BIOGAS STATIONS IN THE CZECH REPUBLIC – SUBSIDIES, COSTS, AND REVENUES

Jaroslav Svoboda[1], Jana Lososová[2]

[1] Ing. Jaroslav Svoboda, Ph.D., * Faculty of Economics, University of South Bohemia, České Budějovice, svoboda@ef.jcu.cz ORCID 0000-0003-3831-7962
[2] Ing. Jana Lososová, Faculty of Economics, University of South Bohemia, České Budějovice, lososova@ef.jcu.cz ORCID 0000-0001-9610-1436

Abstract: The current energy crisis forces us to look for new energy sources in addition to savings. Undoubtedly, their purpose is environmental friendliness and the much-discussed question of independence from other countries. One of the ways is the use of biomass for the construction of biogas stations. The paper deals with this issue in the agricultural sector in the Czech Republic. However, the construction of these stations is relatively demanding in terms of investment, which is why specific subsidy programs have been prepared for their development. However, the operation itself entails further costs but also revenues. At the same time, the article tries to demonstrate this issue in a case study of a selected agricultural enterprise.

Keywords: Biogas stations, subsidies, costs, revenues, agriculture.

JEL Classification: M41, Q14, Q4

INTRODUCTION

Biogas stations (BS) are technical devices designed to transform agricultural substrates, biodegradable waste, and sewage sludge into biogas that can be used energetically (Münster & Meibom, 2011; Dach et al., 2014). Biogas is generally a gaseous mixture created by the activity of microorganisms. This means that all types of biogas of anaerobic origin are produced in the same way in principle, whether the methanogenic process takes place below the surface of the earth, in the digestive tract of animals, in municipal waste dumps, in lagoons, or controlled anaerobic reactors. Biogas generation is the final stage of the biochemical conversion of organic matter under anaerobic conditions to biogas and residual fermented material (Michal, 2005; Rasi et al., 2007). In technical practice, the use of the name biogas for the gaseous mixture created by the anaerobic fermentation of wet organic substances in artificial technological devices, e.g., reactors, digesters, lagoons with biogas collection equipment, etc., has become established.

There are three main reasons for the utilization of anaerobic fermentation of organic materials that come from agriculture, forestry, the municipal economy and the rural landscape. These are the production of quality organic fertilizers, the acquisition of an additional energy source and the improvement of the work and environment.

Environmental improvements will have an increasing incentive role in the decision to build biogas stations, as the energy use of biomass has a positive effect on limiting the concentration of carbon dioxide in the atmosphere compared to fossil fuels. During biomass production, carbon dioxide is consumed during photosynthesis and released back into the atmosphere when the biomass is used for energy. This closes the short-term CO_2 cycle (VÚZT 2007). The Czech Biogas Association (CBA) divides BS into municipal, industrial, agricultural, landfill biogas, and wastewater treatment plants.

In the Czech Republic, biogas production has developed mainly for the degassing of municipal waste landfills and stabilizing sewage sludge in wastewater treatment plants. 80% of this potential is used (Váňa, 2010). The highest potential is in processing agricultural renewable raw materials, i.e., animal droppings and plant biomass. There are currently 574 biogas stations in operation in the Czech Republic, with biogas accounting for 22.9% of energy production from renewable sources (CBA, 2019).

In large-scale farms without ties to the land, animal feces, litter residues, and other organic material are often considered waste. But it can be used for the production of organic fertilizers or organically processed by anaerobic methanogenic fermentation for the production of biogas (Váňa, 2002). In the context of the circular economy, biogas production is seen as a versatile renewable energy source that will help reduce greenhouse gas emissions (Potting et al., 2016). Large-scale biogas production is an established technology with high potential in developed countries. For example, a study by Soares et al. (2020) shows a high potential for biogas production using co-digestion of pig manure and placenta or pig waste with an automatic mixing system. Maroušek & Gavurová (2022) indicate the possibility of using biogas fermentation residues as a well-usable source of phosphorus for plant nutrition.

