się na niezawodność automatyzacji procesu technologicznego
Przeprowadzone rozważania wykazały, że inwestycje w biogazownie rolnicze mogą stanowić obszar zainteresowań inwestorów, jako rolników indywidualnych - posiadających infrastrukturę w postaci budynków chlewni oraz otwartej laguny, w której dotychczas magazynowano gnojowicę świńską.

***Słowa kluczowe**: gospodarstwo indywidualne, gnojowica świńska, biogaz rolniczy, biogazownia mobilna*

Introduction

Renewable energy sources (in Polish: OZE) have become more and more significant component in energetic balance of Poland, constituting a characteristics value of innovative and perspective economy. A special role in the mentioned process is ascribed to energy obtained from biogas, including agricultural biogas [1]. It is manifested in the governmental programme "Directions of development of agricultural biogas manufacturing plants in Poland", developed by the Ministry of Economy and adopted by the Council of the Ministers on July, 13, 2010 [9].

The implemented document in a necessary element of the planned process of establishing, in average, one agricultural biogas plant in each community annually up to 2020; it would utilize agricultural-origin biomass, with the assumption of having the appropriate conditions in the specified community to perform the discussed undertaking. The implementation of the assumptions of the programme is aimed at enabling the utilization of a real available potential of raw material for production of biogas which is present in agricultural by-products and the residues of agri-food industry. According to Curkowski et al. [1], the discussed potential is estimated at ca. 1.7 billion m^3 of the available biogas per year. We should bear in mind that in Poland about 14 billion m^3 of the natural gas are used in Poland annually while the individual users from the rural areas utilize ca. 500 million m^3 of gas.

The development of enterprises is indispensably connected with the skill of investing which is defined as a necessary condition of reproduction of resources in the economy whereas the structural changes in the economy must be an effective tool [11]. The development of the instruments the tasks of which is to evaluate the investment effectiveness has been observed. Therefore, the agricultural biogas plants are nowadays a stable source of electric energy production and more frequently, of heat. They are, simultaneously, one of the developmental technologies of electric energy production from the renewable

energy sources – hence, there is a necessity of conducting the thorough analyses on the level of investment decisions [10].

The most technically advanced biogas plants over the world have been constructed in Germany and Denmark for fifteen years. In the countries such as Austria, Switzerland and Sweden, the development of biogas plants is found at somewhat lower level [3]. In other countries, e.g. Spain, Italy, Belgium and the Netherlands, the first modern biogas-producing plants have been functioned for few years; the successive ones are found in the state of construction. In Europe, many countries are greatly interested in the development of biogas plants, especially Poland, Hungary, Lithuania, Great Britain and Ireland [8; 12].

According to the opinion of Renewable Energy Institute, the mean cost of building a bio-gas plant in Poland as calculated into 1.0 MW is ca. (15÷16) million PLN/MW. Financial model, based upon the calculations and the available materials assumes that the budget of building of bio-gas plant from the purchase of land until starting up the plant would be equal to 16.1 million PLN [10].

It was anticipated to obtain financing means in 2017 in a form of long-term credit. The model assumed that the investor would obtain the sum of 3.2 million PLN at the preferential conditions and, hence, he would obtain the cost of capital at the level of 3% during the whole crediting period. The remaining amount, i.e. 7.2 million PLN would be obtained when assuming the interest rate at the level of 7% in the first period and 6% since the moment of starting up the bio-gas plant. The payment of the interests would begin just at the moment of incurring the obligation; on the other hand, the capital in each of the credits would be paid since December 2018 for the period of 10 years. It was also assumed that in 2017, the investor would receive a decision on granting a subsidy for building of the biogas plant in the amount of 5 million PLN. The remaining sum, i.e. 0.7 million PLN would be the own contribution of the investor. The current expenses and a part of land purchase cost would be paid from the own means of the investor. Technology, premises, equipment and machines as well as infrastructure would be covered proportionally from the external financing sources. The system of co-generation together with the fermentation chambers and installations would be the most expensive element. They would constitute almost a half of total outlays. For the needs of appreciation, VAT tax was omitted. It was assumed that during the investment run, the investor would apply for VAT tax return during each period, so it would become neutral from the viewpoint of investment evaluation.

It was adopted for calculations that the biogas plant would work for 8000 h in the annual scale, that is, 334 days (91% of the whole year). Therefore, there is no much time left for downtime or maintenance work. Service of biogas plant requires at least one person, staying on its territory for the whole time. Many operations are mechanized; nevertheless, in the case of any failure, the immediate reaction is necessary.

