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Implementation of biogas systems into existing infrastructure and their management

Master's Thesis by the 2nd year student
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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

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INTRODUCTION

Background

In recent years, development of sustainable energy resources has shown a rapid growth comparing to the past years. It is expected that the cumulative volume of energy supplied by new sustainable energy resources will increase its share on the global market, finally overtaking traditional energy resources in the long run. The main drivers of this growth are recent technological achievements and political will.

Energy has always been one of the key topics in future development, so it is largely dependent on the government policies. High-level decisions on energy have a huge impact on the future generations and the life of mankind, so the way it will be implemented in foreseeable future will sound in decades after that.

Various shifts occurred among different industries. The energy markets are not exception. The fast improvement of technology and its accessibility from one side, and the warning state of nature from the other shaped a huge interest in sustainable energy in past years. The current energy system, based upon non-renewable resources, might bring a lot of harm and potential danger - not only from ecological point of view, but also from economical and social side. The development of sustainable energy resources indicated a huge progress and has become important not only for ecologists, but also for huge businesses and institutions.

The topic of sustainable energy is relatively new, and theory is not synchronised with practice. This field has been rapidly developing lately, so the theory is often outdated with real-world practice. Nevertheless, it is an extremely important matter in terms of future developments taking into account the current growth rate. However, there is still no clear understanding and vision of how they should be implemented. This fact is highly important in current research and the main aim is to produce a scientific base of possible ways to implement the new energy resources into existing network, factors influencing that process and limitations it may face.

Scientifically, it is a question of time when the technologies will reach the needed level of development in order to be sustainable for the everyday use. In some fields some solutions became a part of everyday life and even replaced the traditional types of resources. However, the humanity still did not create a clear vision of how the new world will look like and, more importantly, how exactly this transition should be carried.

In this work, the current state of sustainable energy development will be analyzed and basing upon it, the possible solutions for the businesses and the society will be brought up. The biogas energy can be used almost everywhere where the humans are present which makes it a far more convincible source of energy for places, with extreme climates like most of Africa or the

North Pole. It is obvious that in such cases extra efforts to built a biogas plant are needed, but nevertheless in comparison, other sustainable energy resources have no place to operate.

From the economical perspective, biogas technologies look favorable as well, due to it utilitarian role not only as a source of energy, but also as a part of recycling processes. The farmers are usually paying for the recycling process of waste, which serves a biogas plant as a raw material. Potentially, the gathering of raw materials can become a new revenue stream for biogas operators. However, this process is complicated by the recycling rules and regulations. Also, apart from the gas itself, moisture and heat are natural outputs of biogas plants. They are also in high demand, especially in the countryside. If the management is efficient, the biogas plant could have up to four mentioned revenues streams, which is a sufficient advantage comparing to other sustainable technologies, taking the market economy into the account.

Research problem

For the understanding of the current state of the research problem the literature review is to be conducted to evaluate the current state of development of sustainable energy management and biogas in particular. The thesis offers extract of knowledge on the factors that influence the process of implementation of biogas systems.

In our work, we decided to concentrate on the biogas energy, which is closely correlated with development of the sustainable energy overall. The biogas energy has numerous advantages comparing to the rest of widely used sustainable energy resources like solar and marine energy. The main advantages are the availability and easy access to raw materials as a natural product of human activities, rapid technological progress that is aimed towards creating a cyclical system by generating energy out of waste and, from the economical point of view, the production of such energy lead to the side-production of products, such as heat and manure, both widely utilized by the civilization.

The literature review indicates the significant number of literature sources on sustainable energy and the technologies behind it, there is much less on implementation of those energy resources into the existing infrastructure. This topic will eventually become very important in next 10-20 years when the time will be to implement the technologies we are currently developing on the massive scale.

Therefore, we are going to concentrate on investigating factors that affect how the biogas technologies could be implemented into the existing infrastructure in the nearest future.

Purpose of the study

The aim of this paper is to identify the main factors that influence the successful implementation of biogas energy resources. To fill this research gap, we develop a case study of the companies that are doing biogas, via conducting in-depth interviews with experts in energy industry and managers of sustainable-energy companies, and analysis of secondary data obtained from the published scientific researches and papers.

The objectives of this study are

- To provide a literature review on biogas energy and outline the specific aspects of its implementation
- To identify the main strategic factors that influence the implementation of the bioenergy
- To prioritise the importance of identified factors through the interviews with experts
- To develop recommendations for companies operating in this industry

Research question

In order to achieve the objectives, we formulate the following research question:

What are the strategic factors that influence the successful implementation of biogas into the existing energy infrastructure?

To answer the research question the qualitative research to be conducted which will help to fill the research gap. The flexibility and change adaptation are the main advantages of this research type. A case study is an empirical way of conducting research aimed to analyze present-day data with the real life implications. For a qualitative inquiry it is important to gather high number of views and opinions on a topic. In order to obtain data on the ways in which biogas technologies are implemented and what drives their efficiency we have developed a case study that relies upon a wide range of sources of evidence.

The companies chosen for the sample allow to create case studies that would bridge the research gap as they are focused on implementation of biogas energy on low and medium level in Europe.

The data used in the case study is based on primary data from the company representatives. The chosen experts for the interviews have relevant background and are involved in current economic and scientific processes in bioenergy field. Most of the interviewees are working for the companies producing biogas or served as experts for the given companies.

Structure of the study

The structure of this research consists of four parts. The first chapter is the literature review observations of the concept of sustainable energy with focus on biogas energy and main peculiarities. The second chapter presents the methodology of the research and the justification of tools used. The third chapter presents the research findings based on analysis of the case companies; analysis of the interviews and validation of factors. The last chapter includes conclusions of the study, managerial and theoretical implications.

The relevance of this research from the theoretical and practical application is the analysis of feasibility of the implementation of sustainable energy and the decision-making process about ways of implementation in the nearest future. This research provides decision-makers with analysis based on practice, the theoretical contribution for the future researchers for the expansion of the theory.

Chapter 1. THE STATE-OF-THE-ART IN SUSTAINABLE ENERGY AND STRATEGIC MANAGEMENT

This chapter provides overview of literature on sustainable energy as well as its implementation strategy. The academic articles in this chosen research area were analyzed to assess the state-of-the-art of the topic of the implementation of sustainable energy technologies from the managerial perspective. The thematic approach is used in the literature review, beginning from the macro level, analyzing the general information on energy markets, renewable energy and biogas, as well as the up-to-date state of energy infrastructure. In this literature review insights about the implementation of new energy resources is being presented. We are focusing on investigating the operations of the energy companies, as well as the new technologies to identify the strategic factors that influence the successful implementation of the new energy resources into the existing energy infrastructure.

The fields of research that are presented in the review are focused on the following areas that are existing experience of implementing sustainable energy and biogas in particular; why some Sustainable Energy Units (SEUs) fail or succeed; what are the advantages of biogas comparing to other sustainable energy; what are the possible predictions of its implementation; what is the influence of institutional and business activities.

1.1 Sustainable Energy Overview

Sustainable energy is a topic that is overviewed by various sciences and since has been researched across various fields of studies. Most of the research is done through engineering prospective, however research on management implications is also present. Sustainable energy as a topic is important for scientists since energy markets are one of the core aspects of global sustainability agenda (Nelson, Rueda & Vermeulen, 2018) as energy is used in almost any business activities. The potential shift in energy sources will cause changes of tendencies, behavior and trends on a global scale. For these particular reasons it is a very important and complicated process, which should be overview in a long-term.

The concept of sustainable energy was brought up by the scientists in 1970s, as by this time the trend of massive pollution was observed due to rapidly increasing consumption and it was clear that the current (or traditional) energy resources storage will come to an end with never-ending increase in needs of the humanity as well (Aguero, Takayesu, Novosel & Masiello, 2017).

Sustainable renewable energy sources are energy resources of constantly existing natural processes on the planet, as well as energy resources of products, vital activity of biocenters of

plant and animal origin (Mardani, Jusoh, Zavadskas, Cavallaro, & Khalifah, 2015). A characteristic feature of renewable energy is the cyclic nature of their renewal, which allows the use of these resources without time constraints.

Typically, renewable energy sources include the energy of solar radiation, water, wind, biomass, thermal energy of the upper layers of the earth's crust and the ocean. Sustainable energy can be classified according to the types of energy (Mardani, A, Jusoh, A, Zavadskas, E, Cavallaro, F, & Khalifah, Z, 2015):

- mechanical energy (wind energy and water flows);
- thermal and radiant energy (energy of solar radiation and heat of the Earth);
- chemical energy (energy contained in biomass).

The potential of renewable energy is practically unlimited, but the imperfection of technology is the lack of the necessary structural and other materials do not yet allow to widely involve renewable energy in the energy balance (Markovska, Duić, Mathiesen, Guzović, Piacentino, Schlör & Lund, 2016). However, in recent years, scientific and technical progress has been especially noticeable in the world in the construction of plants for the use of renewable energy sources and, first of all, photoelectric transformations of solar energy, wind power units and biomass.

The feasibility and scale of the use of renewable energy sources are determined primarily by their economic efficiency and competitiveness with traditional energy technologies. There are several reasons for this (Norrström, 2013):

- Inexhaustibility;
- There is no need for transportation;
- Environmental benefits;
- Lack of fuel costs;
- Under certain conditions, in small autonomous power systems, renewable energy sources may prove to be economically more profitable than traditional resources;
- There is no need to use water in production.

Also, the benefits of switching to "green" energy include eliminating the risks associated with nuclear energy (the possibility of accidents, the problem of radioactive waste disposal), reducing the consequences of a possible energy crisis, reducing costs for non-renewable resources, primarily oil and gas, and reducing emissions greenhouse gases. Thus, the need to use renewable energy sources is determined by such factors (Machrafi, 2012):

- exhaustion in the near future of explored reserves of organic fuel;
- pollution of the environment with nitrogen and sulfur oxides, carbon dioxide, pulverized residues from combustion of produced fuel, radioactive contamination and thermal

overheating when using nuclear fuel;

- a rapid increase in the demand for electrical energy, the consumption of which may increase several times in the coming years.

Some of the researchers investigate and project potential outcomes of implementing sustainable energy units across countries and nations. For example, "Sub-national TIMES model for analyzing future regional use of biomass and biofuels in Sweden and France" (Forsell, Guerassimoff, Athanassiadis, Thivolle-Casat, Lorne, Millet & Assoumou, 2013) is a deep study of the future of biomass stations in two European countries. The authors found out that if those types of energy resources will be implemented in nearest future, it could significantly lower the dependence of those countries on buying foreign energy which in turn benefits economy and well-being of the country. There is however some limitations, that authors underline, mostly connected to the ability of such farms to gather raw materials. It is not clear if mostly farmers and forest owners would agree on selling their biomass to the energy companies and what should influence their willingness – market instruments or institutional interventions.