However, considerable support for agricultural biogas plants has also drawn criticism (Vochozka et al., 2018). High construction and operating costs, the need for large storage areas for raw materials, the significant load on roads and vehicles during the collection of raw materials, the noise of machinery, and the increased risk of soil erosion can be perceived as unfavorable. Quality organic fertilizers, the basis of the sorption complex, do not get into the soil, which can negatively affect soil fertility. The ability of digestate to replace manure is debatable. Opponents of biogas facilities also argue that using crops for purposes other than food is an ethical issue (e.g., Balussou et al., 2018; Barros et al., 2020). On the one hand, the pressure to use renewable energy sources is increasing, on the other hand, the rapidly growing population of the planet will necessarily need food, and the area of agricultural land and its fertility is decreasing. However, Vochozka et al. (2018) report that reducing the input of purpose-grown phytomass will reduce pressure on food prices and improve environmental acceptability.

The economic efficiency of biogas plants is influenced not only by investment parameters, especially investment costs, capital costs, and the amount of non-refundable subsidies, but also by operational indicators, especially revenues from waste management, electricity sales, heat, and digestate. The introduction of biogas and electricity production through a biogas plant is financially demanding and requires investment in many production components. In practice, biogas is most often used as fuel for a BPS combustion engine, where it is converted into electrical energy and heat by cogeneration. Heat production is seasonal mainly due to its application; year-round use assumes the creation of additional financially demanding investments (Poláčková, 2013). National policies set bioenergy prices, and although feed-in prices in Europe are generally still high, their operating time is limited, and they are gradually decreasing. The economic viability of this type of initiative is thus significantly influenced by external political, legal, and market factors (Donner et al., 2020).

1. RESEARCH METHODOLOGY

The goal of the contribution is the evaluation of biogas plants from the point of view of the Czech Republic and is structured in two parts. The first part is focused on the situation in terms of station support. The data source was, on the one hand, legal legislation regulating possible support. Then there are the reports of the authorities that dealt with the payment of subsidies. All sources are then listed at the end of the post. The next part of the contribution is a case study with internal data of a selected agricultural enterprise, which decided on the construction of this station and eventually implemented it. The total investment expenditure is first presented on the data (5-year period). The data at the beginning of the analytical part contain the distribution of operating costs depending on the form of financing – i.e., without subsidy or with subsidy. This is followed by an evaluation of the detailed structure of these costs and revenues using the comparison method. The resulting values of the planned economic result were compared with its actual amount and supplemented with a cash flow indicator (adjustment using the indirect method through depreciation). The accounting data was therefore evaluated from an ex-ante and ex-post point of view.

2. RESULTS

2.1 Support for agricultural biogas stations

Investment subsidies for the construction, modernization, or reconstruction of agricultural BS (biogas station) were provided mainly through the Rural Development program (RDP) 2007–2013 as part of measures III.1 - Measures to diversify the rural economy III.1.1 Diversification of activities of a non-agricultural nature. The support is aimed at diversifying the activities of agricultural entities towards non-agricultural activities, especially in the field of construction of decentralized facilities for the processing and use of renewable energy sources with the aim of energy self-sufficiency in the countryside and fulfilling the obligations of the Czech Republic to achieve 8% of energy from renewable sources.
As part of the Rural Development Program, 143 projects with a subsidy of 2.64 billion crowns were approved as of 8/31/2014. 138 projects for 2.54 billion crowns have already been implemented and reimbursed (Anděrová, 2014). Table 1 shows approved applications by individual calls within the 2007–2013 PRV, including allocated subsidy funds.

Tab. 1 Approved applications under the RDP 2007-2013

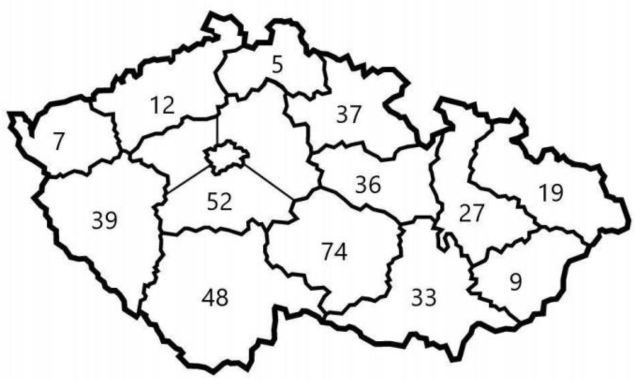
Call	**Number of approved applications**	**Requested subsidy in CZK**
1st round 2007	21	493 895 826
3rd round 2008	18	463 666 286
6th round 2009	28	455 920 895
9th round 2010	61	981 012 993
13th round 2012	26	447 612 727
TOTAL	154	2 842 108 727