A part of the electric energy as well as of heat will be used for process purposes. In the case of heat only 20% of the total heat production will be destined for sale. In the case of electricity, more than 90% of the produced electric energy will be destined for sale purposes. Setting up the biogas plant was planned for the beginning of 2008 so as to enable the implementation of 8000 work hours by the biogas plant during the whole year [10].

When considering the above model, we should expect the barriers to the development of the biogas plants.

Barriers to the development

Construction of biogas plants is undoubtedly a very big investment undertaking. The future investors are required to have considerable financial outlays, a good crediting capability and a wide knowledge in many domains which are mutually penetrating each other at the stage of planning and implementing the investment. Biogas plant, as being one of the methods for obtaining a green energy, may be the instrument effective in financial aspect. The conducted model analysis of building and operating the biogas plant has revealed that it is economically profitable investment. However, there is a very high risk of investing the means in this area. It must be considered at every stage of planning the investment as well as in the later period of its operation. Moreover, the biogas market is characterized by many barriers which must be considered throughout the whole analysis of the discussed enterprise. The attempts to systematize them bring their classification into four main areas: social, organizational, technical and technological, and legal-economic ones [5]:

1) Social barriers:
   - Negative perception of future investors by the inhabitants of the territories where the construction of the biogas plant is anticipated;
   - Concerns of the future investors in connection with a high instability of the sector;
2) Organizational barriers:
   - Lack of local plans for spatial development of the areas;
   - Lack of professional preparation of the officials for running the investments in a sector;
   - Organizational disintegration of the sector at the territory of the country;
   - The necessity of correlating the heat receipt and gas production, especially in the rural areas where there is no possibility to transfer heat (rural areas do not have the heat infrastructure),
   - Lack of the national research laboratories and support centres for the future investors,
   - Lack of reliable investment advisory activity;
3) Technical and technological barriers:
   - Temptation to invest in big biogas plants which bring higher profits and allow obtaining higher return rates from the involved capital,
   - The entities interested in building of small biogas plants do not receive a support on the market, lack of the institutions dealing with introduction of implementation of such small projects;
   - Lack of Polish engineering ideas which would allow adapting the biogas plants to our market and by this, to contribute to

lowering the costs of the investment,
- Initial unsuccessful attempts and the opinion on a high risk of such investment,

4) Legal and economic barriers:
- Lack of a stable support of OZE (Renewable Energy Sources) in the legislation,
- High capital barriers to the building of biogas plants,
- A strong position of energetic enterprises on the market and the necessity of complying to their requirements, being often too high for the farmers who would like to commence the discussed activity on the occasion of running agricultural farms,
- Bureaucracy, existing at the level of applying for support from the public means,
- A long period of return from the involved capital.

The experimental studies on agricultural biogas plants

Poland has a high potential of biogas: about 12% of energetic resources of biomass of the whole Europe, are found at the territory of our country. We are not able, however, to utilize it in an effective way. A lack of technological support from the leading scientific centres in Poland deepens a gap in this sector. The capital intensiveness plays the greatest role. High financial outlays in combination with a long period of return might change only when in Poland the production of particular components necessary for biogas plant building is conducted at the higher scale. In longer perspective the profits for the future investors have not been also specified. In spite of the fact that the Ministry of Economy has developed "Guidebook for the investors, interested in building of biogas plants" [6] which explained many doubts, still the gap on the market is recorded; it does not offer the ready solutions, especially for prosumer co-generation when using micro-biogas plant e.g. up to 40kWel. It is necessary to undertake the successive attempts and develop practical models of functioning for such innovative solutions.

The operation of pilot biogas plant, situated at the territory of agricultural farm in Ocieszyn (Photo. 1a) is one of the examples of the undertaken efforts. The installation for production of biogas, as implemented under the project BIOGAS&EE, financed by the National Centre of Studies and Development within BIOSTRATEG 1 programme, is managed by the Head of the Project, Grzegorz Wałowski, PhD, Eng. The solution of the problem was performed by the Institute of Technology and Life Sciences in Falenty and, more precisely, Department of Renewable Energies in Poznań; the cogeneration system with the so-called biogas treatment at a low pressure is tested at this moment. The biogas is directly supplied to the co-generator with the application of the elements of infrastructure of:
- American producer (Woodward) of automation systems, including advanced controller, throttles with electronic actuators, agitators, controllers of engine work to gas power generators and co-generation aggregates;
- German producer (Karl Dungs GmbH & Co. KG) of high-quality gas fittings, including filters, reducers, zero pressure regulators, integrated electro-valves with tightness control systems,
- Polish producer and distributor of energy-saving heating fittings for central heating system and water heater system (in Polish CWU) (WOMIX), including mixing valves together with drivers, complete systems of pump groups, automatics of heating installations [13].

