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IDENTIFICATION OF EXTERNAL RISK FACTORS: ON THE EXAMPLE OF PRODUCTION OF FERTILISERS BASED ON DIGESTATE

Abstract

In the era of renewable energy development, one of the most important problems is the utilisation of residues of production of the so-called clean energy. In the case of biogas plants, the problem is the utilisation of waste after the anaerobic methane fermentation process of the organic substrate. One of the ways to use it is to produce organic and mineral fertilisers. However, the fertiliser plant may be exposed to a number of threats that may prevent its functioning. To avoid this, the factors that carry the risk need to be identified. The purpose of the article is to identify external risk factors for a fertiliser plant based on digestate. The following types of risk were identified as a result of the research: risk of supplying fertiliser components of inadequate quality; risk of non-compliance with deadlines for the delivery of raw materials or their total absence; risk of the presence of eggs of parasites and pathogenic bacteria in fertiliser; price risk; cyclical risk; risk of competition; currency, credit and interest rate risk.

Keywords

biogas plant, digestate, fertilisers, hazards, risk factors, types of risk.

Introduction

The escalating effects of climate change have forced governments of many countries to revise their energy policy. Many of them prioritised actions to support the production of energy from renewable and alternative energy sources (instead of using conventional sources). One of the popular ways of obtaining "clean energy" is to convert organic waste to gas in agricultural biogas plants. The product obtained in them - biogas (product of anaerobic methane fermentation, biomethane) - can then be used in many ways, for example as a source of electricity; fuel for driving cars; heat source for cooking, heating utility water and heating rooms (pumped into the local gas network). Unfortunately, the substrates used for biogas production are not completely decomposed, as another waste (called pulp, mass or post-fermentation sludge, in short - digestate) is created, which must be disposed of or utilised. Utilisation of digestate entails costs for biogas plant owners, and therefore a better solution for them is to use digestate for other economic purposes. "One of the promising proposals for the use of sludge is to use it for the production of heating pellets for fuel purposes" [1]. This is called thermal utilisation. The digestate (sludge) can also be used to fertilise soil, which contributes to improving its quality. Such a solution brings benefits for both the economy and the environment.

Post-fermentation mass as a source of minerals for plants

Post-fermentation waste used for soil fertilisation can be a valuable source of nutrients for plants and can also improve soil properties, especially in Poland, where acidic and strongly acidic soils are dominant. "Such soils are characterized by low sorption of nutrients and low water retention. As a result, they require an inflow of organic matter, which has a positive effect on many parameters determining the yield" [2].

The use of digestate for fertilising purposes is economically justified for at least two reasons. Firstly, the costs of utilisation of waste generated in agriculture and agri-food industry as well as in households are reduced (in the light of the new method of waste segregation which separates the "Bio" fraction). Secondly, digestate pulp used as a natural fertiliser (which will ensure the supply of necessary biogens to the field) will bring measurable

benefits to nature and farmers, and thus - to final consumers by providing more healthy food to the market. Thirdly, it will generate additional income for biogas plants for the substrates sold [3].

Fertilisers produced with the use of digestate¹ can be used by large-scale farmers, in forestry, horticulture, as well as in nurseries of plants, trees and shrubs. "Considering the digestate in the context of its chemical properties, it should be noted that it contains a large amount of nitrogen (N), especially in the form of ammonia, easily available to plants, as well as other macro- and microelements necessary for plant growth" [4]. In addition to nitrogen, digestate contains mineralised phosphorus and potassium, which has a positive effect on plant growth. Unfortunately, it can also contain heavy metals, which pose a threat to agricultural crops. Therefore, the legislator imposes certain requirements regarding the content of individual fertiliser components and impurities (Table 1).

Table 1. The minimum content of beneficial components for soil and plants and the maximum content of impurities in organic and organic-mineral fertilisers

Component	Solid organic fertiliser	Liquid organic fertiliser	Impurity	Maximum content [mg/kg]
Organic substance [% d.m.]	30	–	<i>Cadmium</i>	5
Nitrogen [%]	0.3	0.08	<i>Chrome</i>	100
Phosphorus [as % P ₂ O ₅]	0.2	0.05	<i>Nickel</i>	60
Phosphorus [as % K ₂ O]	0.2	0.12	<i>Lead</i>	140
			<i>Mercury</i>	2

Source: [5]

In addition, fertilizers produced on the basis of digestate as well as digestate in pure form may be used in agriculture if they meet the requirements of the Regulation [6] of the Minister of the Environment on the R10 recovery process².