Source: Own processing from MZe

The new strategy, whose aim was to limit the purposefully grown biomass with negative impacts on the environment, especially soil and water, was to give preference to those projects that will integrate BS into a technological unit with other (production or other) activities. In this area, the sector of pig breeding and the use of manure appeared to be particularly promising (MZe, 2012). Within the PRV 2014–2020, operation 6.4.3 Investments to support energy from renewable sources, investments aimed at diversifying the activities of agricultural entities into non-agricultural activities leading to income diversification (the project must not serve only to cover the energy needs of the applicant) and the use of by-products are supported, and raw materials for the biological economy, especially in the field of construction of facilities for the processing and use of renewable energy sources (investment in facilities for the production of shaped biofuels and biogas stations). Supported BS has a maximum installed power of 500 kW. Consumables, general costs according to Article 45 NK (EU) No. 1305/2013, and other expenses that are not directly related to the implementation of the project are not supported. Based on the analysis carried out to determine the profitability of the BS, in the case of the construction of the BS, following the Commission Delegated Regulation (EU) No 807/2014, Article 13 e), is set the annual energy value of the targeted biomass (cereals and other crops with a high starch, sugar or oil used for the production of bio-energy) from the total annual energy of the bulk material was established at a maximum of 20 %.The call was only announced in the 4th round in 2017; due to the

change in strategy, there was no interest in this support. Considering the conditions of the call and the overall legislative framework of support, a minimum absorption capacity was found for operation 6.4.3 plan b) Construction of new biogas stations. The evaluator suggested changing the call's conditions (capacity and composition of input raw materials), and possibly reallocating funds. The main reasons for the low interest in investing in biogas stations were probably the new pricing policy and the obligation to use pig slurry in a certain percentage of raw materials. For this reason, it was proposed to redistribute the remaining amount of the operation between 6.1.1 Starting the activity of young farmers (MZe, 2017).
Above all, in the production of biogas, there should be a replacement of agricultural biomass grown in a targeted manner with waste biomass and biodegradable waste. This will not only bring about the use of the biodegradable component of municipal waste, which is currently deposited in landfills in the form of mixed waste but will also eliminate the negative impacts of targeted biomass cultivation on agricultural land, water, and other environmental components (MZe, 2020).
According to data from the Czech Biogas Association, there are 398 agricultural biogas stations in operation in the Czech Republic. The spatial distribution by region shows chart 1.

Fig. 1 Agricultural biogas stations by region



Source: Czech Biogas Association (CBA)

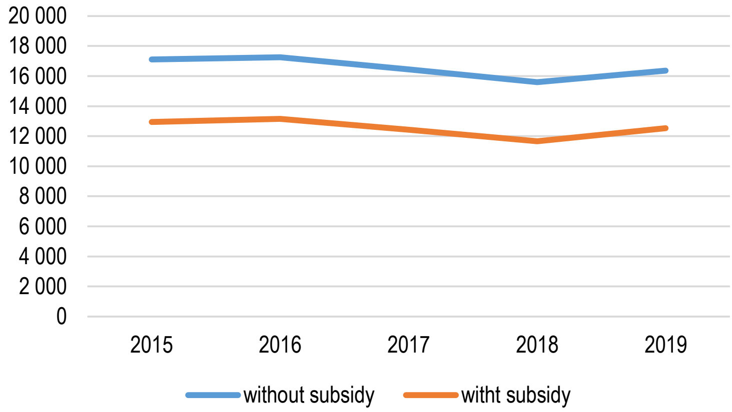
2.2 Construction of a biogas station – case study