1.2 Biogas Overview

One of the most promising types of renewable energy raw materials is biogas. The biogas is produced from the biomass – an organic substance that is usually waste or residual of human activity. Recently, attention to the effective energy use of biomass has significantly increased, and new arguments have appeared in favor of it comparing to other sustainable energy resources (Shi, 2013). The biomass is continuously restored which does not lead to an increase in the concentration of CO2 in the atmosphere. Use of waste (agricultural, industrial and domestic) is extremely efficient to reduce the pollution on one hand and recycle waste materials on the other. Moreover in the industrialized countries in recent years there have been surpluses of cultivated land, which is advisable to use for biomass energy units. Overall, the potential of biomass, suitable for energy use is larger than other sustainable energy resources as the biomass is a natural residual of any human activity.

However, its resource is involved in a very small extent nowadays. Among the different types of biofuel in recent years, biomass has enjoyed a great deal of attention. Perhaps multifunctional use of this product - as a fuel, sorbent, raw material for the production of crystalline silicon and a material that increases soil fertility. Wood has always been a traditional resource - nowadays it takes 10% of global energy consumption (Durocher & Powell, 2013). This could be seen as a positive fact, however the technology that is usually used behind the wood energy is outdated and causes pollution.

What can be used as an energy source?

1. Wood. For many thousands of years, people have been using firewood for cooking, cooking, lighting. Yes, and still in small settlements traditionally this type of energy is used. Unfortunately, this all leads to one of the most important problems of the world - deforestation. However, using the energy of fast-growing trees, such as poplar, willow, etc, solves this problem.

2. Sludge of sewage. Huge amounts of energy are hidden in the waters used by men. When the liquid settles, a huge amount of solid is formed, which during processing by anaerobic bacteria can contain about 50% of organic matter. However, there are significant difficulties in sewage treatment. The main of them is the drying of these waters, because it consumes a lot of heat, which in its quantitative characteristics can exceed the theoretical value of energy with complete combustion of the suspended matter. Also this process could not be related as positive from the point of view of ecology. After combustion, a large amount of carbon dioxide is released. The most correct option in this case is the production of methane by means of anaerobic bacteria. But the settings for this are very imperfect, so this method does not get big in modern times.

3. Livestock wastes. Animal excrement contains a high amount of organic matter that can be used to generate energy. However, just as in the case of sewage, the manure contains a large amount of moisture, so its drying is not beneficial. Then there is another option - this is anaerobic digestion. With it, methane is obtained, and the remaining substances can go to fertilizers for soils. But it is worth remembering that the amount of processed substance is much larger in the more recent manure, therefore, in order for its processing to be economically viable, special constructions are needed that allow collecting all the excrement in one place without losing its freshness.

4. Vegetable residues. After harvesting, unused parts of plants always remain. They represent another source of energy. They contain cellulose - a carbon-containing carbohydrate. Due to the relatively small amount of moisture in the remains, during combustion they release a lot of energy. The limiting factor in the development of this energy source is the seasonality of the growth of crops. To ensure the year-round use of plant remains, special structures are needed for their growth. Also important factors are the need for transportation to the processing site and ease of harvesting.

5. Food waste. They can also serve as a source of energy. Especially considering that, for example, fruit waste contains more carbon containing sugars than in cereal residues, and in residues of meat products a considerable amount of protein. But the presence of moisture makes it difficult to obtain energy by burning waste. Therefore, it is more expedient of them to get

methane with the help of bacteria. But here there is another difficulty: food waste is successfully used in livestock. Therefore this source practically does not develop in our time. The only exception is waste in the form of seeds and husks, as well as residues from sugar cane. For example, in countries where a lot of cane grows, its waste goes to the production of ethanol, which, when burned, releases a lot of energy.

Researchers see the future of biomass in replacing oil, as the source of many chemicals used in the modern world. The objects made of plastic, paints and glues can be produced not from petroleum products, but from biomass. For instance, in current conditions the biomass technology is one of the most sufficient and realistic to implement (Nunes, 2016). This fact is explained by almost full availability of the raw materials in any place of the world in contrast with wind and solar systems. Other sustainable energy sources like wind or solar energy are also studied in numerous scientific papers (Bakirci, 2018, Xiaojing, Diangui, & Guoqing, 2012). In these articles the technologies behind the energy types are explained in full.

Summarizing, we can say that bioenergy is one of the most promising sustainable energy technologies at the moment and there is a huge potential behind it. One of the main factors of inhibition is not the availability of state support for the development of this industry. Not everywhere the government encourages the initiative in favor of bioenergy. Therefore, there is a need to find ways to expand the industry at the state level.

1.3 Factors of bioenergy implementation: macroview

A number of papers (Omer, 2014, Ferrarini, Serra, Almagr, Trevisan & Amaducci, 2017) are focused on topics that complete the broad picture of bioenergy implementation. The topics differ by their nature as the implementation of bioenergy consists of numerous aspects in itself. The main focus of this thesis is the managerial implementation of bioenergy and its development. Therefore, the research was focused mainly on topics such as differentiation of the bioenergy implementation in countries with different levels of economic developments and cost comparison with other energy sources.

Some papers were devoted to economic impact of sustainable energy implementations to the economies of the countries. Beach, Boyd, Uri (1996) provided one of the pioneer works on implementation of sustainable energy, with focus on the United States, where they underlined the main outcomes of the potential shift to the new energy resources. The authors emphasize that government interventions are of extreme importance at least at the initial stages. The benefits of one invested dollar (mainly as a subsidy) into biomass energy creation lead to a profit of hundreds of dollars in the future. However due to the capital expenditures in such a business

being high, their study is limited to developed countries. On the other hand, Shane, Gheewala, Fungtammasan, Silalertruksa, Bonnet, Phiri (2013) present in-depth study of possible implementations of biomass fuel in Zambia. The authors investigated the whole country to find how the biomass technologies can be implemented in this particular developing country. This paper can serve as a basis for branch of analysis focused on developing countries. The reality of sustainable energy in Pakistan is also assessed (Shami, Ahmad, Zafar, Haris and Bashir, 2013). The key outcomes suggested in the paper are possible ways on how to implement this system across the whole country, basing on experience of rural areas. The authors suggest bottom-up approach. Overall, the projected results for both developing and developed countries are positive, however but the main challenges in developing countries as Zambia and Pakistan is still financing such types of bioenergy campaigns.

McIlveen-Wright, Huang, Rezvani, Redpath, Anderson, Dave, Hewitt (2013) examine the practices of sustainable energy implementation in the United Kingdom. The major finding of this work is that after the implementation phase the biomass stations can produce electricity almost at no cost. The plants were studied from the business prospective and proved that biomass stations could generate the same level of electricity as more traditional coal stations. The value of costs of the renewable energy comparing to the traditional ones is specifically important in developing countries as there is usually no financial surplus to invest in potential technologies, but the economic benefits are more of the immediate necessity (Brini, Amara, Jemmali, 2017).

Based on the research, three groups of factors of bioenergy implementation should be emphasized:

(i) Availability of the resources and supply;
(ii) Level of infrastructure development;
(iii) Costs and other financial factors.

In general, a sustainable system should meet the growing electricity demand with less gas emission, reliance on traditional sources, like gas, and lower costs. We will investigate these factors in more detail in the following sections.

1.4 Availability of resources and supply

Many authors emphasize various aspects that link energy itself to economics. Most of the papers are concentrated on the availability of the resources as the core factor to the success of the renewable energy. For renewable energy units such as solar and wind plants, the energy is generated at the location of the plant, for biogas however the raw material (biowaste, crops, sewage) is usually brought externally or, in some rare cases, the biogas plant is located at the

place of gathering of the material for the energy production.

The raw materials for bioenergy are usually residuals of human activities the SEU's should be built not far from the inhabited areas to decrease the costs. Boqiang and Omoju (2017) underline the fact that the transition to renewable energy should be first implemented in the areas where the sources of energy is available in full as it is much easier and convenient. As a side process this would result in scientific progress and more expertise, which would make the process in the areas where there is a shortage of energy much easier. Ali (2017) points out that the energy transition to the sustainable resources is impossible in the areas where such resources are unavailable (e.g. wind, sun, biomass, etc.). The authors bring up an example of the very northern territories of Canada, where none of the renewable energy sources is available. Fortunately, most of the territories have the access to at least one of the renewable sources, but for those that don't the traditional resources shall be used further or in long-term the energy taken from the renewable sources could be stored and transported to given territories.

The raw material for sustainable energy production varies on its type, some of them require a special infrastructure. In scientific paper Kosinkova, Doshi, Maire, Ristovski, Brown, Rainey (2015) study biomass availability in Australia. The study states that even though the main input is biomass itself, water supply is also needed. In some rural areas the availability of water is limited due to natural causes, which brings up a field for scientific research if the current usage of water by SEU could be reduced. Chinnici, D'Amico, Rizzo and Pecorino (2015) focuses on the same problems in Sicily, the region where the climate is dry and water is in shortage. The authors also emphasize the role of matrix-mix input (a mix of biomass and external materials). The paper also states that the current scientific areas of research in sustainable energy are comparably low, so more scientific research is needed.

Finally, the biogas plant produces energy that is also needed to be utilized in full in order for biogas plant to be efficient. The transportation for longer distance requires extra financial inputs usually comparable with the cost of production of the energy. Therefore, if the destination of the final consumer of energy is located far from the station, the biogas will not be operating efficiently. Moreover, the biogas plant produces a high quality digestate and heat, which could also serve as a source of income. From the logistics side the availability of full output utilization within 50-70 km maximum is essential to success of any biogas plant.

In general, availability of resources is the general factor for any energy producer. One of the advantages of bioenergy is the fact that the general resource used for energy generation is usually a natural residual of human domestic and economic activity.

According to the analysis we can highlight second tier factors that influence the availability of resources for the bioenergy plant:

a. The types of residuals of human activities
b. Level of economic activity in the region
c. The supply channels

The combination of these factors altogether gives an optimistic forecast for the implementation of the plant from the side of raw material supply. The lack of some factors may lead to difficulties, the scale of which should be studied prior to implementation, the lack of all factors make the implementation of biogas plant almost impossible in the given region.

1.5 Level of infrastructure development

The topic of infrastructure is also very important in relation to the implementation of the renewable energy and biogas in particular. The main reason for it is importance is the implementation process, to be more specific – what resources and capabilities it would take to make the shift from the traditional energy sources. This could be divided into separate factors and many scientific papers are observing this shift.

One of the core benchmarks that could give a sign of the successful implementation of sustainable energy is overall economic development Lameira, Alcântara, Chiappori & Pereira 2016). This paper studies various cases by country and the implementation of sustainable energy and authors come to a conclusion, that the implementation process is highly complex in developing countries mostly due to the lack of infrastructure. Moreover, the article cites that apart from infrastructure itself there are another complications such as corruption, low regulatory basis and uneducated personnel. All of those have high impact on the development process and put it in a high-risk situation.