Method of research

However, the use of digestate pulp for the production of organic and mineral fertilisers used for agricultural production may raise a number of questions and doubts, including:

- Is their use safe for farmers?
- Is the obtained agricultural production and its products safe for consumers?
- If they are not safe, where can such fertilisers be used?
- What are the risks of using this type of fertilisers?
- What risks should be taken into account when establishing plants producing such fertilisers?
- What threats have to be considered when operating such a plant?

In this article we will try to find answers to at least some of the questions asked. Namely, we will focus on the risk analysis of a manufacturer of agricultural fertilisers produced on the basis of digestate pulp which is a waste of agricultural biogas plant.

The following methods were used in the research: review of legal acts; critical analysis of scientific literature; interviews based on the prepared scenario; factor analysis; synthesis and induction methods; group discussion.

Results of the research

1. Selected external risks in relation to the organic-mineral fertiliser plant

The analysis of biogas plant activity has been the subject of research of many scientists in Europe and abroad. Nicolae Scarlat, Jean-François Dallemand, Fernando Fahl [7] analyzed the developments and perspectives of biogas production in Europe. Kamil Kozłowski, Maciej Pietrzykowski, Wojciech Czekala, Jacek Dach, Alina Kowalczyk-Juśkoc, Krzysztof Józwiakowski and Michał Brzoskia [8] conducted an analysis of possibilities of use of waste from dairy production to produce electricity and heat in the biogas plant, on the example of one dairies located in Eastern Poland. Markus Lauer, Uwe Leprich and Daniela Thrän [9] made an economic assessment of flexible power generation from biogas plants in Germany's future electricity system. In turn, Carsten Herbes, Verena Halbherr and Lorenz Braun [10] examined the factors influencing prices for heat from biogas plants in this country. Erika Winquist, Pasi Rikkinen, Jarkko Pyysiainen and Vilja Varho [11] described the business

¹ Digestate pulp is liquid and solid residues after the methane fermentation process in a biogas plant.

² The R10 recovery process concerns the use of waste as fertilizing or soil improving substances.

opportunities in the Finnish biogas branch. Karin Ahlberg-Eliasson, Elisabet Nadeau, Lotta Leven and Anna Schnürer [12] investigated the production efficiency of Swedish farm-scale biogas plants. D. Ruiz, G. San Miguel, B. Corona, A. Gaitero, A. Domínguez [13] examined the environmental and economic performance of the power production from biogas (using Life Cycle Assessment, Life Cycle Costing and Cost Benefit Analysis methodologies). Nurzhan K. Bulatov, Dauren K. Sarzhanov, Sagyntay Z. Elubaev, Tynys B. Suleymenov and Oyum T. Balabayev [14] proposed the model of effective system of processing of organic wastes in biogas and environmental fuel production plant. Markus Lauer, Jason K. Hansen, Patrick Lamers and Daniela Thrän [15] examined the economic viability of producing biogas and biomethane, on the example of the Idaho dairy industry. Geesche M. Dobers [16] examined issues related to the public acceptance of biogas plant construction in Germany. Kahsay Haile Zemo, Toke Emil Panduro, Mette Termansen [17] analyzed the impact of biogas plants on rural residential property values and implications for local acceptance.

However, the authors of this article have not encountered studies on comprehensive biogas plant risk analysis. Sources of risk can be both internal and external. However, this division is not entirely precise, because they can intertwine with each other and influence each other in a way that neutralises or intensifies the threat.

Each business entity operates under specific market and non-market conditions, which can generally be called the external environment. Changes taking place in this environment may have a positive or negative impact on it. However, the entrepreneur should be worried by these changes that may threaten business continuity and even lead to bankruptcy.

1.1. Risks related to business partners

Under market conditions, the production company must cooperate with many entities, which may include: suppliers of raw materials, materials, machinery and equipment; companies providing services (e.g. transport); brokers purchasing manufactured goods for resale; end customers. Therefore, as the first group, we will discuss the risks associated with business partners.