The investor is a private company engaged in agriculture since 1993. Regarding the legal form of business, it is a limited liability company. The company currently employs an average of around 50 employees. It manages approximately 1,500 ha of agricultural land, on which it mainly produces wheat, rapeseed, and maize for silage. The company focuses on cattle breeding with milk production in animal production. Business in agriculture, like any other, is motivated by profit and maximizing the company's market value. The investor aims to produce crops in demand in the market and can be sold at a profitable price. The project for the construction of a biogas station was developed with the aim of efficient and ecological use of organic residues from animal and plant production, as well as for energy savings through the use of renewable resources.
According to the project developed by the designer, implementing the BS assumes investments in the construction and purchase of a fermenter, mixers, gas storage, cogeneration unit, machine room, deferment, and digestate storage tank. The estimated lifespan of individual BPS components is 10-20 years. Biogas production per year is estimated at 2,000,000 m^3. Biogas will further be used for producing electricity

and heat by combustion in a piston engine. The presented type of cogeneration has the highest efficiency. The proposed cogeneration unit has an electrical output of max 600 kW. The electrical energy will then be sold; the heat will be used only for needs of the enterprise (heating a nearby building, drying primary agricultural products, and in the future, it is intended to heat the stables). There are no potential customers (other companies, households) in the vicinity of BPS, and conducting heat over longer distances is financially very demanding. The primary input raw materials (maize silage and beef slurry) will be consumed from their own sources. The placement of corn silage is designed to eliminate the cost of transporting the raw material to the fermenter. The biogas station will be located exclusively on its land.

The capital expenditure was determined based on the budget prepared by the designer of CZK 73,222,104. Since the implementation was planned within one year, the capital expenditure is not discounted. The company had two options of financial resources to choose from, without subsidy and with subsidy. The considered support is intended as part of the subsidy for projects of the Rural Development Program of the Czech Republic for 2014–2020, operation 6.4.3. The investment to support energy from renewable sources could amount to 40% (i.e., CZK 29,288,842). In the case of financing without a subsidy, the company could use external funding from a bank at an interest rate of 3.98%. These two financing options, therefore, had an impact on **the cost forecast** - see chart 2.

Fig. 2 Costs forecast (in thousands of CZK)



Source: Internal data of the enterprise, own processing.

The average amount of total annual costs in the period under review in the case of non-use of subsidy financing was estimated at CZK 16.5 million, and in the case of subsidy utilization, it was CZK 4 million lower. A more detailed view of the cost structure is shown in Table 2. It is evident that the highest share of costs is made up of depreciation, which is also reflected in the total cost value. The acceptance of an investment grant has an accounting impact on the amount of the asset's entry price. This subsidy reduces the purchase price and therefore the depreciation is lower (from 32% to 25%). Straight-line depreciation is used for the analysis. A biogas station consists of many components and, when included in the property, is divided into 4 groups according to their useful life. The following two highest cost items are naturally formed in Input raw materials (1) - corn hay, manure, cereals (16-21%), and similarly maintenance and repair costs (5). Again, the interest value, which reaches about 15%, is linked to the financing method in the case of using loans.

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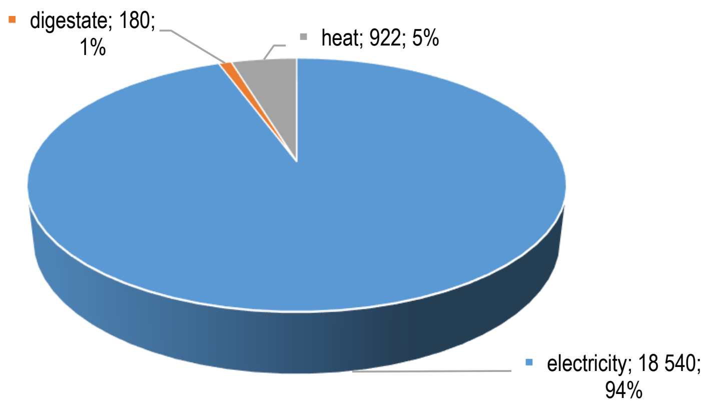
Tab. 2 Cost structure (in %)

Nr.	Cost structure	without subsidy	with subsidy
1	Input raw materials	16,03%	21,16%
2	Power consumption	1,41%	1,86%
3	Water consumption	0,28%	0,37%
4	Fuel consumption	0,52%	0,69%
5	Maintenance and repair costs	17,06%	22,51%
6	Investment insurance	1,38%	1,81%
7	Labor costs	2,06%	2,72%
8	Other operating expenses	14,06%	18,57%
9	Loan interest	14,82%	4,66%
10	Depreciation	32,38%	25,65%

Source: Internal data of the enterprise, own processing.