In contrast, the developed countries show diverse results. Many of them have already implemented sustainable energy units and this energy already takes over the traditional sources. Moreover, the cases of developed countries are much more researched. Kitzing, Mitchell and Morthorst (2012) study the differences in renewable energy in countries within EU. This research proves that the more developed countries such as Germany, Netherlands, Denmark or Sweden have more capabilities to implementing energy than Romania, as the authors cite, due to developed infrastructure. The main reason behind such results is lower side investments. For example, when building a sustainable energy unit there is no need to build new energy lines towards it and the condition of those lines is much better. All of those require lower side-investment in a sustainable energy plant (Schenk & Stokes, 2013).

There are also side factors that correlate with the level of development of the country. The technology behind the bioenergy are very complex, therefore it requires highly educated employees, such as scientists, engineers and biologists. The overall human development of the chosen country is also an important factor. As for developing countries the problem of educated personnel is one of the core barriers to introduce a biogas technologies (Hernández, Lapuerta, Monedero, & Pazo, 2018). For successful implementation and service for the biogas station, the personnel working on a station should have a high-level engineering education.

In conclusion, we can highlight several second tier factors related to level of (infrastructure) development:

a. Level of development of the country
b. Pipes (other infrastructure) conditions
c. Human development

1.6 Costs and other financial factors

The matter of costs is usually referred as the reason behind the shift to renewable energy. In future years all non-renewable energy sources will come to an end, which will shift the prices for them higher and higher decade-by-decade. For instance, the price of barrel of crude oil might cost about 500$ in 30-50 years (To and Grafton 2015), which will make its use almost fully unreasonable in terms of economics. In this instance, the simultaneous development of renewable energy will make the prices for them lower in potential and so the shift would be much more economically reasonable.

One of the interesting examples of such processes is happening Germany. German researchers Lutz, Fischer, Newig, & Lang (2017) point out that the transition to the renewable energy in Germany (and many EU countries in general) is enlightened by already developed infrastructure network the government (or EU) subsidiaries. As a main problem the authors cite the balance between energy development and the economic reason behind it, in other words the government should have the efficiency of the financial resources spent as their main criteria of investments. Moreover, the whole power market competition is being affected by renewable technology development as the number of opportunity costs for given project rises in general (Al-Gwaiz, Chao & Wu, 2017).

The competition between the traditional and sustainable energy shall be linked to the economic benefits of the counterparties (Acemoglu, Kakhbod & Ozdaglar, 2017), as cost of production is the main factor of the competition. This study proves that the renewable energy

costs are getting cheaper on a year-to-year basis comparing to more-or-less flat prices on traditional sources. Leveled cost estimates for new generation projects in the UK are listed in the Table 1:

Power generating technology	**Price (£/MWh)**
Coal	**134**
Wind (Offshore)	**102**
Nuclear	**93**
Biomass	**87**
Solar	**80**
Natural Gas	**66**
Wind (Onshore)	**62**

(Department for Business, Energy & Industrial strategy of the United Kingdom, 2016)

Table 1. Estimated costs for new generation projects

As it is shown in the table the biomass energy costs are on the same level of prices as other sustainable resources, however its more expensive than a traditional resource, used for electricity generation – gas. Therefore, the importance of financial subsidiaries should also be also brought up, however the current trend shows that in medium-term there will be no need to financially support the renewable energy implementations (Vskovic, Gvero, Kalabic, Medakovic & Husika, 2017).

Thus, we can highlight the following as the second tier factors:

a. Comparison of costs of traditional energy (e.g. gas)
b. Costs of raw materials
c. Financial support from the government

1.7 Strategy implementation in energy

The sense of the strategy is to adapt the business to the environment, so strategy shall be viewed as a process, which consists of several stages (Roskos, Moe & Rosemary, 2017):

1. Strategic analysis – gathering of relevant information;

2. Strategic choice - study of the results of strategic analysis, compilation of alternative options, their evaluation according to a number of criteria;

3. Strategy implementation

The recent acceleration of market development has an impact on the companies' management, as they need to adapt to the constantly changing market. Increasing the efficiency of internal resource use in the majority of cases is not enough and, in this connection, the market conditions dictate the change in overall strategy to keep a company successful.

There are no specific guidelines for the organization of the implementation of the strategy (Pramudita, Christoper Dewangga, 2016). Different enterprises differ significantly due to the infinite variety of their internal environment, and due to the variety of strategic situations in the external environment. Dynamic conditions of competition in energy market and different experience, unstable environment and alternative ways of company development comparing to traditional ones, unique organizational culture and own policy, different motivation systems - all this predetermines an individual approach to strategy implementation (Hsiu-Fen, 2011).

At the same time, the accumulated experience and analysis of information on this problem allow us to conclude that it is possible to identify some of the basic steps that most firms need to take when implementing the strategy. Several stages can be highlighted:

1. Definition of the strategy
2. Development of the action plans
3. Implementation of changes
4. Monitoring and control.

When designing a strategy for an energy company, there is a distinction between existing and a newly created company. For existing energy companies, the design process is carried out with the improvement of the management system. For newly created power companies the design process is carried out when the management system is settled. Changing strategy, i.e. its design, aimed at increasing the efficiency of any company.

Prior to setting the energy production, the company should carefully assess the factors such as availability of resources, existing infrastructure and costs. At present, one of the ways to predict the evolution of business models of energy companies is related to the changes in the external environment. For example, the global study of IBM Global Business Services, involving 1,900 consumers and 100 energy companies, revealed radical changes in the relationship between professionals working for energy companies and their customers, driven by rising energy prices, technological innovation and tougher environmental policies. (Valocchi, 2009).

Automation, modern systems of commercial accounting and new energy generation technologies create sufficient conditions for active involvement of energy consumers in industrial production chains. Gradually, customers have a desire to choose their own way to meet their energy needs (Klein & Noblet, 2017).

In developed countries, approximately 84% of consumers would like to change their energy supplier. In addition, in the developed countries, 60% of the energy consumers, ready to build and operate their own small power plants, are provided with free access to electric grids and a potential reduction of energy costs by 50% (Mydock, Pervan, Almubarak, Johnson & Kortt, 2018).

Energy innovators are the most active in developed countries, such as Japan or Germany, which is due to relatively high energy prices and sufficient financial resources from customers against the backdrop of monopolistic behavior of the largest energy companies and active state support for initiatives to develop renewable energy sources (Franke, Jörg, and Kreitlein, 2017) They can ensure the launch of an innovative process in the field of energy business models, and the speed of change will depend on the evolution of technology and increased control by consumers. During the transition period, three models of behavior of energy companies can be distinguished, which will be formed under the influence of two factors: the degree of control from customers and the speed of introduction of new technologies (Klein & Noblet, 2017).

1. Passive resistance to change, i.e. traditional power companies dominate, and consumers prefer historically established relationships with energy suppliers.

2. Transformation of energy companies, i.e. active introduction of new technologies by energy companies. Against the backdrop of the inability of customers to improve their control over energy, such a model will lead to the fact that all benefits will go to power engineers.

3. Transformation of consumers, i.e. the strengthening of control over processes by the simultaneous increase in the requirements of consumers.

Technological development can be adversely affected by a lack of financial resources and weak standardization (Kwasnicki & Kwasnicka, 1996), which pushes the integration of various elements of energy systems. Especially strongly, these factors will affect the process of penetration of sustainable companies into the markets. In addition, the shortcomings of the system of state regulation, for example, lack of access rights for small-scale energy, will negatively affect the involvement of consumers in solving energy problems.

The presence of barriers for new competitors and consumers creates a situation of "privileged" access to that part of the client base that is sensitive to the emergence of new products and services for the traditional energy companies (Bashkin, Galiulin & Galiulina, 2013). Power companies will have to track a competition and product innovations that appear on the market. In the event that the energy company cannot keep with the competition by just copying new technologies, it will be necessary to revise the business model of the power company in accordance with its new position in the market. Ultimately, by developing brands and satisfying the new needs of customers within the existing regulatory regime, energy companies can position themselves as a supplier that offers the choice and offers a wide range of new products and services to paying consumers (Dongnyok, Shim, Kim Seung Wan & Altmann, 2018).

1.8 Summary

Analyzing the set of studies in this particular literature review, we can split them in three large groups: 'broad' – that deal with overview of sustainable energy resources in general; 'Bioenergy specific' that concentrate on bioenergy and address country, region or climate differences and try to connect them to performance and technology differences; 'managerial' – the studies that investigate the role of institutional environment in developing of sustainable energy infrastructure.

The articles analyzed bring a full understanding of the gaps in the current research that could be fulfilled by this particular thesis – the factors driving successful biogas implementation. Bioenergy have a lot of barriers for successful implementing; most of scientific papers highlight the following factors from the macroview:

(i) Availability of the resources and supply;

(ii) Level of infrastructure development;

(iii) Costs and other financial factors.

However, given factors do not give a specific view on how bioenergy should be implemented since there is no clear framework that divides the given factors into more specific

ones (Figure 1)

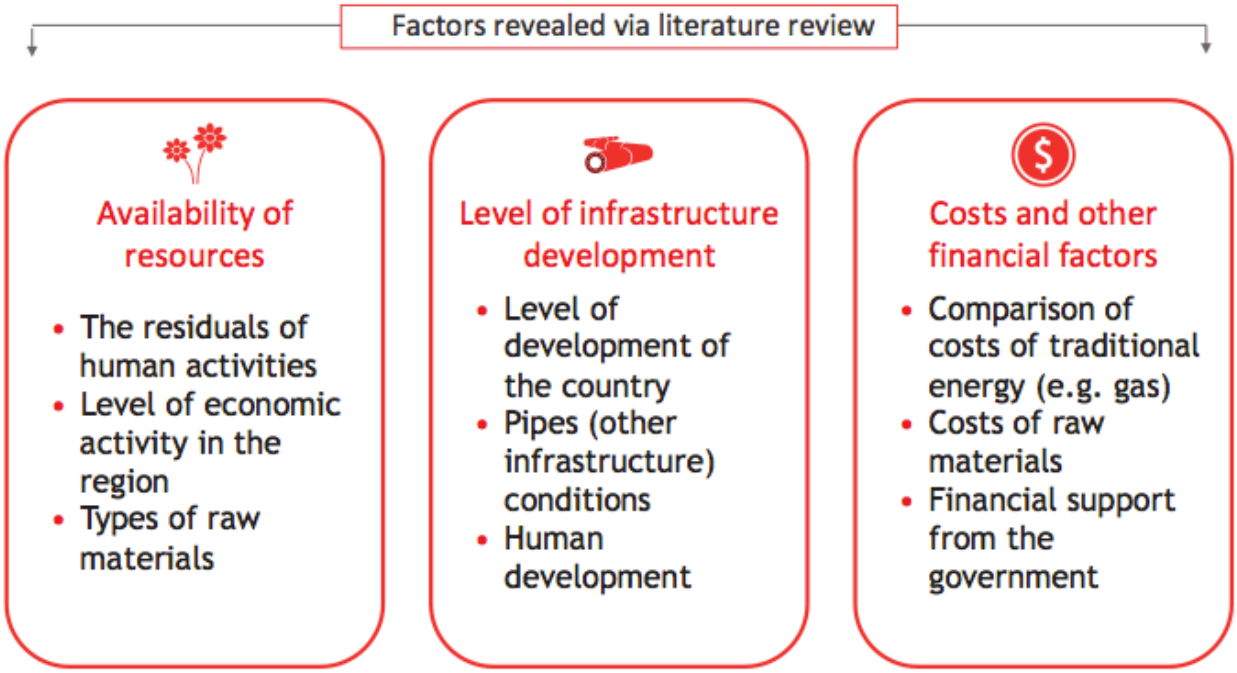

Figure 1. Factors revealed via literature review.