Risk of supplying fertiliser components of inadequate quality. Because the composition of the substrates from which biogas is produced in a biogas plant is not fixed (e.g. it changes in relation to the season of the year or due to a different structure and quality of the input), the chemical composition of digestate can change significantly over time. Even if initially (at the beginning of cooperation between the digestate supplier and its recipient) it met the assumed requirements, there is no guarantee that it will always be identical. Therefore, in a situation when the delivered material is grossly different from the required quality of digestate, a problem arises which consists in quickly finding a replacement in another biogas plant, signing a new contract (short or long-term) for delivery, taking into account the possibility of increased transport costs. This risk increases significantly when the fertiliser manufacturer already has its obligations towards the fertiliser recipients, because failure to comply with them on time may generate additional costs related to the payment of penalty for delay. In an extreme case, the plant owner may not only lose the customer, but also his reputation as a reliable business partner. Unfortunately, this type of loss is difficult to estimate.

Risk of non-compliance with deadlines for the delivery of raw materials or their total absence. Similar consequences are associated with the risk of discontinuing or delaying the supply of raw materials. If the raw material inventory in the production plant is not large enough, the lack or delay of new digestate supply will result in downtime in the plant, and thus - lack of production and difficulties in paying employees' salaries and other obligations. As a consequence, the plant owner will not supply fertilisers to his customers (farmers), who in turn will suffer losses due to the inability to fertilise their fields in a timely manner, resulting in lower harvest in the future. Therefore, farmers will claim damages and the fertiliser plant will suffer severe losses as a result of paying penalties for delay, which can lead to the bankruptcy of the plant.

Risk of the presence of eggs of parasites and pathogenic bacteria in a fertiliser Because in biogas plants, in addition to plant-derived residues, also manure, liquid manure and liquid manure are used, it is likely that the parasite eggs contained in them will get into digestate, which will then be used as an ingredient in the produced organic-mineral fertilisers. A similar threat is caused by pathogenic bacteria from the food sector (including animal waste), as well as those that can develop in the anaerobic methane fermentation process in a biogas plant or during storage of digestate pulp. Then there is a high probability that the eggs of parasites and bacteria (with insufficiently high treatment temperature in the fertiliser production process) will get from fertilisers to the soil and then to the plants grown on it. This is a severe risk to the health of consumers, especially when consuming fruits and vegetables that do not undergo subsequent heat treatment but are consumed raw. That is why it is so important to test the raw material (digestate) before using it for the production of fertiliser, as well as test ready fertilisers in terms of their content of organic pollutants.

All the above types of risk can therefore be defined as the risk of incurring losses due to the inability to ensure continuity of the production process. To reduce their impact, digestate suppliers must be diversified, even at the expense of increased transport costs. Diversification of supply sources also applies to other components used in

the production of fertiliser (e.g. ash from biomass combustion, a special type of fungus with beneficial effects on plant growth and yield, etc.).

1.2. Risks related to the macroeconomic and megaeconomic environment

The external environment also includes the country that has specific impact on individual sectors of the national economy. International organisations may also have such an impact. For example, for the member states of the European Union such organisations are the European Commission, the European Parliament and the European Central Bank. Market factors from both the domestic and global markets also have a certain impact. The above-mentioned factors can generally be described as macroeconomic and megaeconomic. We will discuss them in turn.

Price risk. It is known that the price of a product on the market is primarily determined by demand. Without buyers and demand, there would be no sales and hence no production. The higher the demand with constant supply, the higher the price is. However, in addition to demand, there are other factors, that the manufacturer must take into account, that may also affect the price. These include, above all, broadly understood production costs, including the value of materials, energy, labour, taxes paid and interest on loans. In addition, the price is influenced by the general market situation (e.g. focused on greening in food production), the total supply of the product on the market, which in turn is closely related to the risk of competition. If a new (in this case ecological) product is being introduced to the market, its price may be higher than its artificial substitutes. Therefore, there will be a problem consisting in how to convince potential customers to change their preferences, i.e. persuade them to use a different fertiliser than the one used so far, which is at the same time more expensive. An active advertising campaign will be useful here, which should reach a wide target group, and this involves additional costs, especially in the initial period when the product enters the market. In other words, one should focus on marketing activities while developing their own brand. Other non-price factors of demand are: economic policy implemented in the home country and in the countries of business partners, geopolitical situation, prices on the world market, climate change and its consequences for agriculture around the world.