In terms of **revenues**, sales are planned at the following levels: sales of electricity, heat, and digestate. At the time of the study, the realization price of electricity was from the current price decision of the Energy Regulatory Office (ERO), which establishes support for the production of electricity from renewable energy sources, the combined production of electricity and heat, and secondary energy sources. A fixed purchase price rate will be used to calculate the returns. The price of one kilowatt hour (kWh) is set by ERO at 4.12 CZK. The estimated output is 375,000kWh/month. Digestate is an organic fertilizer created by anaerobic fermentation during biogas production, rapidly releasing nitrogen. His estimate was set at CZK 15,000/month. The secondary product of the anaerobic process is heat, which was calculated at 6,148.8 GJ/year at a heated price of CZK 150/GJ. Only heat for which further use is expected is determined. Unused heat will be wasted in an emergency cooler. The structure of the resulting revenues is shown in chart 3, from which the highest revenues (approx. 94%) will be realized through the sale of electricity.

Fig. 3 Revenues forecast (in thousands CZK; %)



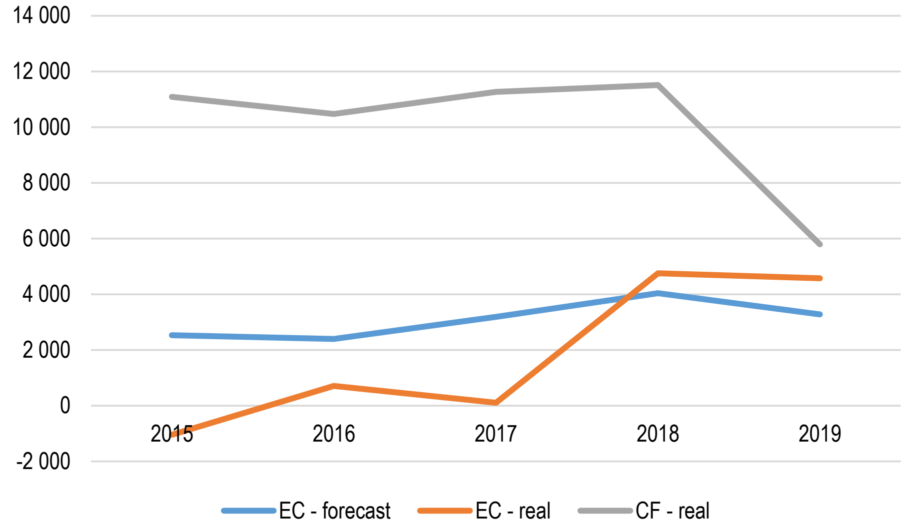
Source: internal data of the enterprise, own processing.

What was the **real development of costs and revenues** that could be worked out after 5 years. Regarding the implementation of the construction of the biogas station, a study was prepared to evaluate the effectiveness of the investment. Both variants (with and without subsidy) were considered as effective and feasible for the company. The variant with the investment subsidy showed better results, but in the end, the variant without using the support was implemented. This situation occurred due to internal company matters. Real revenues from the biogas station average 18,800 thousand CZK. This amount is influenced by three aspects, namely fault-free operation (the station is capable of operating 24 hours, 7 days a week), the quality of input raw materials (the station processes materials of a plant nature and farm fertilizers, or bedding) and the way electricity is sold. The company is protected by tangible property insurance against the risk of operational failure but is not insured against loss of income due to equipment failure. The quality of the input raw materials depends on the climatic conditions. There was a change in the area of electricity sales in 2018. Until this time, the realization price of energy was based on the recent decision of the Energy Regulatory Office, which establishes support for production from renewable energy sources, the combined production of electricity and heat and secondary energy sources, when the purchase price per kilowatt hour was fixed at CZK 4.12. In 2018, the company switched to electricity sales through a combination of electricity sales + the so-called green bonus (Štěrbová, 2021).