Better understanding of those factors would potentially lead to better grasp of how exactly the future behind the bioenergy should look like. It is important to study and invent the propositions before sustainable energy become in great request, so the potential energy resources shift from traditional to sustainable will be properly done and regulated from the initial phase. In the following chapter we will carefully examine the methodology of how the study of the factors for the implementation should be settled up.

Chapter 2. METHODOLOGY

In this chapter, the methodology of the thesis will be described. The research question of this work has been stated in the beginning of this work:

"What are the key factors that influence the successful implementation of the biogas energy systems into the existing energy infrastructure?"

The theoretical proposition of this work is filling the research gap between theoretical and practical knowledge on biogas implementation from managerial prospective. The topic of biogas is being highly covered from the engineering and mechanical perspective, however as the technology is comparably new and rapidly developing, there is a clear lack of managerial perspective on the implementation. This research will analyze and discover key factors affecting the biogas implementation.

All the aspects considered, the proposed methodology of this work is the state-of-the-art. After the literature review, a case study was conducted, which included practical cases of biogas implementation and interviews with experts. And finally, all the data and factors found during the research were validated through the additional round of interviews with experts.

2.1 Description of methodology. Methods of study

The research provided is a qualitative research. For presentation of the method of research a research framework was developed. Figure 2 describes the research framework of this study:

Figure 2. Research Methodology

In a qualitative research comparably low number of case studies are analyzed, however high attention is contributed to the details. Qualitative research allows gathering different types of data analysis and collection.

A case study is an empirical way of conducting research aimed to analyze present-day data with the real life implications. For a qualitative inquiry it is important to gather high amount of views and opinions on a topic. In order to obtain data on the ways how biogas technologies are implicated and what drives their efficiency we have chosen a case study. High amount of sources of evidence is what the case study is relied upon. The topics of research vary greatly as the implementation of biogas is a vast topic with many details affecting the process. Ability to find alternative sources of data is a core advantage of a case study.

According to the research objective, the research can be descriptive, in which situations, profiles or events are shown, explanatory research that study a new observation to understand the current state of development, and explanatory research which concentrates on causes and effects (Saunders, 2007). This research shall be considered explanatory. Flexibility and adaptation are the core advantages of the given research type. Saunders (2007) argues that research studies can be conducted through literature reviews, expert interviews and data analysis. Bryman and Bell (2007), however, state that there may be several uses. Therefore, in this study the researcher conducts interviews with experts in the field of biogas industry in addition to literature review.

The research consists of various methods, which are used to analyze the research topic. All of the gathered data serve as a primary data for the research. Primary data collection allows covering the highest amount of information. The collection of primary data consisted of two parts – practical cases analysis and interviews with company representatives. As a first step, the practical case of companies implementing biogas were observed and analyzed. This step allowed us to gather primary data as well as to see the practice of biogas integration. Interviews with company representatives were also conducted. In-depth interview analysis is included into this part. The information given by the interviewers can be obtained exclusively from the primary source.

Finally, the validation step via conducting a second-round of interviews with the experts to validate the given factors and also prioritize the factors according to their importance. The interviews with the experts allowed to verify the obtain results from their expertise and knowledge.

2.2 Sample selection

The chosen companies for the case study provide diverse material on implementation of

biogas energy on different levels in Europe. The accumulated data will be valuable for the future research on this subject as well as a practical guideline for implementation of new technologies, specifically, which factors do affect biogas energy implementation and their management. The managerial prospect of view on the findings will also be provided. This research is concentrated on the given approach to explore and to gather data on the current state of the situation in the implementation of biogas technologies.

For the sake of adjustment of results, each study is analyzed independently. “What” and “How” questions are answered through the case study, which suits our research. The details of the situation, the reasoning, motivation and subjective meanings are highlighted through the case study (Saunders, 2009).

The case study is important in a real life context. The singularity of each case and an understanding of the complex problem serves as a main purpose. As with every method of research, there are many advantages and disadvantages, among the main advantages are useful form, availability of sources and in-depth subject analysis. However, there are shortcomings, such as subjectivity, consumption of considerable time and management validation.

The choice of research type depends on the research aim and research question, the timeframes, existing knowledge and available resources. The common research techniques are survey, experiment, case study, sound theory, ethnography archival and action research (Bryman and Bell, 2007). Business companies for this study were selected with targeted selection. Targeted selection "is a strategy in which specific settings, people or actions are chosen intentionally to provide information that can not be obtained from other options either" (Maxwell, 2005).

For having the same evaluation criteria the following framework for the analysis of the case (Table 2) was developed:

Consideration topics
General information
• Establishment date
• Field of operations
• Main goal of Implementation
Production data
• Total biogas production

•	Total side products production (heat, fertilizer)
•	Volume of raw materials

Table 2. Case study framework

The choice of companies is based on the opportunity to grasp better idea of the practice of the chosen implementation strategies for selected companies, to engage the logic of replication in several case studies.

To select the appropriate cases, the list of the main criteria was created:

1) Operating biogas or work with operators
2) Has up-to-date machinery and technologies as it is the main criteria of success in the sustainable energy market
3) Has a practical solution to the implementation of biogas energy. The criteria were defined to fulfill the research requirements and research requirements. The following companies were selected: Bio En (Croatia), Mosvodokanal (Russia) and Saveco (Italy). All companies meet the basic criteria. All companies operate on biogas stations in rural areas, processing waste into energy. From a technical point of view, companies operate on different biogas plants. Bio En has a wide development of relatively small factories throughout the country, and Mosvodokanal is implementing a biogas plant to provide energy for its offices and quarters.

2.3 Data Collection

The data is collected from different sources, using several different methods to collect such data, such as observations, surveys and interviews. Corbin and Strauss state that in any research the researcher can use one or more than one of these sources or in combination, corresponding the research goal. (Corbin and Strauss, 2008). The desire to obtain different data selection on the same problem, for example, to combine interviews with observations may also be a consideration.

The data that this research is based upon was obtained through interviews and discussions with industry experts and managers of companies operating biogas. This particular study deals with the company.

Moreover, the case study may also be used testing the theory. Any object can be the case - a company, a network, a business unit, etc. The case study is being used to develop in-depth knowledge and understanding for the research as the cases are chosen for conducting an analysis

and obtaining the answer to the questions of the research. Robert K. Yin (1994) states that the case study as a research strategy is an empirical study that allows gathering context.

It is also very important to note that qualitative research can be deductive, inductive and adductive. Adductive reasoning serves as a method to connect theory to observation. High level of cooperation between students and companies should be marked at very high level. It is very important that the method of case study allows using various techniques to gather primary data, such as case analysis and interviews. In the interview, a direct quote is used to obtain transparent data.

The interviews, as a rule, involve a personal meeting, on which the researcher asks individual questions. There are 4 interview types (general, fixed answer, informal and open-ended). The type of open-ended interview was chosen because it ensures uniformity and is flexible. The general and informal types of interviews do not suit for the given research, as they do not correspond to the type of research, and the fixed answer interviews are rejected, because there is no possibility to predetermine the answers. The main disadvantage of an interview method is that it requires high level of soft and communication skills.

The main purpose of the interview is to obtain first source knowledge and information. Prior to the interview, a brief description of research was sent - it helped the experts to understand the key research goals and prepare for the interview. All interviews were conducted in February-May 2018. The language of all interviews was English. All of them were based on the structure of the interview. As a result of the interviews the description of the activities was obtained as well as experts points of view on the factors found during the literature review.

Conducted interview with managers of biogas operation companies, from following departments: engineering, construction, procurement, IT and strategic development.

2.4 Evaluation criteria and validity

Validity is an important part of the research (Maxwell, 2005). Reality is involved in "objective truth", and there is no possible accuracy that could decide whether analysis has a practical meaning. It is important to identify and obtain the desired levels of effectiveness in the study. The validity of this particular study will be established by three criteria for case studies according to Yin (1994): Construct validity, Internal validity and Reliability.

Construct validity can be increased by a variety of evidence sources, also called triangulation of data. In this research paper 5 interviews were conducted. The collected qualitative data will be compared with the publications of companies in order to increase the

reliability of the construct design. In addition, respondents were invited to review the draft report on case studies to establish an evidence chain.

Internal validity is used only in explanatory studies, which reflects current research, since this research attempts to identify and explain the factors underlying the implementation of biogas companies

Reliability is the reliability of the replication study. The researcher will be an active participant in the study and will depend on the data collected. Therefore, the researcher and bias and influence are inevitable, and the conclusions cannot be reproduced in the same way.

In order to validate the findings, the additional round of interviews was conducted. The experts were asked to comment, validate the factors that were highlighted during the research and evaluate the importance of each factor. This allowed us to have unbiased and independent view on the factors found and to underline the importance of each factor from the practical point of view.

2.5 Limitations of study

There are some natural limitations in the analysis of research. First, there was a sample limitation. If there was no such limit, the research can be expanded by more businesses operating biogas, but also the external organizations and entities connected to sustainable energy, and to get more data on which factors influence the process when choosing an implementation model.

From the study there may be some kind of subjectivity, because the conclusions drawn are based on qualitative data.

2.6 Conclusion

This work mainly contributes to qualitative research. This method allows us to collect more detailed contextual data for analysis of the theory using real data. The study is divided into 2 branches - theoretical and practical, each of which allows to obtain the necessary data and complete the complete picture.

The first stages of the analysis are case studies on the general experience of companies working on biogas, as well as their strategies for introducing biogas methods. Collecting empirical data to analyze the contemporary context of real life. It is important to obtain the highest amount of data as much data as possible; However, there is a wide variety of research topics. Numerous data sources should be one of the core advantages of case studies.

The second step is an interview. Primary data are collected mainly through interviews, since from the experience of experts there are many insights. Interviewers provide information that can only be obtained from a primary source.

Finally, a step of verification, which confirms the reliability of the results of the study as a whole with experts through in-depth interviews. All the factors that were discovered during the study are discussed with industry experts, and are scaled by their importance in accordance with the feedback received.

Since the result of the research is the implementation of a corresponding gap between reality and theory. In addition, the selected methods allow you to collect useful information and data from primary sources.

Chapter 3. RESEARCH FINDINGS

In this chapter, the practical case studies of companies implementing biogas technologies were studied and the new factors of implementation of biogas energy were found. One of which is described in detail and two other included into Appendices. Also, two rounds of interviews were conducted. During the first round the opinions and views from the real-life experience of the experts were identified and analysed, giving new insights and information from the practical point of view. This data allowed us to identify new factors of the biogas implementation and to add them to the general framework of factors found during the literature review. Finally, the second round with experts was held as a validation of all the factors found during this work. The validation included adding the scales to all the factors to understand which ones are the most important once and should be emphasized.