Designing and building of a model of mono-substrate flow biogas reactor was implemented based on the inventory [7]. The fermentation tank is (cylindrical shape) is situated in vertical position and the bottom of the tank has a shape of cut cone with centrally situated drainage hole. The tightness of the fermentation tank is ensured by cover, closing the fermentor, together with the sealing element. The pilot production of biogas (Photo 1a) consisting of the systems: hydrodynamic agitation, heating, immobilization [15], with the use of pork slurry was situated at the territory of agricultural farm, possessing 1100 porkers managed on a slatted floor [14].

Fot. 1. Pilot biogas plant: a) site of biogas plant (a view [Photo by G. Wałowski] – from right: fragment of pig house, mono substrate flow rector for methane fermentation of pig slurry together with the installation for production of agricultural biogas, lagoon for post-fermentation product; b) adhesion bed, made from vertical pipes with coarseness of 80 µm, transported to the inside of fermentor – a view [Photo by G. Wałowski].

a)

b)

Inside the fermentation tank, there is a filling i.e. skeletal bed, made from vertical PVC pipelines, constituting the so-called "basket" (Photo 1b), the role of which is to increase the active surface for development of fermentative bacteria microflora [15].

Summing up

The investments in OZE (renewable energy) are long-term and require systematic and consequent action. What it is unprofitable at the present moment, it may become profitable in the perspective of few years. Many barriers which obstruct OZE development at each level may gradually decrease with the time. All barriers, including those psychological, social, legal, economic and political ones should be minimized or considerably reduced. Moreover, it is necessary to develop the effective instruments, which would promote and encourage investing in the discussed area. The support for the future investors and education of the society is the first step to contribute to increasing the interest in the discussed area among the potential investors. All mentioned activities must be coordinated at the central level as to ensure a full flow of information [10].

Economical profits resulting from the construction of biogas plant may be considered from the viewpoint of biogas producer and local community. For the producer, the sale of energy, certificates of origin, the so-called green certificates as well as other securities, heat and manure or post-fermentation biomass may constitute a source of income.

For community authorities, for example, the taxes paid by the biogas producer to the community authorities may be a measurable economic effect. A direct economic effect may be achieved by the local shops, owing to the sale of fertilizers, plant protection agents and fuels necessary for biomass production.

Also, a part of machines and equipment is purchased at the local market, especially those ones used in the current operation of the biogas plant (oils, greases, small spare parts, materials necessary for ensiling of biomass, etc).

Certain biogas plants deliver heat to the local users (houses, settlements or schools) at the competitive price as compared to the traditional sources. The biogas plant functions almost for the whole year, so it is a stable, constant and reliable heat supplier. The negotiations on the heat prices may be the important bargaining chip at the stage of social consultations. The signing of the long-term agreement, with the consideration of a stable price, would be a profitable solution for the both sides [4].

The conducted consideration has revealed however that investing in agricultural biogas plants may become the domain of interest of the investors; in spite of the fact that the mentioned investments are characterized by a high sensitivity, they bring the value added in a longer period of time. On the other hand, at the present investment costs, it is very important to have the investing support of the biogas plant construction; it would considerably allow abbreviating the period of return and by this, increase the interest of the future investors in building the biogas plants [10].

Acknowledgements

The present study was performed within the frames of the project, financed from the Research Task (statutory) no 11/79/2019 "Development of model, describing the gas permeability of anisotropic porous materials in aspect of adhesive hydrodynamics for agro-energetic applications', implemented by the Institute of Technology and Life Sciences in Falenty, Department of Renewable Energy in Poznań.