Risk of price increase for the components of the fertiliser produced. One of the types of price risk is the risk of price increase by suppliers of raw materials (digestate and other fertiliser components). First of all, it may result from increased demand for them, if, following the innovator (who used them for the first time), other similar production plants (followers) will be created. Second of all, supply reduction may contribute to this (e.g. the supplier has limited or suspended its activities for some reason). Then, there is a need to look for a new supplier that can be located so far that the cost of delivery may exceed the price of the finished product. Third of all, the reason may be the increased demand for raw materials as a result of a new alternative use - e.g. production of pellets for heating purposes, etc. **Risk of increasing motor fuel prices.** Since road transport (trucks) is required to both import raw materials (including digestate) and deliver the finished product (fertilizer) to customers, the impact of fuel costs (diesel oil, gasoline, gas) on production costs, and consequently on the price of the finished product needs to be taken into account. In turn, fuel costs depend on how oil and gas prices change around the world. These prices are usually expressed in US dollars. Therefore, currency risk should also be taken into account in this case. Analysis of the literature on the subject showed that the most important factors affecting the prices of energy raw materials (including crude oil and natural gas) are: global demand, global supply, business cycle phases and the level of investment in a given industry. The risk of political change as well as conflicts and wars around the world are also equally important.

Cyclical risk is associated with the cyclical nature of economic development in all countries. The theory of economics indicates that the most vividly expressed are medium cycles (Juglar cycles), repeating on average every 8-10 years. Unfortunately, in the era of globalization of the world economy, few countries (mainly the ones "closed" to international cooperation) can avoid the impending crisis that covers many countries at once. It is even said that there is an "import" of crisis. Therefore, the question arises as to how the crisis can affect a particular enterprise. When economic circumstances are advantageous, there are many business entities and many new ones appear. This gives a "guarantee" of constant demand and stability of business partners. However, during periods of weak market, companies go bankrupt and people lose their jobs and income. As a consequence, our example plant will experience a drop in demand for fertilisers as well as shortages in raw material supplies and other disruptions in its operations. Unfortunately, all this together can lead to the collapse of the entire company. Therefore, when planning investments, it is necessary to take into account the phase of the business cycle, and in the current activity to make allowance for making plans, especially for long-term planning.

Competition risk. This type of risk is associated with many external factors, including the number of domestic manufacturers of a similar product, its price and production scale, the number of domestic manufacturers of a substitute product (e.g. fertiliser with a similar effect), the quantity and price of imported fertilisers with the same performance characteristics, the nature of the fertiliser market - free-competitive, monopolistic, oligopolistic, monopolistic competition etc. The last factor is the most important one because it determines the

relations of manufacturers of the same or similar product on the market. Only in conditions of a free-competitive market, the plant has the best chance to survival and develop.

Currency risk. If equipment (technologies) for the production of fertiliser (or other - e.g. for product packaging) are bought abroad, then it is also worth considering currency risk in the risk management system. With an increase in the exchange rate of a foreign currency, e.g. EURO relative to the domestic currency PLN (so-called PLN depreciation), the manufacturer will pay more money for the imported equipment in terms of the national currency, as he will have to buy the European currency at a higher rate. On the other hand, if he makes contact with foreign recipients of his goods (e.g. in the USA), then, as an exporter, he has to take into account the potential risk of a decrease in the foreign currency exchange rate (so-called PLN appreciation), because he will get a smaller amount after exchanging US dollars for the PLN. It should be emphasized that the currency risk is the most dangerous in the periods of economic crises referred to above. However, the currency risk should not be underestimated also in other phases of the business cycle, as small fluctuations in the exchange rate, with large amounts of exchange, can pose a significant threat to the financial stability of the production plant.

Credit risk. In general, credit risk is associated with lending institutions (e.g. banks). It consists in the danger that the borrower will not fulfil his obligation to pay the loan instalments in a timely manner (e.g. he will repay them with some delay or unevenly). In a worse scenario, he will not repay part or all of the loan at all. As for the fertiliser plant, credit risk may arise when it sells finished products for the so-called merchant credit. This type of solution is often used for several reasons. The main of them include:

- establishing cooperation with a larger number of recipients who are not able to pay for the goods immediately (e.g. farmers often lack money for sowing and other field works, especially in the spring and summer, so they can only settle accounts after selling harvested crops);
- retaining regular customers who may experience a temporary shortage of cash;
- willingness to reduce expenses related to the storage of finished products that have not been sold due to the temporary reduction of the financial capacity of fertiliser recipients.