3.1. Example Case study: Bio En (Croatia)

Bio En is an electric producing company powered by naturally produced biogas located in Croatia and Slovenia. The company was founded in 2017 by merging of local independent biogas plants based in the region. Nowadays, Bio En is a central and management company, of a larger group of companies:

- 4 Biogas plants in operation
- 3 Biogas plants under construction
- A project for the construction of the waste treatment facility for biogas plants is approved.

Bio En, independently or in the cooperation with its subcontractors, is responsible for the maintenance of biological and technological aspects of energy plants. The main objective is to provide easy management and continuous and smooth operation of all biogas plants. The mission of Bio En is to successfully manage companies and its projects in the way that enables the realization of the set goals and maximizes future profit to the satisfaction of all co-owners and partners.

The location of biogas plants of Bio En is in the rural areas (small villages), however with strong harvesting activities. As Biogas plant is a two-sided business, it serves the local economy on supply, as well as demand side.

The company provides the municipalities with an economic alternative to disposing of food waste by offering premium-recycled material to the consumer to benefit from the anaerobic

digestion process. Also, the company states the promotion of the use of fertilizers enriched with nutrients instead of traditional energy recourses as its mission.

Biogas production input materials are divided into two main groups:

- Substrates:

Fertilizers: beef and pig and manure, poultry manure;

Plant biomass: corn, wheat, wheat and grass silage, fresh grass clippings, stem remains, products;

- Co-substrates or waste from the food processing industry:
- including food, fat, fruit and vegetable residues, compost, industrial waste water rich in proteins and carbohydrates, fat-removing substances.

The final product of biogas production is also the biomass that remains after the anaerobic digestion of organic matter – digestate. This high quality fertilizer is rich in nitrogen, phosphorus, potassium and micronutrients. Compared to fresh manure digestate, digestate has significantly better fertilizing properties due to homogeneity and higher nutritional value, better carbon and nitrogen ratios, and almost complete lack of unpleasant smell. Digestate as a fertilizer can be integrated into conventional and ecological agriculture, where digestate replaces mineral (artificial) fertilizers produced at high fossil fuel consumption. At the moment, co-operatives are financing reproductive material (artificial fertilizers, seeds, preservatives) for sowing corn silage. The plan is to replace artificial fertilizers with digestate in the coming years.

For the production of electricity from biogas it is necessary to provide sufficient amounts of biological waste. Another important side-output of biogas production is manure (liquid cow manure) which will be delivered by cattle farmers and farmers from the region. A purchase agreement for a period of 15 to 20 years has already been signed with the farmers. The manure is a problem for livestock farmers because of the legally prescribed method of disposal (in accordance with the Nitrates Directive of the European Union) so the farmers will transport it to the biogas plant. In the process of biogas production through anaerobic digestion, apart from the raw material the substrates are also used. Different types of biomass can be used for the substrate in the biogas production. Due to the favourable characteristics and proximity of the supplier, silage is used as a substrate for biogas production in the biogas plant.

In that instance, the company has settled up a department that will be the main logistics centre for the feedstock supply for the plants regardless of whether it is their own production or the production agreement with subcontractors. This department will provide during crop production to subcontractors an on going support in the development of processing technology

with the help of experts from the Faculty of Agriculture in Zagreb. The objectives of such support and cooperation are:

- the production of two cultures per year on the same land
- increasing the quality and yield of feedstock per unit area
- the reduction of costs and purchase price per unit of measure
- Subsidiary companies – energy companies that will produce electricity and heat.
- Replacement of artificial fertilizers by digestate

Department is trained to independently or in cooperation with Croatian subcontractors / right holder services technical, as well as, biological and chemical elements of the power plants. The main goal of the department is to ensure the smooth technical and managerial work with a maximum capacity of all plants. In the future, the department will place its services to other companies in the region, and not only to energy companies owned by Bio En.

3.2 Other practical case studies analysis

Apart from Bio En, two other case studies were conducted (See Appendices). Both of the companies operations are highly connected to biogas implementation.

In the first case, Mosvodokanal - a state-owned water company that provides water supply and sanitation in the Moscow region is analysed. The company uses biogas technologies to recycle the waste coming from sewage system. In fact all of the waste is being recycled through biogas stations. Electricity and heat generated through the stations is being used to provide thermal power stations nearby.

This solution allows the company to solve two problems:

- Recycling of waste
- Provide heating and electricity for the thermal stations

It is important to note that the initial motivation of biogas implementation in this case was to find a solution of the ecological problem. Before biogas implementation, all of the waste was merged into rivers nearby, which caused pollution problems. This, the ecologists concluded that implementing biogas systems are the most efficient way of recycling as it also generates electricity for the needs of a company.

Due to the reduction in fossil fuel reserves and the problem of global warming, the units serve as an environmentally friendly alternative sources of energy. Another promising area in the development of alternative energy in the sewer economy is the extraction of heat energy from sewage with the help of heat pumps.

In this particular case the biogas energy aggregation is used as a side service that is being used for the ecology matters. This particular company operates the natural waste from the city, which is being recycled, which serves as biomass for producing biogas. However, the main logic behind the biogas installment is the ability of recycling of natural waste. This allows us to say that the ecology also plays an important role in biogas implementation and, thus include the ecology as a factor of implementation:

Recycling and Ecology

- **Recycling opportunities in the local area**
- **Possible solution of local ecological problems**

In the second case an Italian biogas machinery producer is analyzed. The company usually builds the entire existing infrastructure for the biogas plant from Stage 0. Apart from the direct sales, the company also provides service for the plants after the construction. As each

company, which provides their technology has their own design of the plant it, is essential for the client to have the service done after the implementation.

As the seller of the machinery, the company usually provides desired technical requirements for the client to follow and based on the agreement of the client the company might give discount for the emergency services. The specifications include various technical specifications elements that the client is obliged to follow.

Most of the specifications are connected to the quality of the raw material that is being processed by the engine. The most common requirements are:

- Solid chemical formula of the raw materials
- Constant levels of input of the material
- Agreement to buy chemicals, which are injected into pure biomass, from the list of the trusted retailer

The deviation of the price for the client may vary up to 50% of the total payment.Those insights allow us to conclude that the quality of the raw material play an essential role in the biogas plant management. Thus, based on this study we can add a new factor to the "Raw materials" factor tree:

- **Quality of raw materials**

In conclusion, after all of the cases are analysed the following high-level factors may be added to the structure:

Geographical Reachability

- **Constant energy demand availability in reachable distance**
- **Unburdened transportation of raw materials**

Recycling and Ecology

- **Recycling opportunities in the local area**
- **Possible solution of local ecological problems**

Complimented with one factor contributing to the "Resources" group:

- **Quality of raw materials**

All of the factors found through the practical case study will be analyzed and validated by experts within the interview process.

3.3 Interview analysis

In-depth interviews were conducted with five industry experts representing companies operating biogas. The interviews serve as a primary collection of data to obtain data on real-life experience and practical knowledge of the experts interviewed. The main aim of the primary structured interview round is to obtain new factors that affect successful biogas implementation. Among the factors, mentioned by the experts the following new factors can be deducted:

- Ecology and recycling

The ecology plays a major role in the biogas adoption. In some cases the main purpose of the biogas adoption serves an ecological purpose more than financial.

The biogas plants are designed to technique nearly any kind of natural subjects inclusive of animal slurry, deep muddle, energy crops, vegetable waste, business and industrial waste in addition to household waste. The world is going through challenges in producing sufficient fertilizers for a quick growing worldwide populace, and at the identical time reducing carbon pollution. Anaerobic digestion generation has an efficient manner of meeting these challenges through the recycling of agricultural residues.

"*The most promising and interesting future of biogas technology comparing to other sustainable technologies is the ability to recycle organic waste. In some instances it doesn't matter how much energy the plant produces, but what matters is the ability to recycle and bring a solution to an ecological problem*"

- Senior Technical adviser of biogas implementation program (Russia)

- Raw materials quality

Another factor brought up by the experts is the fact that low-quality of raw materials may cause damage for the bio-engine and bring financial losses for the company. In case of an emergency engine stop, the company takes losses for the time the energy is not produced.

The most biogas plants will be able to increase their profitability if they can process a great variety of biomasses and waste resources. This includes an evaluation of available waste resources in order to build a solid business case. The farmers wanted to process large quantities of manure because anaerobic digestion increases fertilizer quality of manure, which is beneficial to both crops and the water environment. This gives the biogas plants the opportunity to choose the best composition of available resources in order to optimize gas yields, fertilizer quality and production cost. The engine is the most expensive part of the plant, in case of replacement due to low-quality input the company may have to work 2-3 years without profit to cover the loss.

"*The biogas company should work closely with both farmers and energy suppliers to develop the project in order to provide enough high-quality material for the station. It is an essential part of the business*"

- Technical adviser of a biogas plant (Croatia)

- Logistics

The logistics play a crucial function in biogas implementation. The following are the elements of the supply chain of biogas production:

- Resources of biomass
- Harvesting,
- Drying of biomass.
- Pre-treatments of biomass
- Shipping of biomass to the power unit
- Energy conversion

The optimum desire of a biomass type, sort of energy plant, locations, transport, storage and pre- remedies is difficult to make. These selections should be made before the project started. Project leaders need to make a choice for his or her precise situation. Optimization is the method of discovering the satisfactory way of using sources, at the same time not violating any of the restrictions, which are imposed. The "best practice" can be the one, with the lowest price or the highest income. Within the case of biomass logistics, both monetary and energetic goals can be applied. The returns should be sufficient to cover the fees and the energy use for the logistics must be a great deal lower than the energy returns within the plant.

"*Almost 30% of costs are connected to transportation of raw materials, therefore it is important to have to have it nearby to the plant (10-15 km – max)"*

- Senior manager of operations department (Croatia)

- Clusterization

The biogas plant is a complicated system that requires a lot of side processes to support the operation. Main day-to-day operations include:

1. Raw material supply
2. Engineering check
3. Collection of fertilizer
4. Office management

In case of creating a cluster the resources used for keeping these operations can be combined. This potentially saves financial resources therefore increases efficiency of each plant.

The clusterization brings a lot of creation of biogas clusters brings a lot of economic benefits and cost cutting.

"Due to the economies of scale effect, possible saving from the clusterization could reach up to 30%"

- Owner of a biogas plant cluster (Croatia)

- Sustainable levels of energy consumption

The engine of the plant produces energy without interruptions. Therefore the energy that is being produced is being constantly supplied to the pipe (or other source). The energy accumulation is usually financially inefficient as increases both capital and operational expenditures. As an outcome, the energy has to be constantly used by the final consumer.

In reality, most of the constant consumers are households, so the biogas plant has to be build not far from the location of the consumption. As the most common output capacity of the biogas plant is usually enough to feed the population of the village, it is desirable to have the plant nearby.

This strategic location also helps to solve the problem of raw material supply. The closeness to the village allows gathering raw materials from the farmer in more convenient manner.