References

[1] Curkowski A., Onkisz-Popławska A., Mroczkowski P., Zowski M., Wiśniewski G. 2011. Przewodnik dla inwestorów zainteresowanych budową biogazowni rolniczych. Pracę wykonano na zamówienie Ministerstwa Gospodarki w Instytucie Energetyki Odnawialnej, Warszawa.
[2] Faber A. 2008. Potencjał i konsekwencje rolnej produkcji biomasy dla energetyki, Płońsk. http://www.cire.pl/pliki/2/potenc_konsekwenc_.pdf, dostęp 15.06.2016.
[3] Kosewska K., Kamiński J.R. 2008. Analiza ekonomiczna budowy i eksploatacji biogazowni rolniczych w Polsce. Inżynieria Rolnicza 1(99)/, 189-194.
[4] Kowalczyk-Juśko A. 2013. Biogazownie szansą dla rolnictwa i środowiska. Wyd. Fundacja na rzecz Rozwoju Polskiego Rolnictwa, Publikacja przygotowana w ramach Planu działania Sekretariatu Centralnego Krajowej Sieci Obszarów Wiejskich na lata 2007-2013. ISBN: 978-83-937363-0-0.
[5] Krawiec F. 2010. Odnawialne źródła energii w świetle globalnego kryzysu energetycznego. Wybrane problemy. Warszawa, Difin.
[6] Ministerstwo Gospodarki 2010. Przewodnika dla inwestorów zainteresowanych budową biogazowni rolniczych. Warszawa.
[7] Myczko A., Kliber A., Tupalski L. 2012. Najnowsze osiągnięcia z zakresu OZE wraz z przedstawieniem barier we wdrażaniu wyników badań do praktyki gospodarczej (red. B. Mickiewicza), Koszalin.
[8] Oniszk-Popławska A., Zownik M., Wiśniewski G. 2003. Produkcja i Wykorzystanie Biogazu Rolniczego. EC BREC/IBMER, Gdańsk-Warszawa. ISBN 83-86264-91-8.
[9] Program 2010. https://sip.lex.pl/akty-prawne/mp-monitor-polski/raport-okreslajacy-cele-w-zakresie-udzialu-energii-elektrycznej-17711107
[10] Przesmycka A., Podstawka M. 2016. Ekonomiczna efektywność inwestycji w biogazownie rolnicze. Stowarzyszenie ekonomistów rolnictwa i agrobiznesu. Roczniki Naukowe, tom XVIII, zeszyt 6, 176-182.
[11] Rogowski W. 2013. Rachunek Efektywności Inwestycji. Wyzwania teorii i potrzeby praktyki. Warszawa, Wolters Kluwer Polska.
[12] Sygit M. 2005 [on-line]. Przetwarzanie odpadów i produktów roślinnych w biogazowniach-aspekty ekonomiczne [dostęp 11-03-08]. Politechnika Wrocławska. Dostępny w Internecie: http://www.sygma.pl/ index.php/ sygma/wybrane_opracowania/przetwarzanie_odpadow_i_produktow_roslinnych_w_ biogazowaniach_ aspekty_ekonomiczne
[13] Wałowski G. 2020a. Metody oceny oraz szacowania inwestycji, wynikającej ze sposobu postępu prac dotyczących realizacji mikrobiogazowni rolniczych. INNOWACYJNE TECHNOLOGIE POZYSKANIA ENERGII ODNAWIALNEJ. Monografia pod redakcją naukową prof. dr. hab. inż. Wacława Romaniuka, Wydawnictwo Instytutu Technologiczno-Przyrodniczego w Falentach, Falenty – Warszawa, ISBN 978-83-65426-42-0, tom XXVI, 133-141.
[14] Wałowski G. 2020b. Eksperymentalna i numeryczna ocena przepływu substratu i biogazu rolniczego przez złoże szkieletowe adhezyjne. Współczesne zagadnienia TERMODYNAMIKI, Monografia Instytutu Techniki Cieplnej, Wydział Mechaniczny Energetyki i Lotnictwa, Politechnika Warszawska, Oficyna Wydawnicza Politechniki Warszawskiej. ISBN 978-83-8156-127-3, 271-278.
15. Wałowski G., Borek K., Romaniuk W., Wardal W.J., Borusewicz A., 2019. Nowoczesne systemy pozyskania energii - biogazu. MONOGRAFIA pod redakcją naukową prof. dr hab. inż. Wacława Romaniuka. Warszawa, Wydawnictwo Wyższej Szkoły Agrobiznesu w Łomży, ISBN 978-83-947669-9-3

Article reviewed

Received: 06.10.2020 r./Accepted: 13.10.2020 r.