In addition, it is possible to increase one's own accounting liquidity if the production plant accepts drawn bills of exchange in settlements with customers (especially wholesalers). They can be used for further settlements between business entities in subsequent purchase and sale transactions. Another option is realisation of the promissory note by discounting it at a commercial bank, which can withdraw cash before the maturity date in the amount that takes into account the time value of money. However, one should remember that the promissory note should be additionally signed (guaranteed) by three people considered to be solvent and that the deadline for its expiry should not exceed 90 days. Only if such conditions are met, it can be accepted by the bank. Credit risk is associated with the risk of losing accounting liquidity and bankruptcy risk.

Interest rate risk. If an enterprise has financed its investment activities and/or finances current operations with bank loans (long and/or short-term) and bonds (e.g. it issues bonds - long-term debt securities or vouchers or commercial papers - short-term debt securities), it may expose itself to the risk of changes in market interest rates. In the event of an increase in the market interest rate, this is the issuer of the said securities (owner of the plant) that has to repay higher loan instalments, which will adversely affect his economic account. On the other hand, when issuing debt securities with a fixed interest rate, the risk entails a decrease in interest rates, as the issuer will pay interest to bondholders at a higher rate than that set up on the free market, and therefore its opportunity cost will increase, which will not increase the accounting cost, however, it will increase the economic cost. This risk is associated with the risk of losing accounting liquidity and bankruptcy risk.

Discussion with the other scientists and papers

Each type of risk carries some threats to the business entity's operations. Therefore, it is important to include all possible risks in the risk management strategy, which should be understood as diversified risk (i.e. consisting of many types of risk and having many causes and manifestations). In addition, as has already been mentioned, different types of risk are often interrelated, and they can be compound or can mitigate each other. Table 2 shows the consequences of occurrence of individual types of risk and the types of risk they may increase.

Table 2. Types of risks, their consequences and links

Type of risk	Risks and links with other types of risks
<i>Types of risks related to business partners</i>	
Risk of supplying fertiliser components of inadequate quality	Risk related to the inability to produce fertilisers with predetermined characteristics. Legal (regulatory) risk. Risk of incurring penalties for not providing fertiliser to customers that may negatively impact the company's financial result. Risk of losing accounting liquidity. Risk of losing a client. Risk of losing good reputation. Bankruptcy risk.
Risk of non-compliance with deadlines for the	Risk connected with incurring penalties for not providing fertiliser to customers (e.g. compensation to farmers for losses suffered), that may negatively impact the company's financial result. Risk of losing accounting liquidity. Risk of losing a client. Risk of losing good reputation. Bankruptcy risk.