"Biogas unit is usually suited for the agricultural lands, as it solves both supply and demand problems."

- Owner of a biogas plant cluster (Croatia)

- Biological laboratories

The raw material supply for the biogas plant should be of good quality as it may cause damage for the bio-engine and bring financial losses for the company. In this instance it is important to have a quality check.

It is a recurring procedure that have to be done on regular basis in order to prevent low-quality supply inside the engine. The quality check is usually done in special biological laboratories that take the sample of the raw material and assess:

- Chemical structure,
- Purity
- Amount of non-organic material

Therefore one of the essential needs of the biogas plant is the availability of such laboratories with high-skilled biologists in the area.

"*One of the core assumptions that we make when giving a warranty to the bio-engine user is the availability to make regular biological checks of raw materials*"

- Sales manager of bio-engine supplier (Italy)

As a result of non-structured interviews we've received additional insight from experts in the industry and included several new factors affecting successful biogas energy implementation to the list.

The analysis made allowed as to have the list of factors combined from both – theory and practice. As a next step these factors should be verified and given a measurement by the experts in the industry via interviews.

3.4 Results

Case analysis and interviews disclosed new views on the subject of factors that influence the choice of biogas implementation with the exception of the factors that were mentioned within the literature review, industry experts have mentioned further criteria. With their support and participation further factors were revealed and added to the initial factors found during the literature review (Figure 3):

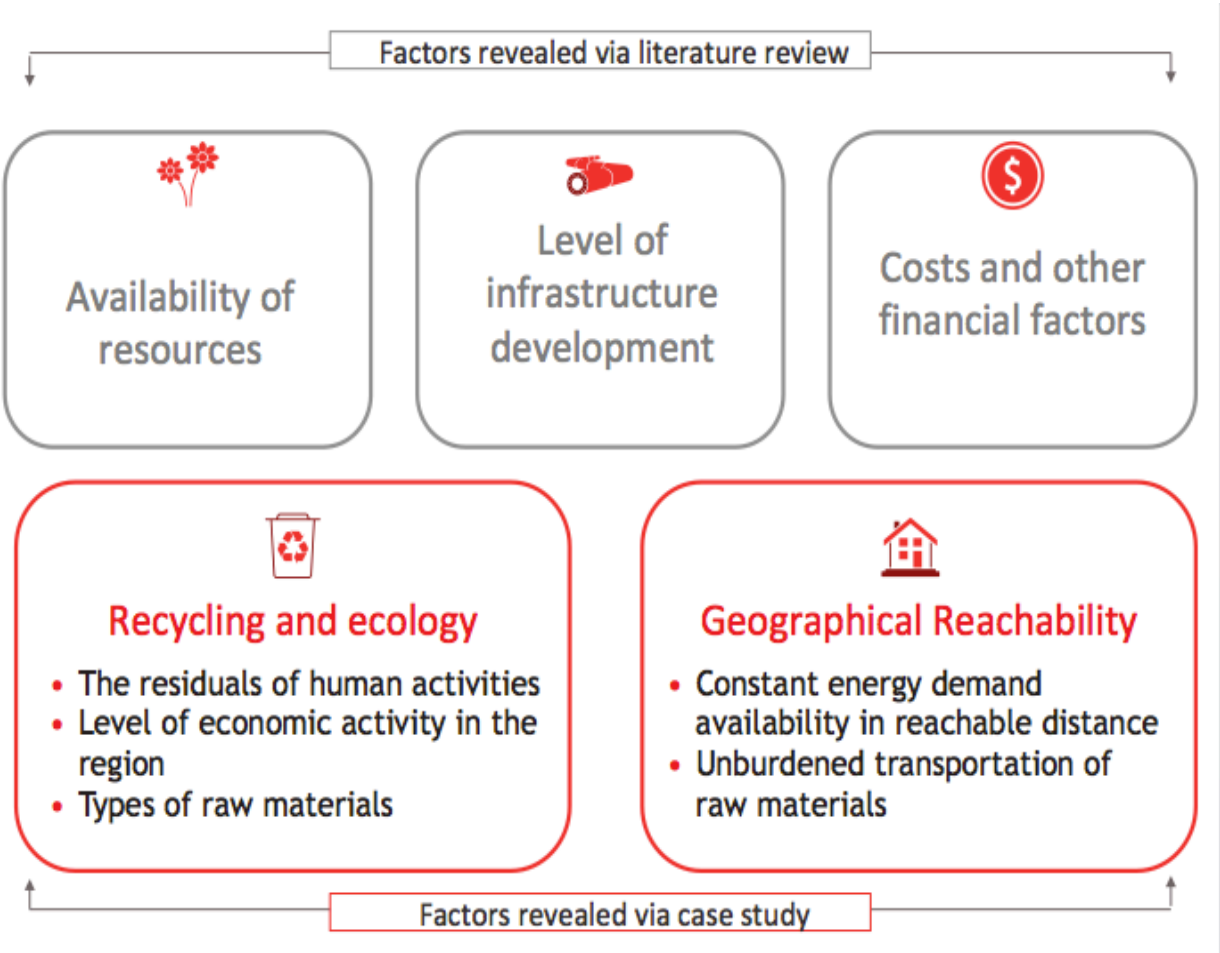

Figure 3. Factors combination

After the factors have been gathered, the additional interview was conducted to validate the importance of a given factor and also add metrics to the understanding of the level of the importance. Apart from the factors highlighted during the literature review, the empirical research brought up new factors the decision-making process about implementation that can be summarized and grouped as (Figure 4):

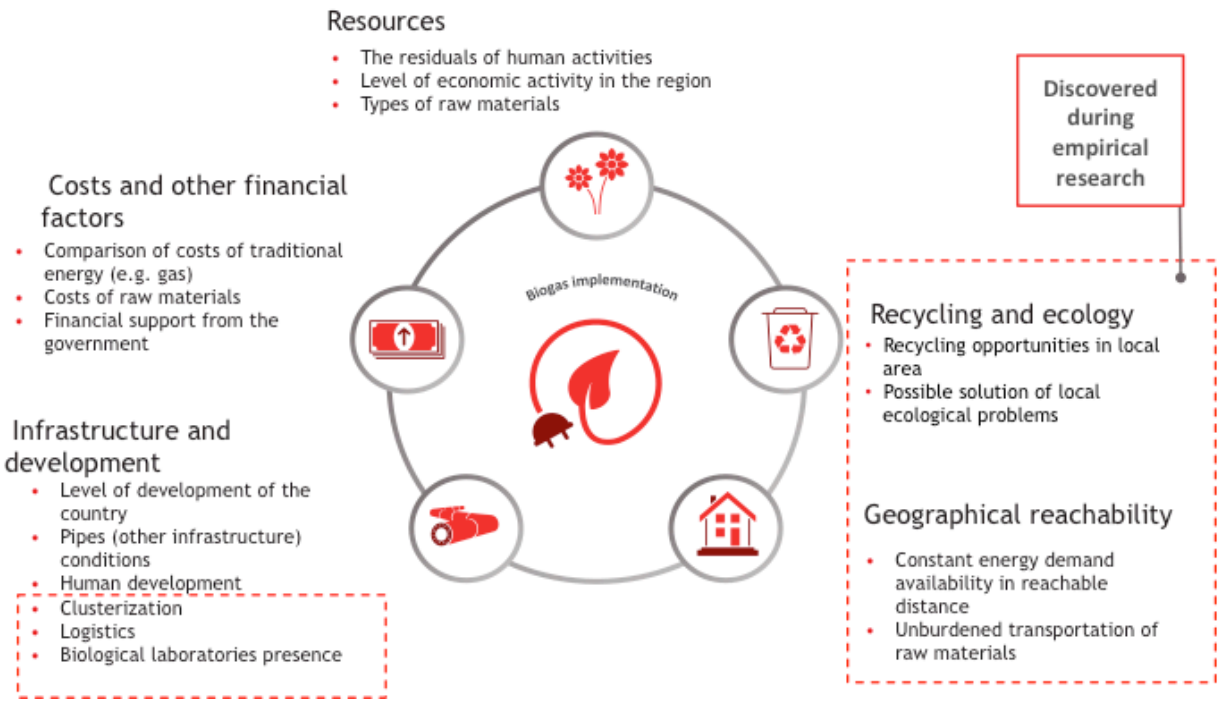

Figure 4. Factors affecting bioenergy implementation

Following Table is summarizing general factors. Thus helping to distinguish most influential factors that corporations take under consideration regarding biogas implementation. As a result of a non-disclosure agreement experts names and positions are hidden. Five experts participated in the interview process; all of the interviewed experts are the decision-makers in their function.

Figures within the Table 3 and Figure 5 indicate that the manager agreed that this specific issue is critical and is vital in decision-making method of biogas implementation. Also each expert was asked to rank the importance of given factors from 1 to 10 to identify the importance of each factor.

Factors	Exp 1	Exp 2	Exp 3	Exp 4	Exp 5	Average
Availability of resources and supply	8	6	7	8	9	**7**
Level of infrastructure development	5	4	4	5	6	**5**
Costs and other financial factors	10	9	8	10	9	**9**
Recycling and ecology	2	2	4	1	1	**2**
Geographical Reachability	3	5	4	7	5	**5**

Table 3. Factors influencing the implementation of biogas energy

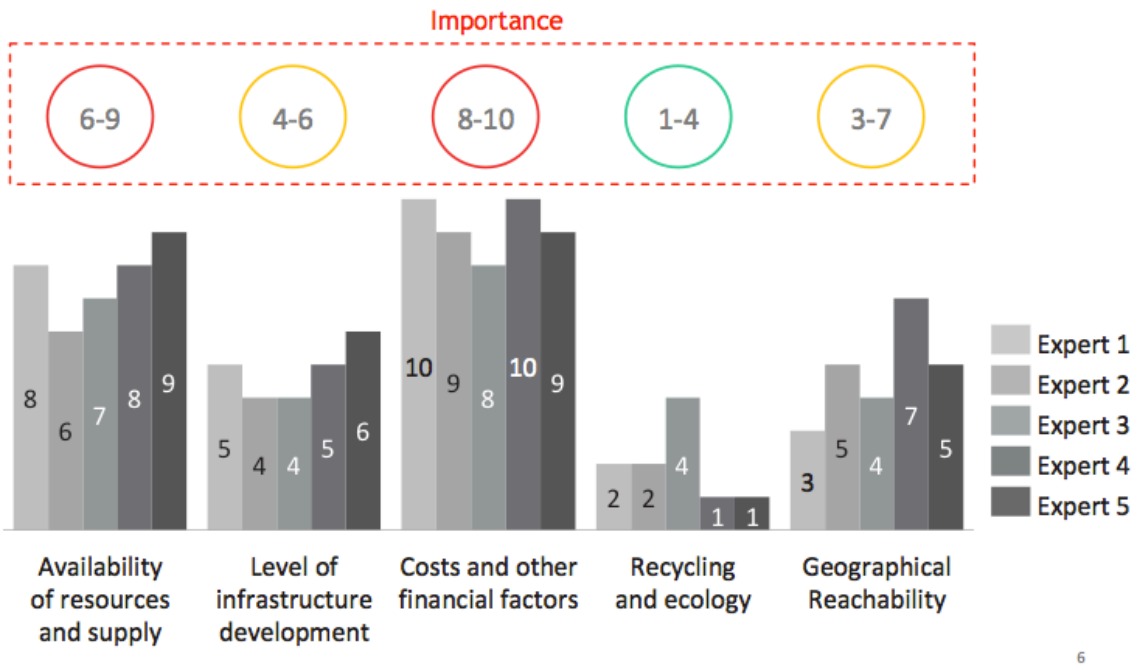

Figure 5. Validation summary

All the managers indicated resources and costs are the most important parts, which influence the process of biogas implementation. Experts state that efficient integration of biogas plant into the existing infrastructure is also important. The correlation of the factors is the main challenge as all the factors combined give a broad view on the implementation technique.