The green bonus regime assumes that the producer will find a consumer (trader) for the electricity he produces and will contractually resolve the issue of deviations with a third party. The delivered electricity is then sold at a market price reflecting the quality of the electricity (supply diagram, controllability, reliability, etc.). The green bonus then represents a surcharge to the market price. It is determined as the difference between the minimum price calculated for the amount of the discount (WACCOZE) and the estimated market price for the given type of renewable energy sources. Green bonuses are paid to manufacturers through OTE, a.s. However, this way of selling electricity already carries a market risk since the purchase prices set by traders depend on the price on the stock exchange. The company has no protection against this risk. Year-to-year fluctuations in electricity revenues are mainly caused by equipment failures, whether it is a failure of a motor, agitator, or another component or equipment downtime due to planned repairs. During the observed period, returns oscillate around the average value, and fluctuations are negligible. Their prediction was therefore determined by a very high-quality estimate with a deviation of up to 5%.

However, the situation is somewhat different when comparing planned and real costs. On average, they reached approx. 500,000 CZK annual increase over plan (in the total value over the monitored 5-year period, an increase of approx. CZK 2.5 million). Their development was very variable. In the first three years, the reality exceeded the plan by approx. 10%, but in the last two years, the situation reversed, and the actual costs were lower in 2019 by approx. 20%. The explanation will give us an insight into their closer structure. Both in the calculation and the real development, the highest depreciations were with an average share of approx. 40%. However, their absolute value dropped significantly in 2019 by up to 60%, apparently due to a change in the depreciation policy. According to the plan, consumption of raw materials (average 17%) and operating overhead (18%) had other significant shares. Furthermore, maintenance and repair costs (average 12%) were also predicted very correctly, which had an upward trend, which is understandable given the wear and tear of the equipment. The total impact on the economic result and cash flow in the distribution of plans and reality is shown in chart 4.

Fig. 4 Economic result forecast, real and cash flow real (in thousands of CZK)



Source: Internal data of the enterprise, own processing.

Although the plan was more optimistic and calculated a profit of approximately CZK 15.5 million in the first five years, the actual development of the economic result can also be described as satisfactory. Apart from the first year, a profit with a growing tendency was realized in excluding 2017, partly 2019, and its total value reached over 9 million CZK. The situation is even better from the view of cash flow, which hovers around CZK 10 million. This is a more meaningful indicator for the company, as it shows how much cash the investment generated, and for the monitored period, it was a positive value of approx. 50 million CZK. However, it is necessary to point out here that the initial investment expenditure and the sources of its financing must also be taken into account during further evaluation (see above).

CONCLUSION

Since 2007, approx. 2.5 billion CZK has been allocated to support biogas stations. Unfortunately, with the change in strategy and conditions since 2014, there has been no interest in these supports. So here you can see the precise impact of essentially political decisions, which, over time, are not entirely correct. As many studies have shown (e.g., Chen et al., 2017; Winquist et al., 2021), currently, the urgency to use renewable energy sources is growing due to climate change and increasing dependence on fossil fuels, more recently because of rising energy prices. The role of biogas is much broader than just providing renewable energy, but it also benefits from reducing emissions from agriculture and closing the loop in a circular economy. However, biogas's future depends mainly on political decisions; above all, a stable and predictable energy policy is needed (Winquist et al., 2021; Trypolska et al., 2021).

Based on the case study, it was proven that the construction of this station is a direct benefit for the investor (in the given example, the investment cost was approximately 73 million CZK and generated a cash flow of roughly 50 million CZK over the observed 5-year period). Of course, the high-quality processing of the feasibility study is the basis for the investor's decision to accept the investment, which was the case in our case. The investor's final decision to finance without a subsidy contributed to the higher investment cost, but it was still financially beneficial. Another aspect in this context in connection with the current energy crisis is the possibility of own electricity generation and thus less dependence on external sources.

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