delivery of raw materials or their total absence.	
Risk of the presence of eggs of parasites and pathogenic bacteria in fertiliser	Risks to consumers' health and compensation payments for them (possible court costs) that can ruin the company. Risk of losing accounting liquidity. Risk of losing a client. Risk of losing good reputation. Bankruptcy risk.
<i>Risks related to the macroeconomic and megaeconomic factors</i>	
Price risk (relative to the price of the finished product - fertiliser)	A sharp drop in demand for the fertiliser produced causes a drop in its price (due to the market mechanism). In turn, the increase in demand for digestate from which the fertiliser is made (e.g. for the production of other goods, for example pellets for heating purposes) increases the costs of fertiliser production and increase its price. The increase in fertiliser production costs may also be caused by the increase in prices of: raw materials and materials, energy and labour, taxes and interest on loans, ecological fees. However, the increase in costs cannot always be passed on entirely to the customer (i.e. the price of the product), as the product may become uncompetitive and clients will not want to buy it. As a consequence - the lack of revenues and collapse of the company. Competition risk. Risk of losing accounting liquidity risk of bankruptcy.
Risk of increasing motor fuel prices	One of the components of the price of many products is the price of fuels. In the case of organic-mineral fertiliser plants, fuels are used to drive vehicles that supply raw materials for production and deliver finished products to brokers and sometimes also to customers. If we consider gasoline and diesel, their prices depend on world prices for the crude oil from which they are made. In turn, the price of this raw material is influenced by many other types of risk (mainly of global significance), for example: the risk of political changes; wars and conflicts; currency risk; phase of the business cycle.
Cyclical risk	The threat due to this type of risk is related to the general condition of development of the national economy, i.e. whether economic conditions are good or bad. When economic conditions are good, enterprises grow, they need more and more raw materials, materials and products. Then both demand and supply are stable. On the other hand, in times of economic downturn - companies go bankrupt, customer demand on most goods and services drops (due to reduced income and the impact of economic instability, and thus changes in the structure and size of consumption), which further increases bankruptcy processes among business entities with various business profiles.
Competition risk	A sharp increase in the supply of a similar fertiliser or substitution product may result in a decrease in demand for the fertiliser produced and/or a reduction in its price. One should also be afraid of domination on the market of one producer of similar fertiliser (monopolist) or an organized group (oligopolists). This risk may increase during the economic downturn, when the demand for most goods and services naturally drops.
Currency risk	Threats related to exchange rate fluctuations on the domestic and global market. These fluctuations may be a consequence of the impact of both national (e.g. balance of payments difficulties, economic and political instability) and global (economic crises, political tensions, wars and conflicts) factors. Entities conducting international exchange, including exports and imports, are most affected by this consequence. Exporters suffer losses in the event of appreciation of the national currency, while importers should be concerned about the depreciation of this currency in relation to foreign currencies, mainly the one that occurs in their business operations. Failure to take into account this type of risk may cause accounting liquidity problems or even lead to the collapse of the company.
Credit risk	In the case of selling fertilisers on merchant credit, there may be a risk that the customer will not pay it back on time or at all. Risk of losing accounting liquidity. Bankruptcy risk.
Interest rate risk	In a situation where an economic entity finances its activities with the participation of foreign capital (e.g. bank credit), it may be exposed to this type of risk. The threat increases with the extension of the maturity of the loan, especially with the use of a variable interest rate (and this is most often the case with long-term investment loans). This threat is associated with an increase in interest rates based on market interest rates, which usually go up in times of crisis and economic instability caused by different reasons. Then the loan instalments increase, and, as a consequence, there may be a problem with maintaining accounting liquidity and reducing the rate of return on investment. Bankruptcy risk.

Source: own elaboration

Uncertainty and impact of research results on science, economy, environment and society

Each type of human activity involves making decisions in conditions of uncertainty and risk. To sum up, the biggest reason for risk is volatility, which can bring both positive and negative effects. However, researchers and practitioners focus on the negative effects of risk, as they can lead to smaller or larger distortions in the stability of the economic entity or even to its bankruptcy. Hence, the attempts are made to identify potential threats (sources of risk) and forecast the consequences of their implementation. Risk identification is the first stage of the risk management process, which sets the foundation for further actions and determines their effectiveness. These activities may be geared to reducing or eliminating risk, depending on the probability of a threat occurring and the size exposed to risk (usually estimated in monetary units). However, the risk of economic activity is not only material losses, but also a threat to human health and life and a source of nuisance to the local community. And the consequence of this state of affairs may be the lack of social acceptance for a given economic activity. Also state organs and institutions may impose penalties in the event of environmental pollution.

Summary and conclusions

Generating energy from renewable sources is currently a priority in the economic policy of most countries, especially highly developed countries, which have the financial means to develop this part of energy, despite its lack of profitability. Hence, the attitude of the government of each country, which supports the idea of renewable energy sources, plays a huge role.

The second important task of current governments is to combat the growing amount of waste generated, mainly by high-standard societies. This waste harms not only the environment, but also people themselves through a negative impact on their health and comfort of life.

The "Biogas Plant - Digestate Fertilizer Plant" tandem at least partially solves both problems of modern societies. However, it is important that the activities of both participants of this tandem are stable and profitable. Business risk management, which starts from the stage of identifying risk factors, plays a significant role in providing them with appropriate operating conditions. Awareness of risk and taking appropriate actions to protect the company against its impact is a necessary condition for survival on the market, which is the main goal of every business entity (especially during periods of economic downturn when risk factors become active).

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