The following prioritization can be implemented to visually show the importance of given factors in biogas implementation (Figure 6):

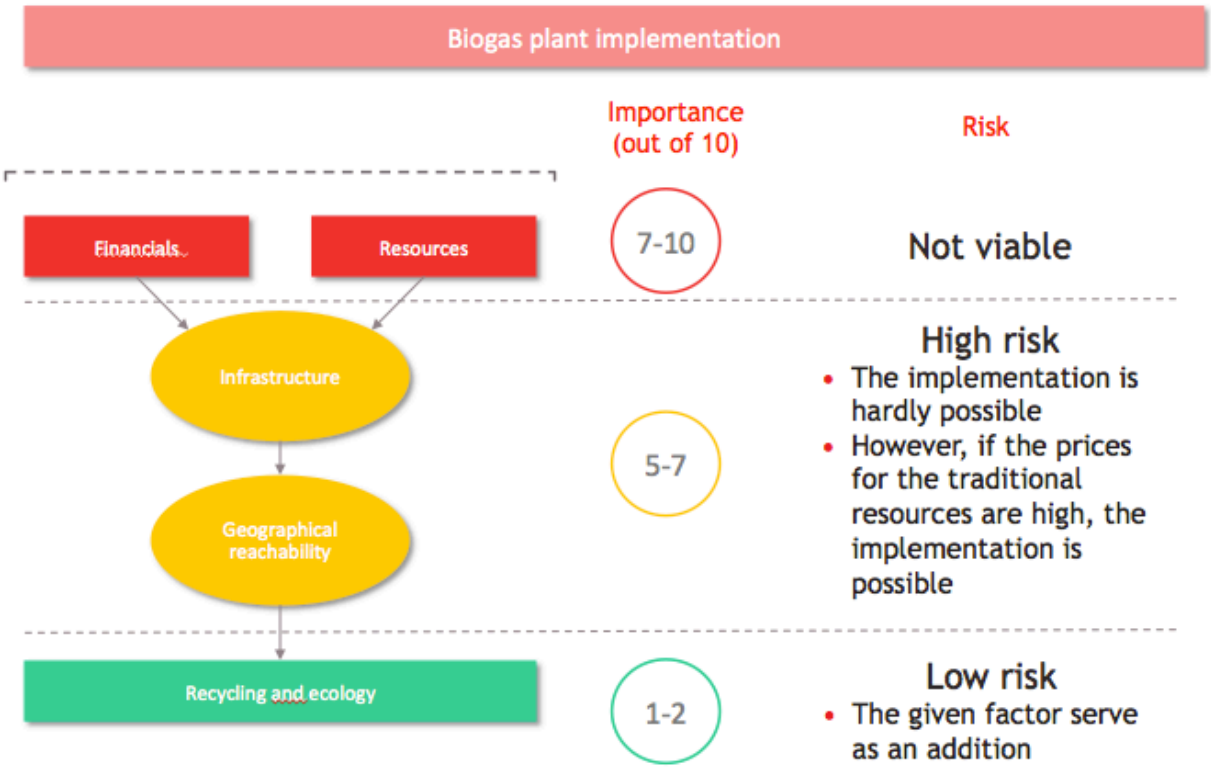

Figure 6. Prioritization of the factors found during the research

3.5 Application of factors in case analysis of Bio En

For practical validation of the factors that were gathered through the literature review and a case study the following framework has been developed to indicate the validity of those factors in a real-life context. We have chosen Bio En's BIOINTEGRA - 2.4 MW plant as a role model, as it reflects the majority of biogas operators among other cases studied.

Bio En BIOINTEGRA - 2.4 MW	
Factors	**C ase implementation**
Availability of resources	The company is operating near the small village, where the vast majority of population are farmers. Most of the farmers have livestock (cows, sheep and pigs), which naturally produce the material for the biomass. Apart from it the biomass used for the plant also consists of silage to improve the efficiency of energy generation, the silage is also a side product of farmers operations.
Costs and other financial factors	The cost of natural gas in Croatia is approximately 90 EUR/mWh, while the cost of biogas generation is on the level of 130 EUR/mWh. However, as Croatia is not a natural gas exporter, the country highly depends on the prices of gas, which are expected to grow in the future. For this reason the EU imposes a feed-in subsidy, which covers up to 50% of the energy generation.
Level of development	According to Logistics Performance Index (LDI), Croatia is in the top-50 countries with best infrastructure. Croatia is also present in top-50 according to Human Development Index (HDI). Both of these indicate highly positive results for biogas implementation.
Geographical reachability	As the company is located in 300 meters from the village, both supply and demand are unburdened.
Recycling and ecology	Prior to the installation of the plant, all of the waste from farmers activities were not recycled and farmers had to deal with transportation issues by themselves. The introduction of biogas plant allowed farmers to solve this problem, as the operating company takes all the logistics on themselves and also pay the farmers for having their waste

Table 4. Real-life application of factors

3.6 Managerial Implications

Today, the companies are operating in a challenging business world with high amount of uncertainty. It turns out, that the most successful companies are the ones who can foresee the situation and react with low amount of adjustment costs and efficient responses. To choose the right approach on the biogas implementation all the factors that influence the success of performance.

The research has a clear practical use; it may be used for companies planning to implement biogas generation on a separate biogas station or as an independent solution to produce energy for their needs. Both, operational and capital expenditures may be reduced, as well as improve economic and organizational sustainability, therefore it is important to analyse the discovered factors at Stage 0 of planning bioenergy implementation.

The information in this research may be used by the managers in developing a business model of future implementations of biogas. By analysing this research paper, the decision-makers may understand the importance of the given factors to have a possibility to gain advantage on a planning stage as careful analysis of the factors found in this work prior to the construction of a biogas plant may result in large amount benefits from financial and operational point of view. The experts who were interviewed prove the managerial implications of this paper.

CONCLUSION

The trends and strategies of bioenergy implementation are studied in this research. Despite a number of scientific researches on sustainable energy and biogas in particular there is little evidence on the managerial view of biogas implementation factors which to be considered when making a decision on the choice of the bioenergy implementation and their significance. We have concentrated on operations of implemented bioenergy units to identify the main strategic factors influencing the implementation process.

The aim of this paper that was to fill the research gap has been reached through the case study of three companies and the primary data analysis obtained via interviews with industry experts who represent companies. Five experts supported the case study.

The objectives stated in the paper introduction have been reached:

- Have provided a literature review on biogas energy and outline the specific aspects of its implementation
- Have identified the main strategic factors that influence the implementation of the new energy resources,
- Have prioritised the importance of these factors through the interviews with experts
- Have developed recommendations for companies operating in this industry

The research gap has been filled by answering the research question through the qualitative research that included primary and secondary data analysis provided through the literature review and case study. As a result of this research the factors of successful biogas implementation were discovered, explained and prioritized.

Theoretical contribution

The research has contributed to the sphere of knowledge on the companies operating biogas, process of its implementation and identification of the core factors, which should be considered when choosing an implementation approach.

The theory of bioenergy implementation is developed from the engineering point of view with high amount of research papers on this topic, however from the managerial point of view the amount of research on the decision-making of biogas implementation is very low.

The following can be listed as a theoretical implication, first of all, the factors that influence the process of decision-making when choosing an approach for biogas implementation into the existing infrastructure. Due to experts participation and scientific articles, highlighting the given topic the theoretical input was made. In addition, the findings were discussed with experts in order to validate and identify the list of factors and then out of those the most important ones in terms of theory and practice were combined. As a result, five core factors that

affect the choice of the implementation of biogas technology were determined. The future research on biogas management may use this paper as a starting point.

Recommendation for future research and limitations

The bigger list of companies may be analysed to compliment the research and understand broader picture on the world tendencies. Majority of case studies of biogas implementation are based in developed countries. The development of industry may allow future research to be done for other parts of the world. In the future more factors could be identified which will allow conducting a Factor analysis for better understanding of the importance of factors.

As there is no general view on the definition and evaluation of the factors related to the bioenergy implementation, the subject area has high potential for researchers for further evaluation of the factors, their interrelationships, specific effect of the factor, barriers of implementation to the given factors and modeling.

The research limitations are related to the uniqueness of each business case. The study consists of essential key elements, which could be developed according to specific needs. The highlighted factors are limited in their use as they are highly connected to the context and setting of the biogas implementation. Each business case has a unique setting, which has to be taken into account when implementing bioenergy.

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APPENDICES

Appendix 1 Case Study of Bio En (Full)

General information

Bio En is an electric producing company powered by naturally produced biogas located in Croatia and Slovenia. The company was founded in 2017 by merging of local independent biogas plants based in the region. Nowadays, Bio En is a central and management company, of a larger group of companies:

- Biogas plant in operation: BIOPLINARA ORGANICA KALNIK 1 - 2.4 MW
- Biogas plant in operation: BIOPLINSKA ELEKTRANA OREHOVEC - 1.2 MW
- Biogas plant in operation: BIOINTEGRA - 2.4 MW
- Biogas plant in operation: BPE DOMEN JURŠA - 1.2 MW
- Biogas plant under construction: VDM DONJI MIHOLJAC - 1.125 MW
- Biogas plant under construction: VDM VILJEVO - 1.125 MW
- Biogas plant under construction: BIOPLIN PROIZVODNJA - 1.2 MW
- A project for the construction of the waste treatment facility for biogas plants is approved.

The Bio En company, independently or in the cooperation with its subcontractors, is responsible for the maintenance of biological and technological aspects of energy plants. The main objective is to provide easy management and continuous and smooth operation of all biogas plants. The mission of Bio En is to successfully manage companies and its projects in the way that enables the realization of the set goals and maximizes future profit to the satisfaction of all co-owners and partners.

The company provides the municipalities with an economic alternative to disposing of food waste by offering premium-recycled material to the consumer to benefit from the anaerobic digestion process. Also, the company states the promotion of the use of fertilizers enriched with nutrients instead of traditional energy recourses as its mission.

Biogas plants

The company operates 4 biogas plants with various energy output. All of them work on the same system. One of the largest plants is located in Gregurovec, Croatia, on which we shall concentrate to explain the business.

A 2 MW biogas plant is located in the village of Gregurovec. The plant has been operational since November 2016. Two cogeneration units produce electrical and thermal energy. The construction of a biogas plant is an essential part in the agricultural process of local farmer business, because it is possible to obtain heat and electricity and provide excellent fertilizer (co-substrate).

Biogas production input materials are divided into two main groups:

- Substrates:

Fertilizers: beef and pig manure and manure, poultry manure;

Plant biomass: corn, wheat, wheat and grass silage, fresh grass clippings, stem remains, products;

- Co-substrates or waste from the food processing industry:

Animal by-products including food, fat, fruit and vegetable residues, compost, industrial waste water rich in proteins and carbohydrates, fat-removing substances.

A 14-year contract with the Croatian Energy Regulatory Agency (HROTE) has been signed for the purchase of electricity by a preferential feed-in tariff, which is corrected annually by inflation and rising energy prices.

The final product of biogas production is also the biomass that remains after the anaerobic digestion of organic matter – digestate. This high quality fertilizer is rich in nitrogen, phosphorus, potassium and micronutrients. Compared to fresh manure digestate, digestate has significantly better fertilizing properties due to homogeneity and higher nutritional value, better carbon and nitrogen ratios, and almost complete lack of unpleasant smell. Digestate as a fertilizer can be integrated into conventional and ecological agriculture, where digestate replaces mineral (artificial) fertilizers produced at high fossil fuel consumption. At the moment, co-operatives are financing reproductive material (artificial fertilizers, seeds, preservatives) for sowing corn silage. The plan is to replace artificial fertilizers with digestate in the coming years.

Strategic implementation and resources

The location of biogas plants of Bio En is in the rural areas (small villages), however with strong harvesting activities. As Biogas plant is a two-sided business, it serves the local economy on supply, as well as demand side.

For the production of electricity from biogas it is necessary to provide sufficient amounts of biological waste. Another important side-output of biogas production is manure (liquid cow manure) which will be delivered by cattle farmers and farmers from the region. A purchase agreement for a period of 15 to 20 years has already been signed with the farmers. The manure is a problem for livestock farmers because of the legally prescribed method of disposal (in accordance with the Nitrates Directive of the European Union) so the farmers will transport it to the biogas plant. In the process of biogas production through anaerobic digestion, apart from the raw material the substrates are also used. Different types of biomass can be used for the substrate in the biogas production. Due to the favourable characteristics and proximity of the supplier, silage is used as a substrate for biogas production in the biogas plant.

In that instance, the company has settled up a department that will be the main logistics

centre for the feedstock supply for the plants regardless of whether it is their own production or the production agreement with subcontractors. This department will provide during crop production to subcontractors an ongoing support in the development of processing technology with the help of experts from the Faculty of Agriculture in Zagreb. The objectives of such support and cooperation are:

- the production of two cultures per year on the same land
- increasing the quality and yield of feedstock per unit area
- the reduction of costs and purchase price per unit of measure
- Subsidiary companies – energy companies that will produce electricity and heat.
- Replacement of artificial fertilizers by digestate

Department is trained to independently or in cooperation with Croatian subcontractors / right holder services technical, as well as, biological and chemical elements of the power plants. The main goal of the department is to ensure the smooth technical and managerial work with a maximum capacity of all plants. In the future, the department will place its services to other companies in the region, and not only to energy companies owned by BioEn.

The existing infrastructure and economic development

Croatia is one of the stable markets in Europe, however it is still developing comparing to Western European countries. As the country does not possess natural resources of energy, the government settled up an Energy Strategy 2009-2020 to support local sustainable energy producers, with a huge emphasis on biogas. Eligible producers that receive incentive fees and have signed power purchase contracts with the Croatian Energy Market Operator (HROTE), has been updated on 10 July 2015:

Plants in Croatia that have been commissioned are:

- 5 biomass power plants, 9.265 MW
- 14 biogas plants, 14.935 MW

Energy Strategy of the Republic of Croatia (2009-2020)

- 20% share of renewable energy sources (RES) in gross final energy consumption
- 10% share of RES in all types of transport
- 35% share of electricity from RES in total electricity consumption
- The RES gross energy consumption for heating and cooling will amount 20% of total energy consumption for heating and cooling
- Production of 84 PJ from RES in 2020

Apart from the local government, the sustainable energy producers are also supported by the EU subsidiaries. In the 2014-2020 programming period, from the European Structural and Investment Funds (ESI Funds) a total of EUR 10,676 billion has been allocated to the Republic of Croatia.

Of this amount, EUR 8,397 billion of funding is available for the cohesion policy; EUR 2,026 billion is available for agriculture and rural development, and EUR 253 million for fisheries development.

In order to get the EU funding, the projects of Bio En will be realized with reliable partners with whom the relationship on mutual expertise and trust has been built. Furthermore, the company is in the collaboration with business partners accomplished in the design and construction of the plants, but also collaborates with team of experts from different fields.

The company is currently implementing the project "Improving the efficiency of the Bioplinara organica Kalnik 1 d.o.o. company" by introducing advanced information and communication technology (ICT) solutions" for which HRK 758,295.00 from the European funds have been approved.

The general objective of EU funds is to develop and increase the competitiveness of small and medium-sized enterprises (SME) in the Republic of Croatia through investment in tangible and intangible assets by introducing new ICT solutions in the business enterprises. This project will optimize 3 business processes, integrate business functions and open 5 new jobs.

Appendix 2. Case Study of Mosvodokanal

General information

Moscow State Unitary Enterprise "Mosvodokanal" is the largest in Russia water company that provides water supply and sanitation in the Moscow region. Mosvodokanal produces drinking water, receives and purifies wastewater, using an infrastructure consisting of dozens of pumping stations, treatment facilities and engineering systems for water supply and distribution, and also recycles the snow mass.

The main activities of Mosvodokanal are:

- water intake, purification and distribution of water in the network;
- collection, transportation and treatment of municipal wastewater;
- operation of water supply and sanitation systems in urban and other settlements;
- reception and disposal of snow masses

The Moscow water supply system is based on two water sources - the Moskva River and the Volga River with tributaries regulated by a system of reservoirs and hydraulic structures. Sources of water supply are located in the Moscow, Tver and Smolensk regions. Water in the capital's houses comes from the Moskvoretsko-Vazuzskaya and Volga water systems.

The sewage system includes a total of 7,900 km of sewerage networks, 156 pumping stations, which daily drainage amounts to about 3.8 million m³ of sewage. Domestic, municipal and industrial wastewater is sent to the sewerage system.

The entire sewerage system is divided into two main basins: 60% of the sewage is sent to the Kurianovsky Sewage Treatment Plant, and 40% of the wastewater flows to the Luberetsk sewage treatment plant with productivity. The treatment facilities carry out uninterrupted reception and cleaning of incoming wastewater, returning to the nature recyclable water. Both of these plants recently adopted biogas system as a part of recycling of water process and production of energy and heat for the plants

Usage of biogas technology

In recent years, progress in the development of wastewater treatment practices is inextricably linked to resource conservation, reduction of greenhouse gas emissions. As a result of fermentation of sewage sludge, biogas is produced, which can be used as an alternative energy source.

Recently a thermal power plant operating on biogas with an electric capacity of 10 MW was put into operation at the Kuryanovskiy sewage treatment plant. The unit provides electricity to 50% of the main technological consumers at the plant and works in parallel with the network of "Mosvodokanal". During the operation of the unit, there were already several cases of disconnection of the external power supply source, while the main technological equipment was

supplied from the unit.

Considering the need to improve the reliability of power supply systems and the positive experience of operating a mini-TPP on the biogas of the Kuryanovsky treatment facilities, a decision was made to build a similar unit in the territory of the Luberetsky sewage treatment plant. At present the facility is built and ready for operation.

Due to the reduction in fossil fuel reserves and the problem of global warming, the units serve as an environmentally friendly alternative sources of energy. Another promising area in the development of alternative energy in the sewer economy is the extraction of heat energy from sewage with the help of heat pumps.

The installation of a 55 kW heat pump at both of sewage pumping stations is used for heating buildings.. Thus, for the first time in Russia, the heat of waste water, which has a temperature of about + 20 ° C, is used to heat the building. At the same time, the cost of heating the station was reduced almost 5 times.

In this particular case the biogas energy aggregation is used as a side service that is being used for the ecology matters. This particular company operates the natural waste from the city, which is being recycled, which serves as biomass for producing biogas. However, the main logic behind the biogas installment is the ability of recycling of natural waste. This allows us to say that the ecology also plays an important role in biogas implementation and, thus include the ecology as a factor of implementation:

Recycling and Ecology

- **Recycling opportunities in the local area**
- **Possible solution of local ecological problems**

Appendix 3. Case Study of Saveco

Saveco is an Italian company, which produces engines for the agricultural biogas energy, which absorbs the biomass and produces gas. The company operates in countries within EU and sells their machinery. Apart from engines themselves, the company also sells the machinery for biogas energy units and provides the services for the companies implementing the sold machinery. Usually the company builds the biogas system, implementing their machinery from Stage 0 of plant construction and remains as a service provider.

The company is operating with different clients – from small biogas operators such as small agricultural farms to large producers. Due to geographical position, most of the clients are the independent biogas units located in the villages, which absorb the biological waste from the farmers. Therefore the most common power of the engine the company sells is from 1 to 2 mW.

Apart from the sales, the company provides service for the plants. As each company, which provides their technology has their own design of the plant it, is essential for the client to have the service done after the implementation. The service they do provide can be divided into two brunches.

- Regular
- Emergency

The regular service is made on a seasonal basis. It includes the check of the key indicators of production, planned change of the renewables and advises for the operator. It is usually included in the upfront price for the client. The emergency service is done in case of a failure of the machinery or significant reduction of the power supplied. It is usually billed to the client separately. The specifics of the biogas plants is the fact, that the failure of the biogas engine causes huge financial impact on the operator, in some cases even one emergency stop per year may be a critical for financial success of the company. Therefore the technical engineers should be available at anytime and the company promises to reach the location of the plant in one day.

The emergency service takes high financial impact for the engine provider as well. The ability to be present at the plant location in one day requires the technical and financial abilities. When signing the contract with the client, usually most of the negotiations are conducted on this basis. The natural will of the client is to reduce the price of the emergency service, while the engine provider needs to forecast the costs of the services to cover the financial losses.

The forecast of such costs are extremely important for both of the companies. The seller of the engine usually provides desired technical requirements for the client to follow and based on the agreement of the client the company might give discount for the emergency services. The

specifications include various technical specifications elements that the client is obliged to follow.

Most of the specifications are connected to the quality of the raw material that is being processed by the engine. The most common requirements are:

- Solid chemical formula of the raw materials
- Constant levels of input of the material
- Agreement to buy chemicals, which are injected into pure biomass, from the list of the trusted retailer

The deviation of the price for the client may vary up to 50% of the total payment.

Those insights allow us to conclude that the quality of the raw material play an essential role in the biogas plant management. Thus, based on this study we can add a new factor to the "Raw materials" factor tree:

- Quality of raw materials

Appendix 4. Interview Mindmap